

December 5, 1854.

JAMES SIMPSON, President,
in the Chair.

The following Candidates were balloted for, and duly elected :—JAMES ROBERTSON and THOMAS WYNNE, as Members, CHARLES ROBERT DRYSDALE and WILLIAM LOCOCK WEBB, as Associates.

No. 919.—“On some peculiar features of the Water-bearing Strata of the London Basin.” By PETER WILLIAM BARLOW, M. Inst. C. E.¹

THE surveys for railways and the subsequent execution of the earth-works, afford invaluable opportunities for the careful investigation of the peculiarities of the stratification of a district, and of these the Author availed himself, during the construction of several lines of railway, traversing the London basin and intersecting the strata in various directions.

The main line of the London and Dover railway commences in the London clay, descends to the Weald clay, again ascends, and terminates in the chalk. The Reading and Reigate line commences in the lower greensand, and intersects all the beds of the London basin, including the Bagshot sand; whilst the North Kent railway cuts deeply into the inferior beds of the lower London tertiary formation.

The construction of local branch lines affords opportunities for completing the investigations in almost every direction, and for noting, not only the character of the various beds as water-bearing strata, but also the disturbances which they have undergone, and the result is laid before the Members for the purpose of eliciting a discussion on this interesting topic.

The strata forming the crust of the London basin, and which are almost universally met with, wherever the London clay exists, are found in the following order :—

- 1, London clay, or upper tertiary ;
- 2, Plastic clay, or lower London tertiary ;
- 3, Chalk ;
- 4, Upper greensand ;
- 5, Gault ;
- 6, Lower greensand.

¹ The discussion upon this paper extended over portions of three evenings, but an abstract of the whole is given consecutively.

The stratum next below this, on the southern side of the basin is the weald clay; but as this is little if at all found on the northern side, where the Kimmeridge clay, or upper oolite appears, the lower greensand is the last which can be considered as forming part of the crust, and it thus constitutes the boundary of the south and north-west sides of the London basin.

The south-west boundary is determined by the anticlinal axis of the weald, which divides the London from the Southampton basin; but the northern boundary is undefined, and it is difficult to trace the line; but as a near approximation, the line may be assumed as passing through Newmarket and Woodbridge.

The general boundary of the basin,—commencing at Folkestone and embracing a district of nearly 8,000 square miles, will thus pass through, or near the following towns:—Hythe, Ashford, West Farleigh, Seven-Oaks, Reigate, Godalming, Pewsey, Devizes, Swindon, Wantage, Tetworth, and Wobourne to Cambridge.

The superficial area of the formation is thus given by Mr. Prestwich:—²

London clay, or upper London tertiary,	2,581	square miles.
Plastic clay, or lower London tertiary .	354	”
Chalk	3,794	”
Upper greensand	172	”
Gault	340	”
Lower greensand	650	”
Total	7,891	”

The level of the chalk below London, as shown in the sections published by Mr. R. W. Mylne, averages about 200 feet below Trinity high-water mark, and the outer edges of the chalk obtain an average elevation of about 600 feet, so that the depth of the basin is about 800 feet; but as the elevation of the outer edges, as well as the depression of the inner part, is very irregular, this can only be given as an approximation. These variations in level are, in some instances, produced by disturbances, causing fracture, or faults, which much affect the adaptation of the water-bearing strata to the supply of water to London, and the extent and direction of these disturbances should be carefully examined. The influence and direction of the principal lines of disturbance have been described by Dr. Fitton, Mr. Prestwich, and Mr. Condamine, and their accuracy is confirmed by the Author's own observations, in the south and south-eastern districts.

² *Vide* “The Water-bearing Strata of the country around London.”
By J. Prestwich, junior. 8vo, London, 1851, page 98.

Mr. Prestwich thus describes two of the principal lines of disturbance :—³

“ Although the tertiary formations around London have, probably, suffered less from the action of disturbing forces, than the strata of any other district of the same extent in England, yet they nevertheless now exhibit considerable alterations from their original position.

“ The principal change has been that which, by elevation of the sides, or depression of the centre of the district, gave the tertiary deposits their present trough-shaped form. If no further change had taken place we might have expected to find an uninterrupted communication in the lower tertiary strata, from their northern outcrop at Hertford to their southern outcrop at Croydon, as well as from Newbury on the west to the sea on the east ; and the entire length of 260 miles of outcrop would have contributed to the general supply of water at the centre.

“ But this is far from being the case ; several disturbing causes have deranged the regularity of original structure. The principal one has produced a low axis of elevation, or rather a line of flexure, running east and west, following nearly the course of the Thames from the Nore to Deptford, and apparently continued thence to beyond Windsor. It brings up the chalk at Cliff, Purfleet, Woolwich, and Loam-pit Hill, to varied but moderate elevations above the river level. Between Lewisham and Deptford the chalk disappears below the tertiary series, and does not again come to the surface till we reach the neighbourhood of Windsor* and Maidenhead.

“ The rise of the lower tertiary beds from beneath the London clay, in the railway section at and immediately south of New Cross, exhibits a transverse section of this line of disturbance. Thence to Windsor it is apparently not continuous, and can be traced only in sections of wells, which show that the chalk along this line comes, at intervals, nearer to the surface than it does either to the north, or to the south, of the presumed axis.

“ This disturbance has an important bearing upon the supply of water to the Artesian wells of London, and may materially inter-

³ The term *disturbance*, as used in Geology, refers to the effect of that subterranean power, which, acting upon the crust of the earth, has produced those elevations of the strata, varying from narrow hill ridges to chains of mountains,—or, even where the country is at present apparently level, has left, in the fractures and contortions of the strata, beneath the surface, evidence of its action. Sometimes, although the disjointed parts may remain nearly horizontal, yet each part will be on different levels ; at other times, the strata assume a roof, or saddle-shaped position. (See ¶ 50 and 118.)

* Windsor Castle stands upon chalk, although apparently in the midst of a tertiary district.

fere with and diminish the supply from the southern outcrop of the lower tertiary strata.

“ There is also, probably, another line of disturbance running between some points north and south, and intersecting the first line at Deptford. It passes apparently near Beckenham and Lewisham, and then, crossing the Thames near Deptford, continues up a part, if not along the whole length, of the valley of the Lea towards Hoddesdon. This disturbance appears in some places to have resulted in a fracture or a ‘ fault ’ in the strata, placing the beds on the east of it on a higher level than those on the west, and at other places merely to have produced a curvature in the strata. I am unable, however, to give its exact course, or structure, which requires further examination. Its effect, at all events, upon the supply of water to London is important, as in conjunction with the first, or ‘ Thames valley ’ disturbance, it cuts off the supplies from the whole of Kent, and interferes, I conceive, most materially with the supply from Essex ; for in its course up the valley of the Lea it either brings up the lower tertiary strata to the surface, as at Stratford and Bow, or else, as further up the valley, it raises them to within forty to sixty feet of the surface.

