in New England and New York to assume the annual evaporation from water surfaces equal to the annual rainfall, which is probably in excess of the fact. Table 2 contains results of experiments made by Mr. Charnock, at Holmfield, England. They are detailed in the Journal of the Royal Agricultural Society, Vol. X. These results are taken from an abstract in the Minutes of the Proceedings of the Institution of Civil Engineers, Vol. XXI. The evaporation from drained ground appears excessive. I conjecture that it was determined by observing the discharge of the drains and deducting this from the rainfall. If so, it includes the flow from the surface as well as the quantity absorbed by plants. The evaporation from water surfaces in England is not on an average equal to the rainfall.

TABLE 2.

Year.	Rainfall.	Evaporation from soil—	
		Saturated with water.	Drained.
	Inches.	*Inches.*	*Inches.*
1842	26.11	30.02	21.56
1843	24.49	31.19	20.11
1844	19.00	37.85	15.40
1845	28.18	31.09	23.26
1846	25.24	33.28	18.38
Mean	24.60	32.68	19.74

These results indicate that large losses from evaporation are to be expected in the drainage grounds appurtenant to these reservoirs, consisting as they do largely of swamps and morasses.

The water taken up by plants constitutes a large deduction from the rainfall. Plants draw up water through their roots, and reject it at their leaves, retaining organic and mineral matters held in solution, water being necessarily the medium through which the plant obtains its nourishment. Many experiments have been made to determine the quantity of water transpired by plants. Not to mention the interesting labors of Woodward, a learned English physiologist, in the latter part of the seventeenth century, we will notice those of quite recent date. M. E. Risler, at Calêves, near Nyon, in the canton of Vaud, Switzerland, has recently given his attention to this subject. He operated both in the laboratory, and by observing the flow from the drains of a field placed in favorable conditions for such observations. He states the daily consumption of water for different kinds of crops as follows:

	Inches.		Inches.
Lucerne grass	0.134 to 0.276	Vineyard	0.035 to 0.051
Natural meadow	0.122 to 0.287	Wheat	0.106 to 0.110
Oats	0.114 to 0.193	Rye	0.091
Beans	0.118	Potatoes	0.028 to 0.055
Indian corn	0.110 to 0.157	Oak trees	0.020 to 0.031
Clover	0.114	Fir trees	0.020 to 0.043

Schleiden, at Jena, found for a mixture of clover and oats grown in earth contained in an iron box, which was weighed at intervals to determine the evaporation, a consumption of about 0.0984 inch per day from the time of sowing till the time of harvesting, a period of 129 days. Very careful experiments upon this subject have been in progress for several years at the Observatory of Montsouris, in France. The grain is grown in earth contained in metallic boxes, and similar boxes without grain are used to determine the evaporation proper. The earth in some experiments has been carefully dried and weighed before sowing and after harvesting. The results have not been essentially different from what precedes. To produce a pound of wheat requires the expenditure of from 800 to 2,400 pounds of water, the quantity being small with highly manured earth and large in the contrary case. In the case of wheat, the maximum consumption of water occurs at the period of flowering, from which it diminishes till the grain ripens, when it ceases altogether. It will be seen from the above that a field of grain—wheat, oats, or rye—may absorb between seed-time and harvest as much as 15 inches of water, and a field of grass still more. This fact will go far to explain the difference observed in the yield of different drainage ground, and even of the same drainage ground in different years. These results appear also to throw some light upon other obscure questions in hydrology; for instance, the prevalent belief that the destruction of forests diminishes the flow of streams. It appears that the quantity of water required by cereal crops is greatly in excess of that required by forest trees, from which it would appear that the clearing and cultivation of forest lands actually does diminish the quantity of water carried off by streams. They enable us to understand, also, how lands, rich in the chemical constituents of certain grains, produce large crops with a small rainfall, like the north of Dakota and Minnesota, where with a rainfall of 17 inches, 30 and 35 bushels of wheat to the acre is no uncommon yield.

The uncertainty of the rainfall as an indication of the flow of streams, has led observers, latterly, to seek for a surer indication in the quantity of water which enters the ground to a depth sufficient to be secure from loss, this being the portion which goes to maintain the ordinary dry-weather flow of streams. It would be more instructive to refer to records of such observations made in this country, did any such exist, which, unhappily, is not the case. Our hydraulic engineers have not hitherto realized the necessity of inquiring so closely into the operations of nature controlling the supply of water. Such observations are made by a percolation gauge, or Dalton gauge, as it is ordinarily called, from Dr. John Dalton, who first directed attention to this subject, near Manchester, in England, in 1796–'97–'98. This gauge, as recently used, consists of an iron vessel, not less than 3 feet deep and 18 inches to 3 feet or more in diameter. It is sunk in the ground and filled with earth, its rim being at the surface of the ground. A pipe leading from the bottom of the vessel enables the water to be drawn off and measured. The surface of earth in the vessel is even with the general surface of the ground, and is usually covered with grass or herbage. Dr. Dalton's average monthly results for the three years 1796–'97–'98, are given in Table 3.

