*(Paper No. 3730.)***“The Dover Watershed and Water-Supply.”**

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IN this Paper the Author proposes to describe the physical features of the Dover watershed, to give particulars of the geological formation, rainfall, yield of wells, gaugings of streams and springs, levels of wells and gaugings of the water in them, and as far as possible to trace the general flow of the underground water, with a view to ascertain in what places the largest supplies of water may be obtained.

The catchment-area from which the town of Dover derives its water-supply is about 17,900 acres in extent. It is triangular in shape, the base, on the south, extending from Dover Castle in the east to Arpinge in the west: the north-east side is formed by a line through the southern portions of the parishes of Coldred, Whitfield and Guston; and the north-west side by a line through Wickham Bushes, St. John's, Swingfield and Paddlesworth; the apex being Lydden Hill on the main road to Canterbury. The district is sparsely populated, containing only the town of Dover, with a population of 48,000, and one or two small villages. The area is almost equally divided between arable and pasture land, and the subsoil is chalk, very barely covered in places on the sides of the hills. In the Alkham valley at Chilton, the alluvial deposit is 11 feet in thickness. The country, which rises into a high table-land, 450 feet above the sea-level, is deeply indented with valleys converging upon the valley of the Dour, through which runs the small river of that name, the only river in the district. The six principal valleys are the Dour, Alkham, Lydden, Poulton, and those traversed by the new and old Folkestone roads.

The Dour valley ends at the mouth of the river in Dover Harbour, and it extends through Buckland, River and Kearsney to Bushey Rough, at which place, near Chilton, is one of the sources of the

river. The Alkham valley extends from Chilton through Wolverton, Alkham, South Alkham, Drellingore, Lower Standen and Coombe, to the high ground north of Caesar's Camp, north-west of Folkestone. The Lydden valley runs parallel with and north-west of the Alkham valley, and extends from Kearsney, through Lydden, Lyoak Wood and Reinden Wood to the high ground near Paddlesworth.

The river Dour is $3\frac{1}{4}$ miles in length, but the normal flow is only about $3\frac{1}{4}$ million gallons per day. According to Hastead's "History of Kent," this stream appears to have been of much greater size in the seventeenth century, and there are records of the passage of vessels as far as Buckland. The visible sources of the Dour are at Bushey Rough and Watersend at ordinary periods, but after periods of heavy rainfall an intermittent spring, or nailbourne, known as the Drellingore, rises and flows over the surface of the ground, following the line of the valley from Lower Standen to Bushey Rough, where it joins the normally visible source. This nailbourne appears first at Chilton, then at Wolverton, a place higher up the valley, and at Drellingore Hole, still higher up the valley, about six weeks after its appearance at Chilton. It appears above ground at Lower Standen, about half a mile above Drellingore Hole, after a very exceptional rainfall. Following the line of the valley, the stream increases in volume until it joins the lake at Bushey Rough, where it augments the water of the river Dour. The distance from Bushey Rough to Lower Standen is about $3\frac{1}{2}$ miles. The stream has risen at Lower Standen three times since 1852, the last time being in the early part of 1877, but it rises much more frequently at Drellingore. It rose at the latter place every year from 1877 until 1883, when it broke out twice. There was no further appearance until 1888, when General Field reported upon it as follows: "Drellingore spring rises in a deep depression in a grass field at the farm of that name, 1 to $1\frac{1}{2}$ miles beyond Alkham (close to the main road to Folkestone). The area covered by water is almost 2 acres, and the depth in some parts probably 12 to 15 feet. The overflow of water passes down the valley in a stream running at some 3 to $3\frac{1}{2}$ miles an hour, in a volume increasing to some 2 feet 6 inches by 3 inches deep, equivalent to a supply of nearly 17,000 gallons an hour, or 407,376 gallons per diem. Reaching South Alkham, the volume of water is added to by other similar springs, which burst out simultaneously, flooding the gardens and sometimes the cottages of the residents. Crossing the valley by a cut, the stream takes the main road as its course for a quarter of a mile to Church Alkham, where it turns into the cut channels and passes on through two fields to Wolverton. A good deal of water is probably absorbed during its course through

these fields, but at Wolverton it receives a large accession from another spring of the same character as that of Drellingeour and a fresh supply at Chilton Farm, whence it flows on to join the picturesque lake at Bushey Rough, and augments the volume of the river Dour." Since 1888 the nailbourne has broken out several times; in 1889, 1893, the winter of 1896 and the spring of 1897. A photograph taken in February, 1897, shows the stream flowing over the whole width of the road above Alkham village.

