

## EVIDENCE AS TO THE CAUSE AND EFFECT OF THE LOWERING OF THE PERMANENT WATER LEVELS IN THE LONDON WATER BASIN.

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THE substance of this paper will merely embody the opinions as expressed by various authorities abstracted from one or two well-known publications. I shall make no attempt to express my own opinion on the subject, nor do I desire to represent the case in a way which would favour my own opinion.

There are manifold causes which contribute to the lowering of the permanent levels, but these can only be briefly alluded to.

*Limitation of Area.*—Only that portion of the water which falls within a certain area, more or less defined, and involving a consideration of underground as well as surface geology, can contribute to the London Basin. This area is far more restricted than the area of the London Basin itself. The overlying Thanet Sand having been exhausted, the Chalk remains as the chief if not the only practical source of supply for deep wells. It is only the Upper Chalk which can be considered as possessing any storage capacity for water. That portion of the London Basin covered by impermeable beds, more particularly that which does not drain towards the Chalk, is not available as a catchment area, and furthermore the overlying Clay has so compressed the chalk as to impair its qualities as water-bearing strata. That portion of the rain falling upon impermeable beds draining to the Chalk contributes to some extent to the underground supplies. There is a further area covered by mixed beds, the permeability of which is unknown. Of that which falls on permeable strata overlying the Chalk, or on the bare Chalk, only a portion percolates to the underground sources of supply. This percolation is variable according to the time of year and varies with different years. The circumstances and

conditions which bring about this variation are too numerous and complex to discuss here. Generally speaking it may be said, however, that about nine tenths of the percolation takes place during the winter months, and only one tenth during the summer months. On an average soil of the Home Counties about a third of the total rainfall may be considered to reach the underground waters, the rest having evaporated, or in some instances passed off into the river. Percolation in some years is as small as 3 inches of rainfall out of a total of 20 to 25, in normal years as much as 7, but in excessive years it has reached 10. Inasmuch as the underground waters are not standing still but are in constant motion, and leak away, and the leakage is greatest as the result of wet years, and that the effect of wet years is soon obliterated, such provision should be made as would ensure that no greater amount is taken than can be supplied by percolation during a succession of the three driest years, during which the rainfall is about 20° below the average.

Our modern system of drainage has resulted in the diversion of a large amount of water, which in dry weather amounts to about 200 million gallons a day from the metropolis, and at storm time to 400 million gallons a day, finding its way into the river Thames at Crossness and Barking. This amount of water would naturally, if not diverted, have fed the soil. The direction of the underground water current mostly follows that of the rivers, being determined partly by surface and partly by underground geology. It has been suggested that the river valleys in the chalk indicate a much damper climate than at present, but modern views do not necessitate this supposition. The river beds and consequent direction of existing rivers appear to have been determined by conditions which prevailed before the Glacial period. The direction of underground waters largely follows the inclination of the geological beds, but in a large measure that of the river beds, and is very complex. In those districts where the dip of the strata and direction of the rivers is the same, the underground water has a twofold tendency to travel in the same direction as the rivers. Much of the underground water appears to find its way into the bed of the River Thames at low tide, and from evidence it would appear that some years ago the underground water leaking into the Lower Thames was equal to if not greater than the amount pumped from the Chalk for the supply of the metropolis. Although the Thames at points, such as at Erith, appears to receive large quantities of underground water, there is evidence that parts of the Upper Thames are depleted by pumping in its vicinity, and the shrinkage of the Thames and Lea as measured up to the end of last year is in part attributed to that cause.

Years ago the overlying Thanet Sand afforded water to the metropolis, but on account of its small outcrop and thinness it became practically exhausted. Wells were then sunk deeper into the Chalk. The Chalk, where covered with clay or other beds, is more compressed, and as a consequence contains much less water, and the clay acts as an impermeable barrier to the rain.

Attempts to obtain water from the Lower Greensand have proved failures, and the formation has been found not to exist under London in many places.

In 1828 the eight Metropolitan Water Companies supplied the metropolis on an average with 29 million gallons a day. Now they are supplying at the rate of about 217 millions, being between seven and eight-fold what it was in 1828. At the former date the amount pumped from the Chalk was only about a quarter of a million gallons a day, now it is about 54 millions.

1,650 private wells are known to exist in London, but the average amount which they deliver a day is not known. As 65 of these wells, sunk by a well-known Engineer, show an available pumping capacity of about 10 million gallons a day, the aggregate amount must be something enormous, and probably much in excess of that pumped by Metropolitan Water Companies.

It has been estimated by one who claims to have exhaustively studied the subject, and who clings to the view that the water under London is practically inexhaustible, that there are 1,000 private wells in the London Basin lifting on an average 100,000 gallons each daily. This would give an aggregate of 100 million gallons a day, and would lead us to believe that the total aggregate pumping and leakage represent a total loss to the London Basin of upwards of 200 million gallons daily.

Unofficial returns made to me of the total water consumption per ton of manufactured product, and the amount of output of certain of our manufactures, would suggest that our manufacturers are drawing enormous quantities of water from the London Basin, and that the above-mentioned estimate is by no means an exaggeration.

In 1893, 172 chalk wells were estimated to yield about 10 million gallons a day, and the number of wells were said to be greatly on the increase.

In places where, 100 years ago, the water when tapped would rise to the surface and overflow, the level is now over 100 feet below ordnance datum.

In 1850 the permanent levels were depressed from 50 to 60 feet at

the lowest point, the depression having been noticed thirty years previously. In 1850 the level was falling at the rate of one foot per annum. In 1893 the fall was variously estimated at between 12 and 18 inches per annum.

It has been estimated that the levels are lowered to such an extent in Hertfordshire that if the pumping was discontinued it would take forty years of rainfall to make the levels up.

If no water were removed by artificial means and no rain fell the levels would fall in consequence of the perpetual natural leaking away. A large proportion of the rainfall is required merely for maintaining the water level. It is only the excess over and above what is necessary to do this that can be artificially abstracted without permanently depressing the levels. The so-called level of saturation is the point at which water will rise in a well, but the actual water in the Chalk gradually grades off from the water level upwards.

The effects of depression were prophesied in 1876, and recent events recorded in evidence show the truth of this prophecy.

In conclusion, I would merely refer to the effects of a permanent lowering. The drying up of streams, springs, shallow wells, loss of power from streams, drying up of watercress beds, loss of fishing, additional cost to manufacturers consequent upon having to deepen wells and raise all water from greater depths, the dying of deep-rooted trees, loss to landscape, loss to farmers and agriculturists. But what would probably concern the Sanitary Congress most would be the danger of pollution of sources of supply through infiltration of surface and contaminated water, more particularly perhaps in chalky districts where water passes by means of fissures.

Finally, assuming that the conditions are such as to occasion further depression, if the same be prolonged the time must come when the water supply, even from the wells in the London Basin, will fail.