TABLE 3.

Month.	Rain.	Percolation.
	Inches.	*Inches.*
January	2.458	1.450
February	1.801	1.273
March	0.902	0.279
April	1.717	0.233
May	4.177	1.493
June	2.483	0.299
July	4.154	0.059
August	3.554	0.168
September	3.279	0.325
October	2.899	0.227
November	2.934	0.879
December	3.202	1.718
Total	33.560	8.402

Mr. E. Risler, before alluded to, made observations upon this subject upon a larger scale, by noting the drainage from a field some three acres in extent, underlaid by drains some 4 feet deep and 33 feet apart. He gauged the water discharged by these drains during the years 1868–'69, at the same time observing the rainfall. His average monthly results are given in Table 4.

TABLE 4.

Month.	Rain.	Percolation.
	Inches.	*Inches.*
January	1.885	0.914
February	2.661	1.603
March	2.492	1.894
April	1.410	0.000
May	4.896	0.106
June	2.725	0.051
July	1.760	0.000
August	1.649	0.000
September	3.174	0.000
October	1.367	0.000
November	1.980	0.783
December	8.051	5.728
Total	34.05	11.08

Records of percolation have been kept at Hemel Hempstead Herts, England, since 1835, having been commenced by Mr. Dickinson, a paper manufacturer, and continued after his death by his partner, Mr. John Evans. Table 5 gives the results obtained by Mr. Dickinson, being the averages for eight years, 1836–1843, inclusive, with a Dalton gauge filled with the ordinary soil of the district, a sandy, gravelly loam, and grassed over.

The apparent anomaly is presented in table 5 of an infiltration in excess of the rainfall for the month of December. This simply indicates that the influence of rains occurring in November extended into the following month.

TABLE 5.

Month.	Rainfall.	Percolation.	Per cent.
	Inches.	*Inches.*	
January	1.847	1.307	70.7
February	1.971	1.547	78.4
March	1.617	1.077	66.6
April	1.456	0.306	21.0
May	1.856	0.108	5.8
June	2.213	0.039	1.7
July	2.287	0.042	1.8
August	2.427	0.036	1.4
September	2.639	0.369	13.9
October	2.823	1.400	49.0
November	3.837	3.258	84.9
December	1.641	1.805	110.0
Total	26.614	11.294	
Average			42.1

Table 6 contains results obtained by Mr. Evans since 1855. His observations extended to the kind of ground known in England as chalk, as well as the ordinary soil of the district. The results are presented in half-yearly periods, viz, winter, commencing October 1, and summer, commencing April 1. A column is added giving the number of wet days in winter, and a column giving the number of days in the year in which more than one-half inch of rain fell.

TABLE 6.—*Results of observations made by Mr. John Evans, at Nash Mills, near Hemel Hempstead Herts, England.*

Year.	Winter commencing October 1.			Summer commencing April 1.			Number of wet days in winter.	Number of days on which more than ½ inch fell.
	Rain, inches.	Percolation, inches.		Rain, inches.	Percolation, inches.			
		Soil.	Chalk.		Soil.	Chalk.		
1855–'56	14.48	6.82	10.47	14.86	2.79	3.09	76	9
1856–'57	11.96	3.72	7.19	14.11	1.11	1.32	71	3
1857–'58	11.81	5.64	7.16	12.27	0.80	0.84	63	5
1858–'59	9.64	0.09	2.69	18.31	0.00	4.22	71	1
1859–'60	16.49	9.27	12.44	20.40	3.16	8.94	93	4
1860–'61	11.56	7.61	7.55	10.38	1.13	1.02	81	3
1861–'62	12.63	7.42	8.19	14.37	2.39	1.77	79	6
1862–'63	11.01	7.56	5.50	13.40	0.00	0.19	82	4
1863–'64	9.24	3.18	5.89	8.42	0.35	0.45	77	2
1864–'65	10.93	3.42	3.55	12.60	0.00	0.00	73	4
1865–'66	20.00	10.47	12.05	15.59	0.03	0.20	103	7
1866–'67	12.60	4.64	6.97	14.37	0.18	1.39	100	4
1867–'68	11.36	2.03	5.36	10.05	0.04	0.42	90	3
1868–'69	17.58	7.64	11.21	12.80	0.02	2.00	104	7
1869–'70	13.33	4.50	8.76	7.59	0.00	0.00	88	6
1870–'71	12.54	2.08	5.35	16.09	0.00	1.72	83	1
1871–'72	11.25	4.65	9.50	14.44	1.00	2.70	85	3
1872–'73	21.55	11.25	16.05	11.29	0.00	0.00	108	7
1873–'74	8.91	1.86	4.40	10.71	0.05	0.65	73	2
1874–'75	11.69	4.15	5.57	15.03	0.00	3.46	87	3
Average of 20 years	13.028	5.200	7.792	13.352	0.652	1.719	85	4

Annual average rainfall, 26.380 inches. Percolation, soil, 5.852; chalk, 9.511. It is stated that Messrs. Dickinson and Evans were enabled by these observations to foretell the quantity of water available for their mill several months in advance, and that orders for the summer are largely regulated by the quantity of infiltration observed during the preceding winter.