In 1898 a well was sunk by the Folkestone Waterworks Company at a point in the valley about a quarter of a mile below Lower Standen, from which a large quantity of water, 1,000,000 gallons and upwards per day, is pumped. Since pumping commenced, the nailbourne has only appeared once, in December, 1903, when the pumps had not been working for some weeks. It rose in the hollow at Drellingore on the 1st December, began to run down the valley on the 22nd December, and ceased to flow on the 7th January following, a period of 17 days. The rainfall for the year 1903 as recorded at Chilton was 41·93 inches, and as recorded at Dover, 37·97 inches. These figures are significant of the effect on this nailbourne of the pumping at the Lower Standen well, when compared with the duration of the flow, about 3 months in the winter of 1896 and the succeeding spring. The rainfall recorded at Dover for the year 1896 was 34·78 inches.

The geological formation of the watershed is chalk, the dip of which is to the north-east. On examination of the cliffs from the sea-shore, it will be seen that at the west end between Folkestone and Dover, the base of the lower chalk is above the level of Ordnance Datum, that it disappears near Shakespeare Cliff below this level, that the middle chalk in turn disappears opposite Dover Castle, and that to the westward towards St. Margaret's Bay the upper chalk alone is visible. Over the greater portion of the area of the watershed the upper chalk caps the hills, but its junction with the middle chalk is seen in the slopes to the valleys. Clay soil overlies the chalk on the high ground, but the sides of the hills are generally bare, and in the deep valleys there is a considerable depth of alluvial deposit, amounting to 11 feet at Chilton.

The Author has kept records of the rainfall at Dover Waterworks for the 11 years 1896–1906, and at Chilton, near Kearsney, for the 6 years 1901–1906; and he is indebted to Mr. Henry Turner for the records at Lower Standen for the 8 years 1899–1906. The records are given in the Appendix. From these it will be seen that the average annual rainfall at the different stations is as follows:—

Locality.	Height of Gauge in Feet above Ordnance Datum.	Average Fall per Annum for 6 Years, 1901-1906.	Average Fall for 11 Years, 1896-1906.
Dover Waterworks	199½	Inches. 27·45	Inches. 27·38
Chilton	126½	30·21	..
Lower Standen	250	26·44	..

At Acrise, a place 500 feet above sea-level and about $3\frac{1}{4}$ miles to the north-west of Lower Standen and $1\frac{1}{4}$ mile outside the watershed, the rainfall for the 30 years 1871-1900 averaged 37·47 inches, but the rainfall recorded at Acrise cannot be applied to the Dover watershed, despite their nearness to each other. The Author considers the Chilton record applies most nearly to the whole area, and he has therefore made use of it in calculating the rainfall on the watershed. The difference between the averages of the Dover waterworks and Chilton gauges for the 6 years 1901-1906 is 2·76 inches in favour of Chilton. Adding this difference to the average for the 11 years 1896-1906 at Dover, a rainfall of 30·14 inches is arrived at, which may be fairly assumed as the average which would have been obtained at Chilton had the gauge been in existence there for the preceding 4 years.