“ The tertiary district thus appears, on a general view, to be divided naturally into four portions, by lines running nearly east and west, and north and south, the former line passing immediately south, and the latter east, of London, which stands at the south-east corner of the north-western division, and consequently it must not be viewed as the centre of one large and unbroken area so far as the tertiary strata are concerned.”

In addition to these, there are other lines of disturbance, which have an important bearing on the question of the water supply. The main line of elevation is the anticlinal axis of the weald, running nearly east and west, which although not within the district under consideration, is the great cause of the elevation of the southern side of the London basin. This elevating action has not occurred with uniformity over the surface raised, but in lines, nearly parallel to the main axis. One of the principal lines runs parallel with the escarpment of the North Downs, tilting up the beds at an angle, at the outcrop of the upper greensand, gault, and lower greensand.

A second line occurs about ten miles to the north, and may be distinctly seen on the Brighton Railway, beyond Croydon, where the chalk dips under the surface at a high angle.

The effect of these disturbances, or lines of flexure, is to intercept, or entirely to cut off the flow of water in the pervious

• *Vide* “ Prestwich’s Water-bearing Strata around London,” page 40.

beds, when accompanied by breaks, or faults in the strata; and there are undoubtedly many others of local importance, as also several cross lines of flexure, one of which is distinctly seen at Deptford, on the North Kent Railway, and it is necessary, before any judgment can be formed of the amount of water to be derived from boring, to examine and understand the disposition of the strata of the locality.

This general description of the district of the London basin is given, with the object of inducing the consideration of the best mode of bringing into practical use the water-bearing strata for the supply of London, when the necessity for such a measure shall arise.

It will be necessary to bear in mind that, of the six beds forming the crust of the London basin, the London clay, or upper tertiary, and the gault, are composed of clays wholly impervious to water; the plastic clay, or lower London tertiary, is partially composed of clay, and partly of pervious sands; but the remaining three,—the chalk, and the upper and lower greensands, generally consist of pervious beds, which receive below the surface, all the water, even of the heaviest rain. It is, perhaps, unnecessary to add, that the water so absorbed, on the elevated districts forming the sides of the basin, descends by gravitation under the London clay, and is the immediate cause of the supply obtained from the Artesian wells of London.

The first water-bearing stratum, in descending the series, is the lower London tertiary, which is to some extent composed of beds pervious to rain. The entire superficial area of this formation is estimated at 354 square miles, 330 of which Mr. Prestwich considers do not contribute to the water supply of London, partly from that portion, which would influence the water under London, being composed principally of clay beds, but also from the eastern, or most effective portion, where the lower beds of the series are exposed, being cut off by the fault, or disturbance, previously alluded to as passing through Deptford, which by elevating the strata, cuts off the flow of the water from east to west.

The south-eastern portion, thus cut off, has a superficial area of 195 square miles, or eight times the effective area for the supply of London, and it is principally composed of pervious beds of the lower part of the series, which is alone sufficient to account for the large supply of water observed, by the Author, on the North Kent line, to which the attention of the Directors of the South Eastern Railway was called in 1850.

That the supply of water to London, from this formation, by Artesian wells, is nearly exhausted, is proved by the fact of the lowering of the level in those wells, the total yield of which is estimated to be from three to four millions of gallons daily.

The second water-bearing stratum, in the series, is the chalk, which presents a superficial area of 3794 square miles, upon which the rain fall is nearly equal to four thousand millions of gallons daily, or equal to five times the summer stream of the Thames at Teddington, and as the surface is almost universally so pervious, that scarcely any rain runs off, even during the heaviest storms, it would at once be inferred, that there is an inexhaustible supply of water, to meet every possible requirement.

Upon this subject however much difference of opinion exists. It is contended, that the greater bulk of water, which is retained near the surface, is returned to the atmosphere by evaporation and vegetation, and that the actual quantity of water percolating below the surface, is only a small portion of that which actually falls, and that the water which does filter into the lower beds, is all again given out by springs, in valleys where the level of the ground is below that of the water level of the chalk, when faults and other disturbances may have interfered with the natural flow of the water. On the other hand it is contended, that the greater portion of the rainfall descends into the formation,—that a portion only is given out by springs, and that the larger quantity finds its way, by subterranean channels, to those parts of the formation, which are intersected by the River Thames and the ocean, and thus makes its escape.

Much controversy on the subject has arisen from the projected supply of water from wells at Watford, upon which an interesting and able report was made by Mr. Robert Stephenson, who gave his authority in support of the project and views of Mr. Homersham, in his proposition to supply the north-western portion of London by this means, and to obtain ten million gallons daily by pumping from a well in Bushey Meadows, near Watford. This project was opposed by the millowners in the neighbourhood, who contended, that this quantity of water must be obtained from the same source whence the springs which feed the mill-streams was derived, and that whatever quantity of water was pumped from Bushey Meadows, the same amount would be abstracted from the millstreams, the pressure being relieved which caused the overflow of the springs. On the other side of the question it was argued, that the springs were derived only from the upper stratum of chalk, and that if the well was made watertight to the depth of 60, or 70 feet, it would have no effect on the surface streams; the supply being obtained from the lower water-channels, which had no connection with the upper supply.

The argument, on this hypothesis, will be best understood from the statement of Mr. Homersham and the report of Mr. Stephenson, with their description of the experimental well at Bushey Meadows, which yielded 1,800,000 gallons daily.

EXTRACT from a REPORT addressed by Mr. HOMERSHAM to the Directors of the London (Watford) Spring Water Company.

“ There can be no doubt this water is derived from the absorption and percolation of the rain which falls upon the hills before described, for it is a characteristic of the chalk formation, when slightly covered with a porous soil, that the heaviest rains, falling upon the sides of the steepest hills, are rapidly absorbed, and large areas of land of this formation, of basin-like forms, are never flooded even in the lowest parts, so rapidly does the greatest fall disappear from the surface.

“ A portion of this water is consumed by evaporation, and in supporting vegetation ; another portion percolating through the surface, is absorbed and gradually gravitates, until, upheld by the density or impervious character of particular beds of chalk, it accumulates in the interstices which abound in various directions, and being conducted by the inclination of these beds, and the direction of such interstices, is found oozing from the sides of hills, or the bottoms of valleys, in the form of springs, which uniting together, with the surface drainage, produce streams, or rivers. Such springs, issuing from the chalk formation, are often of a powerful character, and discharge large quantities of water. The springs of Amwell and Chadwell, near Ware, in Hertfordshire, which afford a partial supply to the New River Company, are of this origin.