Mr. Charles Greaves, engineer of the East London Water Works, in a paper recently presented to the Institution of Civil Engineers, London, details the result of observations made by him during more than twenty years past. He observed the quantity of water delivered by Dalton gauges, a rain-gauge, and an evaporating gauge. A summary of his results is presented in Table 7. The rainfall is very near what may be expected on the Upper Mississippi.

TABLE 7.

Year.	Rainfall, inches.	Percolation, inches.		Evaporation from water-surface.
		In ground.	In sand.	
1852	33.500	11.375		
1853	28.500	5.500		
1854	17.500	1.250		
1855	24.714	2.704		
1856	23.812	4.860		
1857	28.627	8.340		
1858	23.899	3.500		
1859	27.767	7.387		
1860	32.558	10.761	23.456	21.058
1861	23.633	5.711	16.360	25.008
1862	26.581	8.549	21.178	17.332
1863	19.766	3.761	16.411	18.266
1864	15.891	3.824	12.636	18.640
1865	29.248	11.150	27.823	20.124
1866	31.697	12.587	28.112	18.821
1867	27.436	5.162	22.424	20.061
1868	23.308	7.112	20.200	26.933
1869	24.562	8.050	22.137	19.062
1870	20.395	7.225	18.699	20.396
1871	24.083	6.118	20.087	19.583
1872	37.166	12.025	30.050	22.916
1873	23.770	4.050	20.120	20.395
Average, 22 years	25.837	6.866		
Average, 14 years	25.721	7.582	21.406	20.613

These results appear to indicate that streams like the Chippewa, issuing from sandy regions, may be expected to keep up better in dry weather than those coming from clay regions, like the Red River of the North or the Upper Mississippi; and that, since the function of reservoirs is to store up the flood-water for use in times of drought, they promise less benefit to the former class of streams than to the latter.

The vast deposits of unsolidified material overlying the solid rocks are all more or less permeable to water. Pure sand contains, when saturated, 30 to 40 per cent. of its bulk of water; gravel, some 25 per cent. The ground at a certain depth is always found saturated with water, which rises after large accessions from rain sometimes nearly to the surface of the ground, and falls, when not so replenished, sometimes so low that the deepest wells are left dry. In a region of sand or gravel, a fall of 6 feet in the ground-water implies the discharge into the streams of 40 to 55 millions of cubic feet of water per square mile of ground. The water so held constitutes the great reserve which goes to maintain the dry-weather flow of streams. It is, in fact, a subterranean reservoir, filled by infiltration from above, and exhausted by the gradual escape of water to the streams through intervening strata. The ground-water, like the water of streams, is in constant movement, though its movement, as compared with that of streams, is exceedingly slow. The quantity of water flowing in an open channel 100 feet wide and 6 feet deep, with a fall of one foot in a mile, is about 1,000 millions of gallons per day. The quantity flowing through a channel of the same dimensions and slope filled with gravel would not exceed 600 gallons a day. This extreme slowness with which the ground-water moves serves, in some degree, as a regulating-sluice to the subterranean reservoir, securing it against rapid exhaustion.

The preceding facts and considerations, vague and incomplete as they are, enable us to render a more intelligible account than would otherwise be possible of the relation between rainfall and the flow of streams. The absolute amount of precipitation is less important than the circumstances which affect its loss by evaporation. This agency which is nearly dormant during the three winter months becomes active in March, and increases through April as well from the increase of temperature as from the prevalence of winds. In May the demands of vegetation are added to those of evaporation proper, and contributions to the ground-water become very small, in some years ceasing entirely. During the three following months evaporation is at its maximum, and innumerable rootlets are active competitors for every drop of water that enters the ground. Vegetable absorption ceases in September, but evaporation proper does not materially abate till October. Heavy and long-continued rains, occurring between May and October, occasion a temporary rise of the streams, which speedily return to their normal condition, as governed by the supply of ground-water. To understand how a rainfall of an inch or more can occur at this season without contributing anything either to the ground-water or to the volume of streams, we must consider the capillarity of the ground. The latter, like all porous bodies, is capable of containing a considerable amount of moisture which will not escape by gravity. This moisture, during long periods of drought, is gradually reduced by heat and the demands of vegetation, and in that condition a rain of considerable magnitude is expended in restoring the capillary moisture without bringing the ground to a condition admitting of the escape of water by drainage. What precedes will, perhaps, justify the suggestions I have to make as to the meteorological and other investigations required by the reservoir project, viz:

1. While observations of rainfall, evaporation, temperature, &c., in the several reservoir districts will have great scientific interest, and if continuously kept will be of great utility in the future management of the reservoir system, they will afford us but little aid in our present inquiry, viz: the quantity of water to be expected for the supply of the reservoirs. The attempt to infer this result from such data would lead us into a bewildering maze of speculation and conjecture, promising, so far as I can perceive, no practical issue.