Whilst the catchment-area is about 17,900 acres, the underground water of about 1,740 acres at the western extremity, as will be explained later, flows away from Dover; and from about another 1,230 acres, the underground water flows eastwards towards the sea. For the purpose of arriving at the effective rainfall the area is therefore taken at 14,930 acres. With a rainfall of 30 inches, this gives 10,161,731,250 gallons of water per annum, or 27,840,360 per day. Allowing for percolation in the chalk, ascertained by Mr. Baldwin Latham to represent an average of 43 per cent. of the rainfall over a period of 14 years, the result obtained is 11,971,354 gallons per day, and this is the quantity which the Author has endeavoured, as far as possible, to locate.

The Dover Waterworks, from which the town has derived a continuous supply since 1855, are situated at Castle Hill, the water being pumped from three wells, sunk close together to a depth of 220 feet 6 inches in the chalk. These wells are connected at the bottom by short adits, and are supplied by long adits about 7 feet high and 4 feet wide, driven for a length of 330 yards. The level of the lower ends of the suction-pipes of the pumps is 1 foot 6 inches above the level of low water of ordinary spring-tides, and 17 feet 3 inches below the level of high water of ordinary spring-tides; the

rest-level of the water in the wells being about 6 feet 8 inches above high water of ordinary spring-tides, or 17 feet above Ordnance Datum. When pumping is commenced in the morning, after the water has risen to its normal rest level during the night, the water in the shaft is quickly lowered, and the well gauge indicates a pumping depth of about 4 feet over the end of the suction-pipe.

The adits are in the middle chalk: the main adit, 225 yards in length, is driven in a west-south-westerly direction towards the river Dour, the end being about 400 yards from it, and the other adit is driven in the opposite direction. The water comes into the adits from the north-west through fissures which, in some cases originally of considerable size, have been opened out by continued pumping. In 1862, after the works had been in operation only 7 years, it was reported that the bottom of the heading (then 98 yards in length) was covered for a length of about 50 yards from the pumping well to a depth of about 15 inches with sedimentary chalk. A strong clay band appears in the adits for a greater part of the length, but a flint is rarely found. The clay bands hold up the water, and constitute a source of danger during excavation when they are near the level of the roof of the adit, the chalk immediately below them being liable to fall. The north-easterly adit was driven in the winter of 1905 and the following spring. It is 106 yards long, but its effective gathering length is only 71 yards on account of its overlapping a portion of the length of the main adit; this was a necessity of construction in order to allow of the excavated chalk being hoisted up an existing shaft. The yield of the wells is about 1,700,000 gallons per day. By far the greater quantity of water, about nine-tenths of the whole, is collected by the westerly adit, which, having regard to the position of the valley, is what might be expected. There are only three springs in the north-easterly adit, and the yield is 187,200 gallons per day. Another very useful purpose served by the adits is that of forming an underground reservoir from which to pump: they hold about 230,000 gallons of water and enable two of the engines at the Waterworks to run for 5 hours at the same time; that is, until the water stored in the adits is pumped out.

There are other wells in Dover from which considerable quantities of water are pumped, the following being the principal of these:—

Dover Castle well.—This well is 367 feet deep, the level of the bottom being 27 feet below Ordnance Datum and that of the adits 14 feet below Ordnance Datum. There are two adits: one in a S.S.W. direction, 250 feet long, having ten springs in it; the other in a north-easterly direction, 170 feet long, which does not yield any water. The total yield of this well is equal to about 36,000 gallons,

per day. The rest-level of the water is fairly constant, and is about 10 feet above Ordnance Datum.

Western Heights well.—The depth of the well is 426 feet. The adit is in the hard grey chalk, the level being 15·75 feet below Ordnance Datum. The rest-level of the water taken in March was 4·25 feet above Ordnance Datum; but there is considerable variation. The yield is about 168,000 gallons per day.

Priory Railway-Station well.—The depth of the well is 39 feet, the level of the bottom being 7·02 feet above Ordnance Datum and the rest-level of the water 14·28 feet above Ordnance Datum. The yield of the well is 167,000 gallons per day.

Buckland Paper Mills.—Old well (artesian, 12 inches in diameter). The depth of the well is 100 feet, and the level of the bottom 52·14 feet below Ordnance Datum, the rest-level of the water being 45 feet above Ordnance Datum. The quantity of water pumped per day is 662,400 gallons.