“ Another, and by far the greatest portion of the rain which falls upon the chalk formation, encountering no such impervious beds, continues to descend through various fissures, until arrested by the bed of gault clay lying beneath the chalk, it fills the lower cavities, and accumulates to such a height as to force its way through subterraneous passages communicating with the sea. In this manner an enormous amount of water is discharged through the shingle, or sand which covers the coast, and even into the bed of the sea itself.

“ The area of land above, or sloping towards Watford, and consisting for the most part of steep chalk hills, embraces more than 1200 square miles, and calculating that only a depth of twenty inches of rain per annum falls in this locality, at least one-half, or ten inches, may be considered as reaching the lower fissures ; and that this last amount is underrated, there can be no doubt, when it is remembered, that here the yields of the rivers and springs only account for a small consumption of the depth of rain falling, and that the rapidity with which water is absorbed by the chalk formation, prevents any large amount being carried off by evaporation. This depth of ten inches of rain per annum, percolating through a surface of 1200 miles, is equal to supply the immense quantity of four hundred and eight millions of gallons per day,

for every day in the year, which at present finds a vent and is discharged along the coast.

"It is proposed to sink a well, or wells, and to drive adits into the chalk formation, under Bushey Meadows, for the purpose of intercepting and tapping the fissures above described; and that a much larger quantity of water than will be required for your undertaking (namely eight millions of gallons per day) may with facility be procured in this manner from a very small area, there can be no doubt, from the fact, that a well sunk at Bushey Meadows, in 1840, by order of a Committee of the House of Lords, only 12 feet 6 inches diameter at the bottom, and 34 feet deep, with four small bore-holes, 5 inches diameter, and 130 feet below the surface of the ground, was found to supply 1,800,000 gallons per day. An experiment was made in 1840 under the direction of Mr. Robert Stephenson, who reported that when the water was lowered 26 feet by pumping, 'it rose with a velocity equal to 2.02 feet per second, thus yielding 174,500 cubic feet or 1,091,000 gallons per 24 hours.' It must be remembered, that this was the velocity with which the water regained its original level (a few inches below the surface of the ground); the quantity yielded when the water was 24 feet below the surface, was much more than the above amount, being equal to 1,800,000 gallons, as before stated."⁶

EXTRACT from the REPORT of Mr. ROBERT STEPHENSON to the London and Westminster Water Company.

"It is almost needless that I should inform you, that of the water which descends as dew, or rain upon the surface of the London clay, little, if any, can be considered as absorbed into the earth, and that whilst a part either again re-ascends into the atmosphere as vapour, or enters into the composition of animal and vegetable bodies, by far the greater portion flows off into the main drain of the district, the river Thames.

"In this respect there is a most material difference from that portion of the surface where the chalk comes to light, divested of any covering which could intercept the passage of the moisture, being not only extremely porous, but also full of fissures in every direction, a very rapid absorption takes place, and we accordingly find, that there are but few streams carrying off the surplus surface water, and that these are insignificant, and, indeed, many of them dry during the greater part of the year. The rapidity with which the water finds its way into the bowels of the earth, also in a great measure prevents evaporation, and we are therefore justified in assuming, that the quantity which descends upon the surface

⁶ *Vide* Report to the Directors of the London (Watford) Spring Water Company. By S. C. Homersham, C.E. January 1850, p. 1.
[1854-55. N. s.]

of the chalk, finds its way, with very slight diminution, into the fissures below. The lower beds of the cretaceous group, and the gault which immediately succeeds it, again present an impermeable stratum of clay, causing the water to accumulate through the lower regions of the more porous chalk. An enormous natural reservoir has thus been formed, and the level, up to which it may be considered as quite full of water, is the lowest point where it can find a vent and overflow; therefore, as the chalk communicates, under the coasts of Norfolk, Suffolk, and Essex, with the ocean, this level, in the present case, may be considered to be the same as the mean height of the sea.

"That there is, however, an extensive accumulation of water, above this level, will be obvious, when it is considered that the friction, which from the nature of the small fissures and pores must exist, will necessarily prevent the water from exerting rapidly its hydrostatic pressure, and for this reason it cannot flow off with sufficient velocity. The higher parts of the chalk belt which surround the London clay being saturated, will allow of its escape to the surface, wherever it can find a nearer, or more ready vent, than its subterranean one.

"The greater, or lesser facility, which from lines of fissures, soft strata, and pores, the water may encounter, in flowing towards the centre of the basin, will also govern its surface, and cause it to assume an inclination, the angle of which will represent the friction; and in this manner we may readily account for the different levels, which often appear anomalous, at which the water will be found to stand in wells."⁷

In the years 1842 and 1843 and again in 1849, papers on analogous subjects were read at the Institution of Civil Engineers by the Rev. J. C. Clutterbuck,⁸ when much discussion arose on the expressed views of Mr. Stephenson and Mr. Homersham.

Mr. Clutterbuck asserted, that the water-level under London was reduced from 50 to 60 feet, by the number of borings and wells into the chalk, and sand, and according to his opinion, their influence extended to the mill-streams at Watford. He denied that water might be abstracted from the lower chalk, without influencing the springs on the surface, and stated that the level of the water, in several wells in the vicinity, was lowered when the engines were pumping from the experimental well in Bushey Meadows. The reduction of the water-level under London was also mentioned by Mr. F. Braithwaite, and confirmation was

⁷ *Vide* Report by R. Stephenson, C.E. to the London and Westminster Water Company. Tract, London, 1840, page 3.

⁸ *Vide* Minutes of Proceedings Inst. C. E., 1842, vol. ii., page 155; 1843, vol. ii., page 156; and 1849-50, vol. ix., page 151.

offered to the previous statement of Dr. Buckland, that the consumption of the London wells was greater than the supply, indicating that the strata were not sufficiently permeable to prevent ultimate partial exhaustion. The water was shown to travel through the fissures and joints of the chalk and by the beds of flints and not through the material itself; so that it was not by any means certain, that water would be obtained by boring into the chalk, unless there was some previous knowledge of the direction of the fissures, or water channels, which were generally found where disturbance had occurred, and still less likely, when the chalk was covered with a heavy mass of clay.