2. Daily measurements of the flow of a stream of known drainage area in each of the several reservoir districts would, it appears to me, afford better guidance on this point than any other data obtainable at equal expense. The results so obtained could usually be taken as a standard for the entire district. Such measurements are not necessarily very expensive. A weir can often be made at a slight expense, and a daily record of the height of water, which is all that is necessary to determine the flow, can be kept by any intelligent person resident in the vicinity at a very moderate expense. Where a series of accurate current measurements, accompanied by gauge readings, are made upon a stream covering considerable variations in volume, the height, as shown by the gauge, becomes thereafter an approximately accurate indication of the flow. Of course, streams must be chosen not liable to artificial fluctuation. Meteorological observations, as collateral and explanatory of such measurements, have great value.

3. Accurate records of the daily stand of the several rivers intended to be benefited by these reservoirs are indispensable, and I would recommend that permanent gauges be established for this purpose.

4. An important question will arise in regard to the reservoirs on the Upper Mississippi, viz: Admitting that they can be filled, can a sufficient quantity of water be drawn from them to materially affect the Mississippi? Suppose, for instance, that it should be necessary to draw temporarily at the rate of 4,000 cubic feet per second from Lake Winnebigoshish, which it is proposed to raise 14 feet, and which lies some 65 miles by river above the Falls of Pokegama, the river falling some 23 feet in that distance. The outlet of Lake Winnebigoshish for some 20 miles has a high-water volume of not over 1,000 cubic feet per second. The increased quantity can only be carried in virtue of an increased slope and cross-section. It appears from the measured discharge of the river in 1874–'78, that an increase of volume from 541 to 891 cubic feet per second corresponded to a rise in the lake of 1.85 feet, from which it appears that when the lake is not more than 1.85 feet above low-water it cannot discharge more than 900 cubic feet per second. Although an increase in volume does not involve a proportional increase in height, it is fair to presume that a discharge of 4,000 cubic feet per second would involve a rise of 6 or 8 feet in the outlet, and that the reservoir could not be drawn upon at that rate after it is more than half emptied. The difficulty will be increased by the dams across the Mississippi at Pokegama and the mouth of the Vermillion, which reduce the slope of the river between Winnebigoshish and Pokegama, and by the discharge of the Leach and Mud Lake reservoirs. This is a subject to which future inquiries should be directed. The difficulty will tend to correct itself by the gradual enlargement of the channel in consequence of the increased discharge.

It appears to me that the cheapest and readiest method of solving the several physical questions connected with the project is to proceed immediately with the construction of a cheap dam at one of the reservoir sites on the Upper Mississippi. A dam, for instance, at Lake Winnebigoshish, consisting of an earth embankment with wooden sluices could be constructed for $40,000. If the operation of the reservoir is found sufficiently encouraging, the system can be extended from year to year as the government furnishes the means.

Very respectfully, your obedient servant,

JOSEPH P. FRIZELL.

CHARLES J. ALLEN,
Captain Corps of Engineers, Brevet Major.

RAINFALL RECORDS FROM OFFICE OF THE SURGEON-GENERAL UNITED STATES ARMY.

Fort Snelling, Minn.