New well (artesian, 15 inches in diameter). The depth of this well is 144½ feet, the level of the bottom being 89·93 feet below Ordnance Datum. The rest-level of the water is 45 feet above Ordnance Datum, and the quantity pumped per day, 964,800 gallons. These two wells are on either side of the river, and at a distance of about 30 feet and 40 feet respectively from it. It will be observed that they have been sunk to a greater depth than was apparently necessary. It is not known at what depth the springs were tapped, but the reason given for the new well being sunk 44½ feet deeper than the old well is that it was thought best to ensure an adequate depth being obtained, while the boring apparatus was on the site. After Buckland Paper Mills were destroyed by fire and pumping had ceased, the old well, which was the only one then in existence, overflowed at the end of 1887 and the beginning of 1888, for about 6 months, at the same time that the Drellingore spring, or nailbourne, was overflowing; and the Author is of opinion that the underground stream, of which the nailbourne is the overflow, is the same which supplies these wells. Analysis proves that the water from the wells is a pure chalk water, and is consequently not obtained by leakage from the river, the water of which is polluted by paper-mills higher up.

Lower Standen wells.—The only other important wells in the watershed are those of the Folkestone Water Works Company at Lower Standen and Lyoak, Lydden. The quantity pumped from the former is 1,000,000 gallons per day. A 30-hours' pumping trial carried out at this well in February, 1907, resulted in a yield of 2,700,000 gallons in that time, but there is no record of a more extended trial: it may be taken, however, that the constant yield of this well would average much

more than the 1,000,000 gallons per day actually pumped from it. The Lydden well has not yet been pumped from, as the demand does not necessitate the use of its water.

The quantity pumped from the wells described is as follows :—

	Gallons per Day.
Dover Waterworks	1,700,000
Dover Castle	36,000
Dover Western Heights	168,000
Dover Priory Station	167,000
Buckland Paper Mills	1,627,200
Lower Standen (Folkestone Waterworks)	1,000,000
Total	4,698,200

Generally speaking, the rest-level of the wells in the town of Dover remains practically constant, which may be accounted for by their close proximity to the sea. The rest-level of the wells at Buckland Paper Mills, about $1\frac{1}{2}$ mile from the sea, would vary slightly if they were not pumped from.

For the purpose of estimating the quantity of underground water, it is necessary to take into account the position and yield of each well, both as regards the direction of flow of the water and the proximity of the well to the sea. In the case of a well situated on the line of flow of the underground streams, and distant from the sea, only the quantity of water actually pumped can be taken into account, as the surplus water will pass on to other wells, to the surface streams or to the sea, and will probably be gauged elsewhere; but the yield of wells close to the sea may be calculated for this purpose on the maximum quantity pumped during a series of trials carried out at different times of the year, because the surplus water flows off at the rest-level.

Of the water flowing out to sea from the Dover watershed, the River Dour discharges visibly $3\frac{3}{4}$ million gallons in 24 hours, and perhaps an equal quantity passes in and beneath its bed in the same time. A number of springs of varying size also discharge into the sea between high- and low-water marks; but it is of course impossible to estimate the quantity flowing from all of them. Gaugings of some of them taken by the Author yielded the following results :—

	Gallons in 24 Hours.
Lydden Spout	143,809
Spring near Convict Prison	218,520
„ „ Ness Point	264,240
„ „ Frenchman's Fall	479,610
„ „ „ „	118,980
„ „ Gate's Hole	38,268
„ „ Canterbury Cave	70,497
„ „ „ „	131,040
„ „ „ „	240,750