Mr. John Dickinson laid before the Institution the experiments, made by him, for ascertaining the actual quantity of water which passed through the vegetable soil, and was received into the chalk. The apparatus, which was suggested to him by Dr. Dalton of Manchester, who had previously made experiments in the new red sandstone district, consisted of a cylindrical vessel 10 inches in diameter and 3 feet deep, to which were attached two pipes, one at the top and the other at the bottom; this he had filled with the soil of the country, and as the bottom was pierced with holes, the water passing through the soil contained in the vessel, was conveyed into a receptacle beneath, for the purpose of being measured with minute accuracy.

TABLE showing a comparison between the Quantity of Rain falling on the surface of the Earth and that which penetrated through it.

MONTHS.	1843		1844		1845		1846		1847		1848		1849	
	Common Rain Gauge.	Dalton's Gauge.	Common Rain Gauge.	Dalton's Gauge.	Common Rain Gauge.	Dalton's Gauge.	Common Rain Gauge.	Dalton's Gauge.	Common Rain Gauge.	Dalton's Gauge.	Common Rain Gauge.	Dalton's Gauge.	Common Rain Gauge.	Dalton's Gauge.
January .	1.46	1.25	1.90	.80	3.35	2.40	3.97	5.05	1.80	. . .	1.33	0.81	1.80	. . .
February .	2.42	1.95	3.62	1.50	.70	. . .	1.28	.84	1.42	1.76	3.25	3.00	2.18	.40
March .	.88	. . .	2.22	2.65	1.30	. . .	1.09	.02	.99	. . .	3.57	2.75	.97	.09
April .	2.10	. . .	.53	. . .	1.45	. . .	2.52	.28	1.68	. . .	2.68	.70	. . .	. . .
May .	5.00	.74	.47	. . .	2.25	. . .	1.59	. . .	2.15	. . .	0.21	. . .	. . .	. . .
June .	1.56	.25	1.18	. . .	1.60	. . .	0.51	. . .	2.30	. . .	3.19	. . .	. . .	. . .
July .	2.09	. . .	1.95	. . .	2.30	. . .	1.90	. . .	1.91	. . .	2.42	. . .	. . .	. . .
August .	2.66	. . .	2.72	. . .	1.97	. . .	3.28	. . .	1.21	. . .	2.38	. . .	. . .	. . .
September .	.63	. . .	1.42	. . .	2.00	. . .	1.70	. . .	2.06	. . .	2.12	. . .	. . .	. . .
October .	4.82	. . .	4.38	1.15	1.65	. . .	6.36	3.98	2.59	. . .	4.50	2.58	. . .	. . .
November .	2.45	2.70	3.07	3.57	2.94	.30	1.45	1.70	. . .	1.12	.47	. . .	. . .	. . .
December .	.40	.30	.31	. . .	3.02	2.80	.90	. . .	3.40	2.38	2.92	2.68	. . .	. . .
	26.47	8.10	23.57	9.65	24.55	5.50	26.55	10.27	23.20	4.14	29.69	12.99	. . .	. . .

The deduction drawn by Mr. Dickinson from these experiments, was that the water actually received into the chalk, was not more than sufficient to account for the volume of the streams in the district, but he did not appear to give any detailed calculation to show how he arrived at this conclusion. This is however a point

of great importance, as upon it depends the propriety of drawing water from the chalk at Watford. The Author has endeavoured to make a comparison, founded on the best data he has been able to procure, at the same time remarking that he cannot place perfect reliance on the results of Mr. Dickinson's experiments, as in his opinion the only really satisfactory manner of arriving at a correct result as to the amount of water which infiltrates the soil, would be by sinking cylinders of much larger dimensions and in several positions, so as to obtain an average result. The ground should be under-pinned and a bottom added to the cylinder without disturbing the surface soil.

Assuming, however, the rate of infiltration given by Mr. Dickinson; the measurements made by Mr. Beardmore, of the discharge of the River Lea, are compared with the infiltration of the square miles of the district drained.

The following table of observations (see page 53), originally published in the Parliamentary Report, has been recently corrected by Mr. Beardmore.

The total discharge is 10,050 cubic feet per minute, which is equal to 6332 million feet per annum. The total number of square miles of drainage is 444, and the fall of rain per annum, allowing 844 inches to infiltrate, is 8706 millions; the actual discharge of the river is, therefore, $\cdot 61$ or less than two-thirds of the amount which infiltrates.

This result of the observations of others is given without vouching for its strict accuracy, and it is to be regretted, that better data on this important subject cannot be procured. The Author's own observations, particularly in the south-eastern district of the London basin, as to the escape of water from the sea-coast, when the chalk is intersected, and as to the maintenance of deep water, without superficial scouring-power, lead him not to be surprised to find, that even a greater portion was not returned in the stream, as its escape can be readily explained in this way.

In the table of discharges of rivers there appears to be some discrepancy in the result of different streams; the run per square mile, in the case of the Mimram, which is the highest, viz., 34 \cdot 04 cubic feet per minute, indicating nearly the whole infiltration; while the Ash gives only 14 \cdot 10, or an amount not exceeding 2 $\frac{3}{4}$ inches out of the 8 \cdot 44 inches infiltrated. The inference to be drawn from this irregularity, in the comparison of the rivers with the area of drainage, is that the supply of the river has little reference to its drainage ground, and that the quantity yielded is determined by the level, as compared with the water-level in the chalk, disturbances in the strata from faults, &c., and by the facility of communication to the surface, by the fissures which facilitate the communication of the water with the subterranean supply.

STATEMENT of the Discharge of the River Lea between Hertford and Field's Weir, March, 1850.

	Cubic Feet per Minute.	Total Cubic Feet per Minute.	Square Miles of Drainage.	Run per Square Mile in Cubic Feet per Minute.
<i>Discharge of Branches above Hertford.</i>				
Lea Proper at Horns Mill	2,185	..	105	20·81
River Beane at Molewood	1,483	..	83	17·87
River Rib at Ware Park	959	..	61	15·27
River Mimram at Panshanger	1,532	..	45	34·04
Total above Hertford		6,159		21·23
Main river at Ware Mill	5,344	..	..	..
New River	1,250	6,594	..	..
Chadwell spring, say	506	..	..	..
Total valley at Ware . . . . .	..	7,100		24·78
Area to Hertford . . 294 sq. miles				
Add to Ware . . . 2·5 ,,				
Total 296·5 sq. miles				
<i>Field's Weir.</i>				
(81 feet above Trinity high-water mark.)				
Stort proportion	1,376	..	105	13·10
Ash proportion	480	..	34	14·10
Run at Ware, as above	5,344	..	..	..
Increase from springs between Ware and Field's Weir.	1,100	..	11	..
Total without the New River . .	..	8,300	..	..
Add for New River, &c. . . . .	..	1,750	..	..
Total of joint valleys . . . . .	..	10,050	444	22·63

Note.—Field's Weir is 81 feet above Trinity high-water mark. In the month of March, 1850 (a particularly dry one), the mean discharge of water over it was 8,000 cube feet per minute, exclusive of the abstractions by the New River; and the lock-keeper at the weir is of opinion, that the discharge of March, 1850, is about what occurs in the dry months of summer.