	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Year.
1836	......	......	......	......	......	......	7.28	5.55	4.45	0.55	0.70	0.63	......
1837	0.27	0.35	0.33	0.95	2.65	3.46	2.73	1.32	5.10	3.15	1.37	2.34	24.02
1838	0.65	0.76	0.15	2.41	3.05	4.76	11.11	3.08	0.71	0.16	0.43	0.45	27.72
1839	1.34	0.36	0.71	2.71	3.28	1.80	3.50	1.04	1.61	2.11	1.66	1.07	21.19
1840	0.49	0.49	0.65	1.55	2.31	3.50	2.89	3.40	2.33	2.21	3.22	0.13	23.17
1841	0.24	0.21	1.43	1.40	1.50	4.24	1.57	1.17	6.10	1.55	0.84	1.42	21.67
1842	0.95	0.72	0.44	2.17	1.68	3.73	1.78	4.81	4.83	......	3.46	0.60	......
1843	1.15	1.46	0.82	0.75	3.12	5.22	2.00	1.84	5.14	0.50	1.43	0.27	23.70
1844	1.50	0.72	0.97	5.16	4.50	1.64	4.80	4.37	4.26	0.97	0.77	0.58	30.24
1845	0.49	1.40	2.80	3.15	1.51	6.80	2.56	3.28	2.21	0.66	0.40	0.08	25.34
1846	0.52	0.03	1.71	2.90	2.00	3.10	4.95	3.80	2.33	2.45	2.10	0.21	26.10
1847	0.29	0.11	0.44	0.45	4.96	2.66	3.66	2.49	4.00	0.37	1.71	0.66	21.80
1848	0.62	1.13	1.71	0.18	5.28	2.83	4.60	3.19	2.46	0.68	0.10	0.40	23.18
1849	1.00	0.61	4.11	5.62	6.57	3.14	7.59	9.60	2.75	5.35	1.40	1.95	49.69
1850	1.67	0.83	2.23	2.60	0.57	4.62	6.15	2.97	1.82	0.32	1.68	0.04	25.50
1851	0.20	0.13	1.23	2.68	3.96	2.15	2.60	3.29	3.64	1.18	2.31	0.05	23.42
1852	0.06	0.14	2.04	2.49	4.72	0.08	2.74	0.89	0.72	0.82	0.22	0.15	15.07
1853	0.00	0.01	0.02	0.73	4.08	7.59	1.65	2.57	2.14	0.01	0.56	1.11	20.47
1854	0.72	0.03	1.03	2.51	4.30	3.31	3.92	1.75	6.55	1.23	0.60	0.64	26.59
1855	1.67	0.41	1.84	0.28	1.23	2.38	1.32	4.41	6.26	0.90	2.38	1.67	24.75
1856	0.89	0.18	0.22	4.47	1.62	0.76	2.47	1.09	3.24	3.97	1.70	2.01	22.62
1857	3.48	0.94	0.79	4.25	2.05	6.74	0.65	2.03	2.46	0.00	5.75	2.95	32.09
1867	......	......	......	1.59	2.42	7.42	3.22	2.13	5.39	0.76	......	0.15	......
1868	3.25	2.74	1.40	1.26	3.17	1.50	2.52	6.43	2.21	3.68	2.80	1.25	32.21
1869	1.10	5.12	0.41	0.51	3.10	3.53	4.58	6.37	7.69	0.97	0.58	0.87	34.83
1870	3.09	1.11	2.78	1.11	3.32	0.81	2.63	5.86	2.49	1.39	1.13	0.35	26.07
1871	0.79	0.30	2.11	3.88	2.41	3.46	1.28	3.02	1.56	1.31	0.92	0.74	21.78
1872	0.24	0.25	1.46	0.97	1.80	1.98	2.24	2.77	3.01	0.20	0.50	1.60	17.02
1873	0.48	0.72	0.47	2.61	4.06	3.80	2.54	1.11	1.10	0.75	0.76	0.31	18.71
1874	0.49	0.63	0.33	0.35	1.12	7.77	1.55	1.27	3.45	0.64	0.75	0.21	18.56
1875	0.77	0.63	1.49	1.70	2.24	4.68	1.20	8.82	1.61	0.71	1.29	1.98	27.12
1876	0.63	1.30	2.45	3.00	6.30	1.00	2.10	0.51	6.24	1.17	2.52	1.19	28.32
1877	......	......	......	......	......	......	......	......	......	......	......	......	31.43
1878	1.03	0.35	0.87	1.05	2.77	4.16	5.66	1.80	3.53	2.14	......	......	......
Total	30.07	24.17	39.44	67.44	97.65	114.62	102.04	108.03	113.39	42.86	44.14	30.07	764.38
Means	0.97	0.78	1.27	2.12	3.05	3.58	3.09	3.27	3.43	1.34	1.42	0.94	25.48

The rainfall is expressed *in inches*.

Fort Ripley, Minn.