Of these springs only the first two discharge from the Dover watershed, the others flowing eastward between Dover and St. Margaret's Bay and issuing from the upper chalk. Lydden Spout is described in Hasted's "History of Kent," and appears to have had a local reputation for many generations. It issues from the face of the cliff on the foreshore at a point about $\frac{3}{4}$ mile west of the Dover Colliery at Great Fall. There is a fault here, and the spring is on the lower grey chalk at the base of the middle chalk, about 20 feet above high-water mark. As previously stated, the lower chalk, viewed from the foreshore, disappears below the level of Ordnance Datum near Shakespeare Cliff and the middle chalk near Dover Castle. (The greensand appears near Folkestone.) Having regard to this and to the fact that Lydden Spout is the only spring issuing from the chalk cliff-face between Folkestone and the Admiralty Pier at Dover, it would appear that the direction of the flow of the underground water in the portion of the watershed adjoining the coast west of Dover is towards Dover Harbour, or about parallel with that coast. Some years ago, when the inner harbour at Dover was deepened, several springs were met with in the middle chalk. These and the springs issuing on the foreshore in Dover Bay, near the Castle, may be regarded as water from the Dover watershed.

In 1898 the Author prepared an underground water-survey of the Dover watershed, taking the levels of the wells and reducing them to Ordnance Datum. From 1898 to 1906 he has kept a monthly record of the wells in the Alkham Valley (Fig. 1, Plate 6). By running sections (Figs. 2, 3 and 4) in different directions through the wells and plotting the water-levels, the flow of the underground water is found to be towards the River Dour and in the direction of its course. There is, however, a small area at the western extremity of the watershed in which the water flows towards Folkestone. The records of the water-levels in the Alkham Valley are of interest when considered in connection with the rainfall records and the results of pumping at the Lower Standen well, the latter having the effect of depressing the level of the water for some distance below the well. The depression, however, is not so extensive as might be supposed, and this no doubt is due to the very powerful flow of underground water beneath the valley line, and to the fact that this water is served by underground feeders along its course from a great portion of the area of the watershed. A careful study of the levels of this water in the valley will show the effect of the rainfall on the area; whereas some of the wells on the hills, as, for instance, Hope Farm well, are not greatly affected by the rainfall.

The hydraulic gradient between Lower Standen well and Bushey Rough pond is 1 in 324, there being a fall of 53 feet in $3\frac{1}{4}$ miles. When the nailbourne broke out in this valley in December, 1903, exceptionally heavy rains had fallen over the district from the beginning of April of that year until the end of the following January, and there had been no pumping at Lower Standen well, from which previously about one million gallons per day were pumped. This well is sunk into the lower chalk, which is practically impervious, the water flowing through the fissures.

With a view to ascertain the rate of flow of the underground water, the Author, at intervals during 9 days, put 12 lbs. of chloride of lithium into a well at Lower Standen, which, with other wells lower down the valley, the Dover Waterworks wells and the Dour water, had been previously tested for lithia by spectrum analysis with negative results. Samples were taken from the same sources 5 days later, also with negative results. The well next below the one in which lithia was first put was 1 mile distant from it. No further tests were made officially, but 6 months later lithia was discovered by an independent analysis in the Dover water-supply, 6 miles distant. How long it had taken to reach Dover the Author does not know. He has not had an opportunity of testing the rate of flow with fluorescein, a colouring matter which can be detected when diluted to the extent of 1 in 100 millions.

As regards the water-bearing qualities of the chalk, it may be stated that the upper chalk is of a friable nature, absorbs the rainfall very rapidly, and like the middle chalk, parts with it very slowly. The middle chalk is closer in texture and has more defined channels in it. The lower or grey chalk is hard, practically impervious, and contains fissures even larger than those in the middle chalk, but not so numerous. The impervious character of the lower chalk was tested when sinking the shaft for the Channel Tunnel near Shakespeare Cliff, Dover, where a thickness of 91 feet was found. This work was not interfered with by the percolation of sea-water, either in sinking the shaft or in driving the heading under the sea. When the water broke into the Simpson Pit, as it was called when the old Channel Tunnel workings were converted to the purposes of coal-mining, on the 6th March, 1897, the pit had been sunk to a depth of 303 feet, and the temperature of the water seemed to show that it came from a feeder at a great depth. On the 20th March, 1898, the Author took the temperature of the water when pumped to the surface of the pit, and found it to be 69° F. At that time the yield was 60,000 gallons per hour, estimated to be made up of 20,000 gallons from the greensand,