These reasons for and against obtaining water from the chalk, north of London, induce careful consideration whether there may not exist other sources of supply, whence an ample quantity might be obtained, when the necessity may arise, without interfering with existing streams; and the south-eastern district presents itself, inasmuch as there are three large districts without any stream whatever, the waters of which are now wasted in the Thames, and the Author's conviction of the abundance of the supply of water, and of the facility for obtaining it was so strong, that he addressed a report on the subject to the Directors of the South-Eastern Railway in the year 1850, from which the following

extract will most briefly express his views, and to which is added an interesting report, on the same subject, by Professor Ansted. After describing his observations on the south-eastern district, the Author proceeds to state that—

“On the North Kent line the locomotives are also supplied with water from the chalk, both at Gravesend and Strood; at the latter station the water is conveyed in pipes from the Higham tunnel, where powerful springs, yielding 300 gallons per minute, are intersected above high-water mark.

“At Erith, Plumstead, Woolwich, and other parts of the line, an abundance of water is found, at a few feet from the surface. In the Plumstead Marshes, springs, yielding from 200 to 250 gallons per minute, appear on the surface of the ground in the line of railway. In the Charlton Marshes springs also occur, yielding above 200 gallons per minute; and at the Abbey Wood station, in a boring of 30 feet, the water rises above the surface. Since this Report was first written, I have measured a group of springs which occurs near Northfleet station, yielding between 5,000 and 6 000 gallons per minute, the greater part of which is again absorbed by the porous strata, before reaching the river.

“I also observed the remarkable fact, that between Lewisham and Strood (twenty-six miles), only one stream, which has its source in the chalk district (*viz.*, the Cray), crosses the line of railway from the hills to the south, which led me to the examination of the south bank of the river Thames, with the view of ascertaining whether the water of the district, between the railway and the North Downs, drained into the river between high and low water mark; and, from the observations made by me at Woolwich and Erith, I am convinced that this is the case, and that the absence of streams on the surface is to be explained in this way.

“The thickness of mud, overlaying the chalk, prevents the smaller springs from appearing; but at Erith, several powerful springs are seen, one group of which I measured, and found 500 gallons per minute flowing from it. Within 100 yards, other powerful springs are visible, which I did not measure, but have no hesitation in stating, that a quantity of water, exceeding 1,500,000 gallons per day, escapes in a length of 250 yards of the river bank; which opinion was confirmed by Professor Ansted.

“At Woolwich, several similar springs occur; one of which is used by the shipping there for fresh water, which is obtained by

⁹ The Darent also crosses the railway, but has its source in the Weald, and does not obtain any of its volume from the chalk; on the contrary, there is good reason to think that the flood waters of the Weald are absorbed by the chalk, in their passage over it to the sea.

excavating a hole in the beach, when the tide is out; and a well has been sunk at Woolwich Dockyard, by Mr. T. Clark, which yields 1,000 gallons of pure water per minute.

"At Erith and Greenhithe, &c., water is obtained in a similar way for the shipping, by wells on the river bank, which intercept the fresh water in its escape into the river.

"The springs on the south river bank are, I am informed, found wherever excavations have been made for the erection of works, among which may be noticed the dry docks at Woolwich, and the piers at Greenwich and Gravesend. Between Rochester and Dover the same absence of surface streams is to be observed; and there is no doubt that the remarkable fact of the Swale, Stangate, and other creeks preserving deep water, is to be attributed solely to the springs in the chalk, which act as scours, otherwise these channels would rapidly silt up with mud, like Whitstable harbour, where I have been obliged to use artificial means to produce a much less depth of water."

EXTRACT from a REPORT, by Professor ANSTED, on the Supply of Water to be obtained from the North Kent District; addressed to the Chairman and Directors of the South Eastern Railway Company.

"THE natural surface drainage of the district, under consideration, is exceedingly small. No large stream crosses the country, the Darent, with its tributary, the Cray, conveying into the Thames but a very small quantity of water, and no other stream of any magnitude entering the river at all between the Ravensbourne and the Medway. With the exception, also, of one branch of the former stream, no drainage whatever can be traced, conveying water out of the district. It is proper to mention, besides, that a part of the water of the Darent, sufficient to turn a mill, is derived from other sources, as it comes in from beds cropping out from under the chalk between Sevenoaks and Shoreham.

"The annual rain fall, near London, is estimated at twenty-six inches, and of this it is usually considered that twelve inches either enter the earth directly by absorption, or pass over the surface in streams and rivers. In so open a district, as the one we are now considering, by far the largest portion of this passes into the rock, and as less than 10,000 millions of gallons drain into the Thames annually by the Darent, there must remain a quantity equivalent to more than 20,000 millions of gallons (say sixty millions of gallons per day) which is probably at present delivered in springs in the bed of the Thames, or passes out into the sea. This quantity is, however, capable of being intercepted.

"By examining the springs near the right bank of the Thames,

we are enabled to learn the true condition of the chalk, with regard to its water contents, and to explain the phenomena presented on sinking to a certain depth below the surface. Many such springs exist, and a vast multitude of borings have been made in the district. I proceed to notice those only which have fallen under my own observation, believing that these are sufficient to justify the conclusion to which I have arrived.

“The springs to which I allude are:—1st, a small group near Greenwich Marsh; 2nd, borings and wells at Woolwich; 3rd, springs and borings near Abbey Wood station on the North Kent line; 4th, springs at Erith; 5th, springs near Northfleet; 6th, springs coming out at Higham, near Shorne. I might refer to others at the foot of the chalk hills beyond Higham, but these will be found sufficient.

“At Greenwich Marsh, close to the coping of the tram road and the high road, a spring comes out of the chalk, quite at the top of the rock, running about 250 gallons per minute, and proceeding directly to the Thames. A few hundred yards beyond, towards Charlton, another small stream is seen by the road side of less power. Near Charlton the workings in the chalk, in a large quarry there, are limited in depth by the wetness of the rock.