1849	......	......	......	......	......	......	......	......	......	......	......	......	......
1850	1.36	0.91	1.05	2.67	1.52	6.00	11.92	2.51	1.77	1.45	3.65	0.51	35.32
1851	1.41	0.24	0.26	0.97	5.56	5.50	......	3.15	8.74	1.93	2.82	0.36	......
1852	0.13	0.42	6.61	2.37	3.96	2.10	3.92	1.37	6.40	1.27	3.10	2.87	34.52
1853	0.18	0.34	1.06	1.31	1.45	8.72	4.35	2.64	3.31	0.95	1.18	0.63	26.12
1854	0.67	0.03	0.79	0.97	4.34	3.68	0.62	1.69	4.40	0.91	0.24	0.15	18.49
1855	0.41	0.28	1.12	0.36	1.68	4.88	4.03	3.58	4.95	0.06	1.96	0.24	23.55
1856	0.28	0.08	0.01	4.88	2.01	3.81	4.53	2.11	1.36	3.86	0.72	1.68	25.33
1857	1.67	1.68	0.74	1.16	2.68	5.66	......	......	......	......	0.00	0.46	......
1858	1.21	0.55	0.61	2.15	1.90	1.80	3.95	1.77	4.14	0.44	0.67	0.62	19.81
1859	0.57	0.50	4.49	1.44	5.85	4.00	0.66	1.65	3.87	0.35	2.10	0.52	26.00
1860	0.57	0.72	0.38	1.06	8.23	5.91	2.44	1.50	3.20	4.73	0.99	0.88	30.61
1861	1.10	1.95	0.65	2.80	5.10	4.11	1.89	5.88	3.04	2.36	3.13	0.41	32.42
1862	5.59	0.03	1.35	1.46	1.52	1.65	1.79	1.71	2.17	0.45	0.58	1.09	14.39
1863	0.72	0.50	0.29	0.61	1.89	0.28	0.60	5.47	4.32	1.97	0.31	0.24	17.20
1864	0.32	......	1.40	0.35	0.92	0.90	4.07	1.37	0.90	0.20	0.60	0.40	......
1865	0.00	1.26	1.40	2 05	......	2.27	......	6.50	3.72	......	0.34	......	......
1866	1.20	0.15	1.45	......	0.18	......	......	......	1.34	......	1.96	0.02	......
1867	0.46	1.10	0.42	0.70	2.30	9.80	10.90	1.00	1.10	0.51	1.25	0.80	30.34
1868	1.30	2.15	1.15	2.10	2.60	0.85	6:02	2.26	3.95	1.80	3.50	0.35	28.03
1869	0.65	1.15	......	......	......	......	......	......	......	......	......	0.90	......
1870	1.57	2.48	1.86	0.54	4.30	......	......	......	4.22	1.11	0.34	0.54	......
1871	1.01	0.94	3.49	3.30	0.51	4.91	3.07	4.79	2.38	1.78	4.20	3.64	34.02
1872	1.07	0.71	1.28	1.54	4.35	3.81	6.82	4.10	3.92	2.19	3.64	1.34	34.77
1873	2.09	3.41	2.76	1.19	4.59	9.18	5.46	2.18	1.94	4.71	2.19	1.08	40.78
1874	0.83	0.80	2.00	0.63	2.31	9.30	......	8.20	2.17	2.25	2.60	2.36	......
1875	1.03	1.48	3.35	1.95	4.40	2.33	3.99	3.59	3.05	0.36	1.60	1.04	28.17
1876	0.54	0.94	1.16	1.14	4.10	2.43	1.74	2.60	1.86	1.06	1.29	0.62	19.48
1877	0.86	0.00	0.86	2.38	1.84	4.46	......	......	......	......	......	......	......
Total	23.80	24.80	41.99	42.08	80.09	108.34	82.77	71.62	82.22	36.70	44.96	23.75	519.35
Means	0.85	0.92	1.55	1.62	3.08	4.33	4.14	3.11	3.28	1.60	1.73	0.91	27.33

Fort Ridgely, Minn.

	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Year.
1855	4.63	1.58	3.96	0.68	2.24	3.21	2.44	6.34	5.10	0.80	1.40	2.40	34.78
1856	3.14	0.45	0.17	2.54	1.30	1.46	2.30	1.33	1.00	4.24	0.89	4.38	23.20
1857	5.85	5.54	3.60	2.90	4.95	2.85	1.45	3.25	3.95	0.39	2.84	0.81	38.38
1858	0.85	0.53	0.60	3.66	2.93	1.16	4.75	3.26	2.58	0.96	0.96	0.28	22.52
1859	0.61	0.49	4.22	1.62	6.47	7.04	5.90	1.30	2.54	0.46	1.37	0.83	32.85
1860	0.00	1.20	0.34	1.01	2.27	1.58	2.68	1.06	4.13	1.34	0.53	0.83	16.97
1861	0.40	1.20	1.20	1.71	3.76	1.52	1.09	3.11	2.36	2.81	2.48	0.25	21.89
1862	2.55	1.80	2.95	1.57	1.85	3.48	1.31	6.76	4.94	1.15	0.75	0.94	30.05
1863	0.11	0.33	0.42	0.28	2.75	0.54	0.88	8.17	2.00	1.91	0.33	0.45	18.17
1864	0.22	0.01	1.14	0.14	1.23	1.45	3.89	2.16	0.91	1.76	0.21	1.34	14.46
1865	0.62	2.75	1.05	1.57	4.72	4.24	......	7.52	5.95	2.88	0.22	0.85	......
1866	0.73	0.90	0.99	......	0.09	......	......	......	......	1.15	2.15	0.06	......
1867	0.74	0.88	0.36	1.50	......	......	......	......	......	......	......	......	......
Total	20.45	17.66	21.00	19.18	34.56	28.53	26.69	44.26	35.46	19.85	14.13	13.42	253.27
Means	1.57	1.36	1.61	1.60	2.88	2.59	2.67	4.02	3.22	1.65	1.18	1.12	25.31

Fort Pembina, Dak.