20,000 gallons from the Hastings beds, and 20,000 gallons from an unknown depth, the temperatures being 58° F., 62° F., and 80° F. respectively. On the same day, the temperature of the spring running into Bushey Rough pond at Chilton was 50·2° F., of Lydden Spout 51·7° F., and of the sea (11 a.m.) 44·9° F. It is difficult to account for the difference in temperature of the two chalk-waters or to apply the rule for temperature of water due to depth, namely, an increase of 1° above the normal temperature for every 52 feet of depth.

In the Appendixes are given analyses by Mr. Sidney Harvey of water from the Dover Waterworks, from Bushey Rough pond, and from the River Dour. The first mentioned is a sample taken in July, 1907, and it may be observed that the figures for total hardness, 18·8, permanent hardness, 3·3, and total solid matter, 22·47 grains per gallon, are higher than usual, the average being 17·0 to 17·7, 1·8 to 2·2, and 21·28 grains per gallon respectively : this is probably due to the water coming from the new adits, and the figures will diminish to the normal.

The observations and results recorded in this Paper have been with difficulty extracted and condensed from a mass of data collected during a long period of time. The Author is indebted to Mr. Joseph Lucas for information as to the geological data obtained during his survey of the watershed in 1898.

The Paper is accompanied by three drawings and one tracing, from which Plate 6 has been prepared ; by an Ordnance map showing the positions of wells, geological data, etc. ; and by two microphotographs.

APPENDICES.

APPENDIX A.—TABLE I.—DOVER WATERWORKS RAINFALL RECORD, 1896-1906.

Diameter of Gauge, 5 inches. Height above Ground, 1 foot 6 inches. Height above Sea-Level, 199.53 feet.

Month.	1896		1897		1898		1899		1900		1901		1902		1903		1904		1905		1906	
	Ins.	Days	Ins.	Days	Ins.	Days	Ins.	Days	Ins.	Days	Ins.	Days	Ins.	Days	Ins.	Days	Ins.	Days	Ins.	Days	Ins.	Days
January.	1.28	12	2.71	19	0.73	9	2.83	16	3.98	22	0.68	10	1.42	10	2.72	22	3.52	20	0.91	10	4.04	23
February	0.04	2	2.09	15	1.13	12	2.25	10	5.73	18	2.05	16	1.61	13	1.79	12	2.57	21	1.02	13	2.59	21
March	2.51	18	3.54	16	2.20	13	0.80	7	1.05	12	2.25	15	1.14	7	1.98	19	1.61	13	3.49	20	2.11	18
April	1.15	10	2.10	16	0.69	8	3.35	16	1.02	7	1.67	16	0.45	6	3.06	16	1.09	7	2.86	16	0.99	6
May	0.34	4	0.71	10	3.87	20	2.37	11	1.34	7	0.89	7	1.99	22	3.30	14	2.27	16	1.67	9	2.19	11
June	3.36	9	1.49	9	1.90	9	1.03	6	3.00	15	0.93	7	2.33	13	4.09	10	1.01	9	5.24	15	3.69	9
July	1.04	7	0.37	3	0.76	5	1.06	3	1.34	6	0.59	4	1.71	10	3.39	14	1.26	10	0.94	5	0.38	6
August	3.71	18	3.47	16	2.76	7	1.01	6	2.92	15	1.70	9	4.92	20	3.64	14	2.06	8	2.31	13	0.46	6
September	7.63	23	1.98	14	0.37	4	3.09	15	0.94	6	1.27	8	0.42	7	3.15	12	1.30	12	2.42	14	2.55	9
October	7.07	20	0.23	2	3.44	11	2.40	8	2.10	14	1.79	14	2.09	17	4.61	26	2.55	14	2.85	19	3.38	17
November	2.72	12	1.96	14	2.46	10	2.36	11	4.47	22	1.07	10	2.27	13	3.33	14	1.19	9	5.22	21	6.24	22
December	3.93	24	3.15	18	1.88	10	1.79	10	3.45	20	4.56	18	2.28	13	2.91	15	3.39	18	0.94	9	2.37	17
Total	34.78	159	23.79	152	22.19	118	24.34	119	31.34	164	19.45	134	22.63	151	37.97	188	23.82	157	29.37	164	30.99	165