“Several springs rise between Woolwich and Abbey Wood station, and after traversing the marshes, empty themselves in the Thames. At Woolwich, very large quantities of water are readily obtained by moderately-deep sinkings in the chalk. It is clear that everywhere along this district the water exists in the chalk above low-water level: and as there are no retentive beds overlying the chalk, the true source of supply must be in that rock.

“At Abbey Wood station several springs are seen rising in the marshes, and a small boring made behind the station, not reaching the chalk, affords a constant flow of water from overlying sands. Between Abbey Wood and Erith I did not observe any spring, but at the latter place the chalk is laid bare by cuttings, and is found to hold water, about the level of high-water mark. Water is here, therefore, very readily obtained by shallow wells into the chalk.

“Near Northfleet a considerable body of water rises in numerous springs, and combine to form a considerable stream, which at one spot, where Mr. Barlow and I made a rough estimate of the quantity, appeared to move as much as 5,000 gallons per minute, or seven millions of gallons per day. This large quantity is, however, so far absorbed and lost, before entering the river Thames, that a three-foot culvert is amply sufficient to pass it across the high road at the place called Stone Bridge, about

half a mile from Northfleet. It is right to state, that there is here a considerable thickness of alluvial mud, through which the stream passes, and it appears that formerly a creek, or inlet must have opened from the river, which is now silted up. The absorption of the water is, however, very well illustrated at this point.

“At the entrance of the tunnel, at Higham, a strong spring comes out of the chalk, at some distance above high-water mark, and delivers as much as half a million gallons of water per day.”

EXTRACT from a SUPPLEMENTARY REPORT, by Professor ANSTED, addressed to the Chairman and Directors of the South Eastern Railway Company.

“Since forwarding my Report on Monday last, the 11th instant, I have had an opportunity of examining, in company with Mr. Barlow, various springs of fresh water coming out on the right bank of the Thames, between Erith and Gravesend, and only visible at low water, on the occasion of spring tides. As the condition of these springs affords most satisfactory and distinct proof of the existence of a large quantity of water, capable of being supplied from the chalk of this district, I have the honour to submit now a short statement, supplementary to the Report already in your possession.

“At Erith, when the water is very low, a group of exceedingly strong springs may be seen issuing out from the thick mud on each side the pier, and within a range of a few hundred yards.

“It is clear, from the great abundance of water pouring out from these springs after the unusual dryness of the last few months, the driest season of the year, that the source of supply is quite independent of present, or recent rain. It can only be the result of a very wet condition of the chalk; and I have found, by actual experiment, that the solid chalk, in this locality, has a much greater capacity for water than other specimens I have examined, holding, in fact, more than half its bulk of water, when fully saturated. The springs breaking out at and near Erith are, at present, entirely useless, running at once into the Thames; but there would be no difficulty in intercepting them, either by borings, or a tunnel, at a low level. I am satisfied, from the appearance and number of the springs, that the quantity of water, as estimated, by Mr. Barlow, (a million and a half gallons per day), is very much within the mark.

“Along the shore, from Erith towards Northfleet, there are no springs observable, in consequence of the distance of the chalk and the thickness of the river silt; but near the dockyard, at the latter place, where the chalk re-appears at the surface, an extremely powerful spring pours out, near the low-water mark of

spring tides, along a line at least twenty feet in length. There were no means at hand by which we could in any way measure the quantity, except by comparison with known streams, but it would probably be safe to estimate it as equivalent to a million of gallons per day.

"Beyond Northfleet, where the chalk is seen on the river bank, the water everywhere oozes out from the exposed surface, and trickles down in a multitude of very small streams. This affords equally good evidence of the wet condition of the chalk, and proves that a tunnel through it would be constantly full.

"I am therefore decidedly of opinion, from the appearance of the springs at low water, that the whole of the chalk between Erith and Gravesend is saturated with water, considerably above the line of low-water level, and that a very large supply, equivalent to several millions of gallons per day, from three localities only, might readily be intersected by a tunnel, or a number of bores."

The effect of the great transverse fault, passing through Deptford, which has been described by Mr. Prestwich, is to cut out the water on the east side from assisting the supply of London; therefore, in endeavouring to arrive at an estimate of the supply to be derived from the North Kent district, this line is considered as the boundary on the west side. It will be found, that west of the Medway there are 190 square miles of exposed chalk, or chalk covered with the permeable sands of the lower tertiary, and east of the Medway 320 square miles; allowing 8.44 inches = 322,000 gallons per mile daily to infiltrate, the quantity per annum which is wasted in the river and the sea, will be 60 million gallons per day, west of the Medway, and 100 millions of gallons per day, east of the Medway. In this calculation the infiltration given by Mr. Dickinson is assumed, but it would appear, from the number of springs, that a much larger quantity infiltrates in this district, from the dryness of the soil and from the rain-fall being rather greater.

The mode of securing this water would be by driving in the chalk, between high and low water mark, a heading similar to the Thames and Medway tunnel,—a work which is executed with very little cost, as in most cases arching would not be necessary,—and which would intercept the greater part of the supply; but boring might be adopted, when any disturbance of the beds indicated the probability of water fissures.

Before closing this part of the paper it is necessary to describe a very important practical result, obtained since the Author's report was written, in 1850. Water-works have been constructed at Woolwich, the supply being derived from the chalk formation, to which the softening process of Dr. Clark has been applied with marked success; and it is only justice to Mr. Homersham, the

Engineer, to notice the complete manner in which all the details of the works have been arranged. The water has been obtained principally from headings in the chalk, of an aggregate length of 120 yards; the direction of which has been determined on the principle of intersecting as great an extent as possible of the inclined beds. The actual quantity, at present obtained, is 600,000 gallons per day, which is amply sufficient for the district it is intended to supply; but there is no doubt that any further required quantity may be obtained, by the extension of the headings.

It is perhaps unnecessary to explain the simple and effective softening process of Professor Clark; it consists of the addition of a certain quantity of pure lime to the chalk water, the salts of which principally consist of bi-carbonate of lime. The bi-carbonate being a soluble salt, the extra quantity of carbonic acid has a greater affinity for the pure lime, than for the carbonate, and thus by the mixture, both the lime and the bi-carbonate are converted into a carbonate, which is insoluble and sinks to the bottom, if left at rest for a few hours, the water becoming beautifully clear and transparent. Professor Clark's process will, however, best be understood by his own description:—

“To understand the nature of the process, it will be necessary to advert, in a general way, to a few long-known chemical properties of the familiar substance chalk; for chalk at once forms the bulk of the chemical impurity that the process will separate from water, and is the material whence the ingredient for effecting the separation will be obtained.