1871	......	......	......	......	......	......	......	2.95	0.23	1.13	0.54	0.47	......
1872	0.28	0.25	0.45	2.00	1.90	2.09	3.09	0.82	1.67	1.16	0.53	2.95	17.19
1873	0.41	0.75	0.35	0.39	2.11	2.91	1.30	2.38	2.05	0.56	0.66	0.18	14.05
1874	0.26	0.25	0.35	0.20	1.55	3.41	1.40	2.21	1.54	0.29	0.30	0.12	11.88
1875	0.04	0.03	0.05	0.38	1.05	3.64	2.05	2.37	0.32	1.29	0.23	0.15	11.60
1876	0.14	0.55	0.52	0.55	5.59	2.30	6.66	5.61	0.95	0.34	0.87	0.62	24.70
1877	0.07	0.31	1.14	0.95	4.12	9.58	1.63	0.46	1.50	0.86	0.52	0.90	22.04
1878	0.05	0.21	2.03	3.75	2.22	3.41	3.55	4.32	1.64	4.28	......	......	......
Total	1.25	2.35	4.89	8.22	18.54	27.34	19.68	21.12	9.90	9.91	3.65	5.39	101.46
Mean	0.18	0.34	0.70	1.17	2.65	3.91	2.81	2.64	1.24	1.24	0.52	0.77	16.91

Fort Abercrombie, Dak.

1860	......	......	......	......	......	......	......	0.59	2.09	2.81	2.36	0.94	......
1861	0.50	0.32	0.56	3.98	6.69	1.85	1.66	4.78	0.33	0.63	1.79	0.30	23.39
1862	0.70	0.90	0.78	1.82	1.61	0.95	1.68	0.29	1.12	0.36	0.35	0.82	11.38
1863	0.15	0.74	0.39	0.04	0.87	0.26	0.79	4.62	1.38	3.29	0.26	0.61	13.40
1864	0.18	0.14	0.94	0.45	0.38	1.72	7.24	1.75	1.60	1.16	0.25	1.04	16.85
1865	0.24	2.08	2.00	4.20	0.83	1.46	......	3.30	0.60	1.10	0.02	0.08	......
1866	0.93	0.02	0.62	......	0.20	......	......	......	0.92	0.99	1.24	0.01	......
1867	0.95	0.45	1.95	0.45	2.14	6.83	3.70	0.76	0.50	0.03	......	1.30	......
1868	1.30	0.60	1.28	0.83	2.48	3.05	4.25	1.38	3.09	0.05	0.27	0.32	18.90
1869	0.10	0.50	0.86	2.26	4.32	1.02	0.50	6.40	5.92	0.10	0.70	......	......
1870	0.30	0.38	1.48	0.32	4.04	2.01	2.70	2.80	5.10	1.10	0.10	0.14	20.47
1871	0.60	0.72	1.40	1.36	0.36	4.10	1.62	0.57	1.40	0.62	0.70	1.82	15.27
1872	0.40	0.41	1.50	1.50	4.20	10.15	3.45	2.35	0.90	2.20	0.22	0.55	27.83
1873	0.50	0.51	0.69	2.00	2.20	3.65	0.92	4.03	0.44	0.26	0.14	(?)	(?)
1874	(?)	0.80	0.39	0.70	1.70	8.16	1.29	4.33	0.76	0.60	(?)	(?)	(?)
1875	(?)	(?)	(?)	(?)	3.17	2.96	0.32	2.12	......	(?)	0.50	(0.90)?	(?)
1876	0.80	0.08	0.66	(?)	0.20	0.50	1.10	1.95	0.45	0.10	0.70	0.95	(?)
1877	0.20	0.10	0.60	1.70	1.35	......	......	......	......	......	......	......	......
Total	7.85	8.75	16.10	21.61	36.74	48.67	31.22	42.02	26.60	15.40	9.60	9.78	147.49
Mean	0.52	0.55	1.01	1.54	2.16	3.24	2.23	2.63	1.66	0.96	0.64	0.70	18.44

Fort Winnebago, Wis.

	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Year.
1836	......	......	......	......	......	......	......	0.16	4.53	0.77	1.28	1.77	......
1837	0.48	0.91	0.25	2.41	3.18	4.80	5.66	2.89	5.39	0.79	3.23	1.35	31.34
1838	2.03	0.20	0.08	2.98	0.86	2.40	7.67	5.35	2.64	1.49	1.77	0.41	27.88
1839	0.92	0.47	0.79	1.84	3.59	4.53	0.83	4.38	1.43	8.14	1.27	0.76	28.95
1840	0.80	1.17	0.48	1.46	2.03	3.71	5.79	3.47	1.45	4.03	2.68	0.05	27.12
1841	0.18	0.48	1.54	1.49	1.51	5.45	3.70	3.79	6.58	1.25	0.55	1.98	28.45
1842	0.84	0.56	1.71	1.85	1.17	5.04	3.24	2.14	3.45	0.21	3.12	1.18	24.51
1843	0.72	0.62	0.39	2.14	4.18	4.07	1.20	1.22	4.41	0.60	2.67	0.58	22.80
1844	1.51	0.58	1.33	3.52	......	4.07	5.40	5.16	2.73	0.73	1.56	1.75	......
1845	0.67	2.49	3.10	2.67	1.46	4.09	4.37	1.53	......	......	......	......	......
Total	8.15	7.43	9.67	20.36	17.98	38.16	37.86	30.09	32.61	18.01	18.13	9.83	191.05
Mean	0.91	0.83	1.07	2.91	2.25	4.24	4.21	3.01	3.62	2.00	2.01	1.09	27.43

Fort Howard, Wis.