APPENDIX A.—TABLE II.—RAINFALL RECORD AT CHILTON FARM, KEARSNEY, KENT.

Diameter of Gauge, 5 inches. Height above Ground, 1 foot 6 inches. Height above Sea-Level, 126·54 feet.

Month.	1901		1902		1903		1904		1905		1906	
	Inches.	Days.	Inches.	Days.	Inches.	Days.	Inches.	Days.	Inches.	Days.	Inches.	Days.
January	0·81	11	1·70	10	2·79	20	4·43	18	1·00	6	4·77	19
February	2·08	16	1·61	12	1·49	8	3·08	19	0·95	11	3·05	21
March	2·36	16	1·20	8	2·29	20	1·71	13	4·08	21	2·13	19
April	1·95	14	0·63	6	2·93	15	1·47	9	2·75	13	0·99	7
May	0·95	7	1·94	22	4·69	11	2·33	14	1·59	7	2·34	13
June	1·20	9	2·19	14	3·58	9	1·01	9	5·69	14	2·44	8
July	0·83	4	1·65	11	5·00	14	2·03	8	0·97	3	0·69	6
August	2·07	9	5·47	17	4·39	15	1·95	9	2·42	17	0·55	5
September	1·37	6	0·47	6	2·49	13	1·55	13	3·19	15	1·88	8
October	1·84	12	2·18	12	5·38	23	2·55	13	3·00	16	4·49	16
November	1·02	11	2·56	14	3·07	13	1·21	8	5·72	20	7·33	16
December	5·21	18	3·01	14	2·83	12	3·72	15	0·93	8	3·03	16
Total	21·69	133	24·61	146	41·93	173	27·04	148	32·29	151	33·69	154

APPENDIX A.—TABLE III.—RAINFALL RECORD AT LOWER STANDEN, NEAR FOLKESTONE.

Diameter of Gauge, 5 inches; Height above Ground, 2 feet 11 inches; Height above Sea-Level, 250 feet.

Month.	1899		1900		1901		1902		1903		1904		1905		1906	
	Inches.	Days.	Inches.	Days.	Inches.	Days.	Inches.	Days.	Inches.	Days.	Inches.	Days.	Inches.	Days.	Inches.	Days.
January . . .	3·26	19	3·58	19	0·74	13	1·54	12	2·36	19	2·67	19	1·21	15	3·25	22
February . . .	2·41	12	5·15	21	1·60	14	1·34	11	1·35	13	2·49	22	0·90	14	2·17	20
March	1·02	10	1·13	16	2·20	16	1·28	10	2·07	19	1·48	12	2·97	23	2·05	19
April	3·33	21	0·98	8	1·81	13	0·77	7	1·88	17	0·99	8	2·01	15	1·18	8
May	2·41	12	0·65	8	0·73	6	2·02	21	3·30	15	1·19	15	1·59	9	1·64	12
June	1·12	6	4·29	16	0·99	8	2·04	14	3·56	11	1·42	10	5·95	17	1·87	9
July	1·56	7	1·14	6	1·09	6	1·79	12	4·38	16	2·01	9	0·97	5	0·97	4
August	0·75	7	2·04	13	1·45	9	3·55	17	4·67	16	1·31	11	2·34	16	0·63	9
September . . .	2·95	15	0·96	6	1·05	7	1·66	10	1·84	11	1·91	12	2·96	16	2·05	10
October	3·50	12	2·06	15	1·78	12	2·07	18	4·70	26	2·40	13	3·09	15	3·90	16
November . . .	2·53	14	4·71	21	0·91	14	1·91	14	2·50	15	1·40	14	4·45	21	7·22	19
December . . .	2·00	13	3·24	20	4·12	17	3·14	17	3·36	18	2·75	17	0·79	13	3·03	16
Total	26·84	148	29·93	169	18·47	135	23·01	163	35·97	196	22·02	162	29·23	179	29·96	164