“In water, chalk is almost, or altogether insoluble; but it may be rendered soluble, by either of two processes of a very opposite kind. When burned, as in a kiln, chalk loses weight. If dry and pure, only nine ounces will remain, out of a pound of sixteen ounces. These nine ounces will be soluble in water, but they will require not less than forty gallons of water for entire solution. Burnt chalk is called quick-lime, and water holding quick-lime in solution is called lime-water. The solution thus named is perfectly clear and colourless.

“The seven ounces, lost by a pound of chalk on being burned, consist of carbonic acid gas—that gas which, being dissolved under compression by water, forms what is called soda-water.

“The other mode of rendering chalk soluble in water is nearly the reverse. In the former mode, a pound of pure chalk comes to be soluble in water in consequence of losing seven ounces of carbonic acid. To dissolve in the second mode, not only must the pound of chalk not lose the seven ounces of carbonic acid that it contains, but it must combine with seven additional ounces of that acid. In such a state of combination, chalk exists in the

waters of London—dissolved, invisible, and colourless, like salt in water. A pound of chalk, dissolved in 560 gallons of water, by seven ounces of carbonic acid, would form a solution not sensibly different, in ordinary use, from the filtered water of the Thames, in the average state of that river. Chalk, which chemists call carbonate of lime, becomes what they call bi-carbonate of lime when it is dissolved in water by carbonic acid.

“Any lime-water may be mixed with another, and any solution of bi-carbonate of lime may be mixed with another, without any change being produced: the clearness of the mixed solutions would be undisturbed. Not so, however, if lime-water be mixed with a solution of bi-carbonate of lime: very soon a haziness appears; this deepens into a whiteness, and the mixture soon acquires the appearance of a well-mixed whitewash. When the white matter ceases to be produced, it subsides, and in process of time leaves the water above perfectly clear. The subsided matter is nothing but chalk.

“What occurs in this operation will be understood, if we suppose that one pound of chalk, after being burned to nine ounces of quick-lime, is dissolved so as to form forty gallons of lime-water; that another pound is dissolved by seven ounces of extra-carbonic acid, so as to form 560 gallons of a solution of bi-carbonate of lime; and that the two solutions are mixed, making up together 600 gallons. The nine ounces of quick-lime, from the pound of burnt chalk, unite with the seven extra ounces of carbonic acid that hold the dissolved pound of chalk in solution. These nine ounces of caustic lime and seven ounces of carbonic acid, form sixteen ounces—that is, one pound of chalk—which, being insoluble in water, becomes visible immediately on its being formed, at the same time that the other pound of chalk, being deprived of the extra seven ounces of carbonic acid that kept it in solution, re-appears. Both pounds of chalk will be found at the bottom, after subsidence. The 600 gallons of water will remain above, clear and colourless, without holding in solution any sensible quantity either of quick-lime, or of bi-carbonate of lime.”

Simple as is the process, it requires attention to make it effective, first to give no more than the correct proportion of quick-lime to the bi-carbonate to be decomposed, otherwise the water is hard from excess of lime, and secondly the thorough mixture and incorporation of the quick-lime with the water. This is effected by a cylinder containing prepared lime, or milk of lime, in connection with the pipe, which conveys the water from the pumps to the reservoir. The cylinder contains a piston, moved by machinery, a given amount at each stroke, by means of which a certain estimated quantity of lime-water is caused to pass into the water, as it flows through the pipe.

To effect the thorough incorporation, or mixing of the lime with the water, it is passed through cylinders with partitions pierced with holes of different sizes, before it reaches the reservoir for settling, which it enters of a milky colour, but after twelve hours' subsidence, the water becomes beautifully clear and bright and agreeable to the taste.

Hitherto little importance has been attached to the upper and lower greensand formations as water-bearing strata; but it has been shown in the interesting treatise of Mr. Prestwich, that they are deserving of careful consideration.

The upper greensand, which immediately underlies the chalk, and so much resembles its lower beds, that it is difficult, in some cases, to draw the line where it commences, is of very variable character and thickness. To the eastward of London, it possesses so small a superficial area as to be of little importance as a water-bearing stratum; but as it approaches Godstone the thickness increases to 50 feet, and its character is more defined. The well-known firestone quarries, on the west of the London and Godstone turnpike-road, are situated in this formation, at an elevation of 450 feet above the level of the sea. The thickness and superficial area increase to the westward, and at Devizes, at the end of the vale of Pewsey, it attains a thickness of 140 feet; the elevation being again above 400 feet, although at Dorking and Guildford the altitude very little exceeds 100 feet above the sea.

To the north-west of London, between Swindon and Cambridge, it is found to exhibit a considerable area, at an elevation varying from 135 to 400 feet. The total superficial area is estimated by Mr. Prestwich at 172 square miles, but it probably receives some assistance from the drainage of the escarpment of the lower chalk. From this area he deducts 102 miles, as a London supply, from the portion not permeable, on account of the mixture of clay, and from the effect of the great transverse fault. But there is a doubt as to its efficiency, as a water-bearing stratum, from its small thickness rendering it liable to be influenced by faults.

The lower greensand, which is separated from the upper, by the gault,—a dark impervious clay,—presents a much larger area for rainfall, and is often well situated for receiving the drainage of the gault. Unlike the upper greensand, this formation is more marked in the south-eastern side of the London basin, where it attains a thickness varying from 400 to 600 feet, and not unfrequently an elevation equal to the North Downs, forming the ridge on which Sevenoaks, Dorking, &c., are situated. The beds are variable, consisting of ferruginous sands, with layers of limestone, and occasionally of clay and fullers'-earth; but generally they are permeable.

On the northern side of the basin, the character of the ridge is

less marked, but it is more arenaceous, consisting principally of yellow and ferruginous sands, with thin seams of sandstone. The average elevation is 200 feet, and the thickness is estimated at 380 feet.

Mr. Prestwich estimates the total superficial area at 650 square miles, of which 420 miles are cut off from London by faults, or are composed of impervious beds, leaving only 230 miles as effective contributive surface.