1836	0.50	1.64	3.20	6.37	5.20	3.50	5.06	2.07	4.78	1.59	2.01	1.72	37.64
1837	1.23	0.88	1.81	3.53	6.48	4.31	5.67	4.25	5.04	1.17	2.89	2.69	40.55
1838	1.97	0.53	0.14	3.41	1.54	6.77	7.03	5.66	3.36	3.29	2.58	1.28	37.56
1839	2.03	1.08	1.85	2.48	3.79	4.05	3.35	2.69	0.77	5.26	2.25	1.68	31.28
1840	0.30	0.30	0.26	4.17	1.69	7.29	5.86	3.79	1.25	3.02	2.05	0.50	33.57
1841	0.58	0.39	1.69	2.11	2.46	5.48	......	......	......	......	......	......	......
**	......	......	......	......	......	......	......	......	......	......	......	......	......
**	......	......	......	......	......	......	......	......	......	......	......	......	......
1850	......	......	......	......	......	4.92	6.34	6.94	2.69	1.10	2.59	0.95	......
1851	1.12	1.50	0.78	1.58	8.50	3.15	5.07	2.67	3.26	1.10	2.26	0.28	31.47
1852	1.77	0.66	3.87	2.97	2.15	......	......	......	......	......	......	......	......
Total	9.50	6.98	13.60	26.62	31.81	39.47	38.38	28.07	21.15	16.53	16.63	9.10	212.07
Mean	1.19	0.87	1.70	3.33	3.98	4.93	5.48	4.01	3.02	2.36	2.38	1.30	35.34

RAINFALL RECORDS FROM OFFICE OF THE SIGNAL SERVICE, UNITED STATES ARMY.

Saint Paul, Minn.

1871	......	......	......	......	......	......	......	......	......	2.07	1.83	1.17	......
1872	0.64	1.15	2.43	3.17	5.97	4.28	4.41	0.93	3.45	0.52	1.91	0.00	28.86
1873	1.31	1.54	1.34	2.44	4.63	7.74	3.83	4.61	2.56	2.57	0.79	0.38	33.74
1874	0.49	1.07	2.24	0.95	1.65	11.67	1.95	3.90	5.76	3.21	1.90	0.72	35.57
1875	1.41	1.72	2.19	2.27	3.06	4.33	0.82	8.74	2.16	1.56	0.84	1.56	30.66
1876	0.73	0.66	1.43	2.23	3.15	2.92	2.73	5.28	2.99	1.27	0.93	0.25	23.67
1877	0.55	0.01	1.57	1.92	5.43	7.13	0.52	2.83	2.56	3.62	1.24	1.42	28.80
1878	1.00	0.67	1.24	2.43	2.33	3.58	4.47	1.43	2.13	1.80	0.61	0.40	22.09
Total	6.13	6.82	12.44	15.41	26.22	40.75	18.73	27.72	21.61	16.62	10.05	5.90	203.33
Mean	0.88	0.97	1.78	2.20	3.75	5.82	2.68	3.96	3.09	2.08	1.17	0.72	29.05

Duluth, Minn.

1872	......	......	......	0.54	4.57	4.66	5.83	2.74	5.01	0.42	2.48	0.48	......
1873	0.75	0.93	2.29	0.22	3.99	9.79	7.21	2.45	5.06	2.98	1.59	1.16	38.42
1874	0.67	0.61	1.84	0.49	1.80	10.81	2.62	5.62	5.59	3.00	5.44	1.37	39.86
1875	0.86	0.98	2.11	2.82	2.45	1.84	0.47	6.19	1.93	2.60	1.78	1.10	25.13
1876	0.69	0.93	2.16	1.99	3.64	4.57	3.93	3.90	4.21	2.25	2.76	0.83	31.86
1877	1.55	0.10	0.78	1.20	6.28	4.88	3.37	1.48	5.67	3.88	1.05	1.95	32.19
Total	4.52	3.55	9.18	7.26	22.73	36.55	23.43	22.38	27.47	15.13	15.10	6.89	167.46
Mean	0.90	0.71	1.84	1.21	3.79	6.09	3.90	3.73	4.58	2.52	2.52	1.15	33.49