APPENDIX A.—TABLE IV.—ANALYSES OF WATER FROM DOVER WATERWORKS, RIVER DOUR, AND BUSHEY ROUGH POND.
By Mr. SIDNEY HARVEY, F.I.C.

All numerical results are expressed in grains per gallon. The hardness is expressed in grains per gallon of carbonate of lime.

Description.		Dover Water-Supply.	Water from River Dour.	Water from Bushey Rough Pond.
Appearance		Clear	Clear	Clear.
Colour		Greenish blue	..	..
Smell		None	None	None.
Chlorine in chlorides		1.61	1.82	1.47
Phosphoric acid in phosphates		None	None	None.
Nitrogen in nitrates		0.38	0.15	0.17
Ammonia		None	0.0022	Trace only.
Albuminoid ammonia		0.0014	0.0140*	0.0028
Oxygen absorbed in 15 minutes		Trace only	Considerable amount	Trace only.
" " 4 hours		0.014	0.278*	0.022
Hardness before boiling (total)		18.8	18.1	16.9
" " after boiling (permanent)		3.3	2.1	1.0
Total solid matter		22.47	22.26	20.72
Microscopical examination of deposit		Slight and unimportant	Organic debris	Slight and unimportant.
		The above results are satisfactory throughout and indicate water organically pure and free from sewage percolation. The microscopical examination is also satisfactory.	Organically impure as shown by the figures marked thus *	Calls for no adverse remarks the results being satisfactory throughout. The Analyst is of opinion that this pond includes a spring of pure water, as the figure for chlorides agrees with that of the purer chalk waters in this part of Kent.

APPENDIX B.—DESTRUCTIVE ACTION OF THE DOVER WATER ON A CAST-IRON
PUMP-BUCKET IN USE AT THE WATERWORKS.

The bucket, which is 20 inches in diameter, originally had white-metal seatings, and it was found that the cast iron, at the dovetailing of the white-metal, and also at the webs, became so pitted as to cause the seatings to break away. This was at first thought to be due to some action set up between the metals owing to the presence of too large a percentage of lead, but a reduction of the latter did not alter the result. Brass seatings were then substituted, and although, owing to their construction, the joints between the metals were not damaged to an equal extent, the destructive action on the webs of the bucket, where the water was continually rushing through, was not diminished. It then became apparent that the iron used in the bucket was unsuitable. Mr. Thomas Kennedy, of Kilmarnock, expressed the opinion that the decomposition was due to electric action caused by free carbon forming a positive to the negative of iron, and he kindly undertook to have the iron analysed and experimented upon by immersion in lime water. The result of analyses of this iron and of a compound of 4 Scotch brands was as follows :—

	Pump-Bucket Iron.	Scotch Iron.
	Per Cent.	Per Cent.
Silicon	2·745	1·91
Sulphur	0·1029	0·0167
Phosphorus	0·829	0·656
Manganese	0·413	0·66
Combined Carbon	1·0	0·13
Graphitic „	3·0	2·55

The balance in each case being iron.

When polished and examined under the microscope, the pump-bucket iron proved to be of small grain, but very open texture, and mottled in appearance; the graphite was in small isolated and segregated patches. The iron was immersed in lime water for $3\frac{1}{2}$ hours. It was then seen that the galvanic action was very decided, the pitting being visible to the naked eye. The dark patches could be removed in a very short time with slight friction, and their removal would lay the white solid open to the further action of the water. The excessive amount of silicon in the iron had absorbed part of the bicarbon and liberated the chalk, depositing it at the bottom of the beaker.