He estimates the actual amount of rainfall at 77,660,660 gallons per day on the upper, and 241,500,920 gallons per day on the lower greensand, of which there will be infiltrated 27,735,960 gallons, on the upper greensand, and 145,811,720 gallons, on the lower greensand, and of this quantity, he considers, that from six to ten millions of gallons may be obtained, in London, by Artesian wells, from the upper greensand, provided faults do not interfere, and from thirty to forty millions from the lower greensand. His concluding deductions, attaching much more significance to the lower greensand, on this important point, will be best conceived in his own words:—

“ These calculations, although offered only as very general approximations, give results sufficiently marked and decided, that even admitting the necessity of not inconsiderable corrections, I think they establish strong *primâ facie* evidence in favour of the upper and lower greensands, beneath London, containing unusually large quantities of water, which may be rendered, without difficulty, available for the supply of the Metropolis, by means of Artesian wells. What their yield might be, could only be determined, exactly, by actual experiment; but judging from analogy, if the lower tertiary sands, with dimensions comparatively so limited, can nevertheless furnish not less than 3,000,000 to 4,000,000 gallons of water daily (and, if, as is probable, they supply much of the water found in the upper beds of the chalk, beneath London, their yield may amount to 8,000,000 or 10,000,000), then I submit that there is a reasonable probability, after allowing for the present under-drainage of the tertiaries of the upper greensand,—with an effective area and a thickness three times greater than those of the lower tertiaries,—yielding daily, and without diminution, from 6,000,000 to 10,000,000 gallons; and of the lower green-sand, —which exceeds by ten times the lower tertiaries in both these respects,¹⁰—yielding from 30,000,000 to 40,000,000 gallons of

¹⁰ It is also to be observed, that probably none of the water passing into the greensands is lost by transfer to other deposits, as both of these are confined between perfectly impermeable strata; whereas there can, I think, be little doubt that much of the water from the tertiary sands passes into the chalk. It is not

water in the 24 hours, taken at about the surface level. This is more especially probable with regard to the lower greensand, when its extreme permeability, in comparison with that of the lower tertiary sands, is considered, and would tend, with other causes, to give it an additional value beyond that which is here assumed.

"The height of the outcrop of the greensand has also to be taken into account; it is such that it would cause a much more rapid discharge of water at London than can be effected by the tertiary sands." "

One advantage possessed by an Artesian well in the greensand, is the height to which the water will rise above the surface;—the tertiary sands and the chalk are intersected by the River Thames, near London, and therefore the Artesian wells cannot rise much above low-water mark, and it is only in positions inland, considerably above the level of the sea, but where the situation is still below the water level of the country, that the water in the Artesian wells from the chalk and sand will rise above the surface.

The outcrop of the lower greensand has an average level of 200 feet above high-water mark, and the upper greensand as much as 260 feet, and it is nowhere intersected by the sea, except at the south-eastern portion of the London basin, at Folkestone. The lower greensand is, however, excavated by the valley of the Medway to within 2 feet of high-water mark, and the upper greensand to within 30 feet of high-water mark, at Cambridge.

Taking the low points into consideration, with the assistance of the experience obtained from the Artesian well, in the Plaine de Grenelle, at Paris, where the water rises 120 feet above the surface of the ground, although the outcrop nearly descends to the level of the sea, between Rouen, Havre, and Caen, Mr. Prestwich investigates what would be the probable rise at London. He has taken the two lowest points of the outcrop, in the northern and on the southern sides of the zone,—the former in the neighbourhood of Cambridge, and the latter near Maidstone,—and to each of these points he considers the water as flowing from the whole length, respectively, of each opposite zone of outcrop, westward of their parallels. By this plan, there is a series of inclined planes, passing over London, and a mean of them is taken, as the probable height to which the water will rise, giving a result of from 130 to 136 feet.

If, however, there is any fault, or disturbance to prevent the flowing of water to Maidstone, which is very likely, then the

impossible, however, that the pressure of the water in the chalk along the marginal edges of the tertiary sands may, in some places, and near the surface, establish a flow of water from the former into the latter deposit.

"*Vide* "Prestwich's Water-bearing Strata around London," page 126.

height to which the water would rise at London would evidently be greater.

The data from which these conclusions are derived, both with reference to the height and quantity from an Artesian well in the greensands, are undoubtedly to a considerable extent conjectural, the beds may be wanting, faults may interfere, or the water may be cut off by argillaceous beds, but having the confident opinion of Mr. Prestwich, whose detailed examination of this district and accurate knowledge of every part of the London basin, so fully qualifies him to judge, and having the result of a similar experiment in the Paris basin, where 880,000 gallons are produced daily by an Artesian bore of 1800 feet in depth, it is a subject of regret, that so interesting an experiment has not been before made in London, where the depth of the upper greensand is estimated at about 900 feet, and the lower greensand at a little more than 1000 feet, and where the expense would consequently be much less than in Paris.

The bearing of the question, here discussed, upon that of the present water supply of the Metropolis is very evident, indeed the attention of the Author was directed to the subject, by the general public demand for a more copious supply, derived from a purer source than the River Thames, within the range of the tide, and by the parliamentary investigation; when schemes of all kinds were proposed. His intimate acquaintance with the district, whence it had been necessary to procure water, for the use of the locomotive engines on the South Eastern Railway, further determined his views; but in bringing the question before the Institution, he would wish to divest it of all commercial character, and to place it before the Meeting for scientific discussion. It must not be disguised, that there has been much clamour against the present water supply, without considering the enormous and rapid extension of the Metropolis, and of the towns on the banks of the Thames. In the commencement of the present century, the population of London alone was less than half its present amount.

In 1701	the population was	674,000	souls.
1801	„	864,845	„
1811	„	1,009,546	„
1821	„	1,225,694	„
1831	„	1,776,556	„
1841	„	1,870,727	„
1851	„	2,362,236	„

The present estimate is 2,750,000.

This marvellous extension would have demanded improved means of supply, even if there had not been any change of social habits; but when civilization and luxurious habits advance with

equal strides, baths become necessities of life for all classes, and sanitary measures enforce the copious use of water in all ways, in the dwellings, the thoroughfares, and the sewers, it is evident great exertions are necessary, to meet the demand, and any person habitually passing up and down the Thames, above bridge, must be struck with the meagre and polluted appearance of the stream, upon whose bosom, within a few miles, such boundless commercial wealth is borne. It must not be forgotten, however, that nature has wisely provided for the effect of rivers being the natural sewers of a country, by giving to the water the power of certain chemical and mechanical actions, whereby it purifies and settles down all the animal and vegetable refuse carried into it, and, as a case in point, it is asserted by seamen, that no water ever taken to sea, is so good as that from the Thames, after it has fermented and subsided.

The water companies have now extended their pipes, or removed their pumping machinery, to places so high above London Bridge as to be entirely beyond the influence of the tide and of the more immediately polluted portion of the river, and for the present, the supply will, no doubt, be improved in quantity and quality, but whether any further extension may eventually become requisite, must depend on the future state of the Metropolis; the water-bearing strata treated of in the paper has, therefore, been pointed out as an efficient auxiliary in time of need.

[Mr. P. W. BARLOW.

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[1854-55. N. s.]