other cases, the two under-mentioned eminent chemists agree in their conclusions on this point, as will be seen by the following table, the quantities having reference in the first case to 100,000 parts, and in the second to a gallon of water:—

| | Dr. Frankland. | | | Prof. Wanklyn. |
|---|---|---|---|---|
| | Organic Carbon. | Organic Nitrogen. | Nitrogen as Nitrates and Nitrites. | Albuminoid Ammonia (representing the Organic Matter containing Nitrogen). |
| Caterham well (chalk) | ·020 | ·006 | ·027 | 0·000 |
| Spring near Moor Park (lower greensand) | ·030 | ·010 | ·045 | — |
| Cold Harbour (lower greensand) | — | — | — | 0·000 |
| Otter Spring (chalk) | ·026 | ·012 | ·422 | — |
| Loch Katrine | ·256 | ·008 | ·031 | 0·130 |
| Welsh waters | ·289 | ·004 | ·022 | — |
| Cumberland Lakes | ·211 | ·006 | ·009 | — |
| Thames water at Hampton | ·260 | ·024 | ·192 | 0·134 |

At the same time the water is kept at a uniform low temperature and protected from light and air, conditions unfavorable to the existence of living organisms. Springs from such sources probably represent potable waters in their best state; and amongst the favourable specimens of such waters may be instanced many chalk springs, the water from the lower chalk at Caterham, and some of the springs of the Lower Greensands of Surrey.

It is satisfactory to know that there exists within easy reach of London a supply of the best and purest spring water which, in case of need, could readily be rendered available as an auxiliary source of water supply for the metropolis, in quantity sufficient at all events for drinking, if not for other purposes.



## PART III.

# ON THE PRESENT WATER SUPPLY OF THE METROPOLIS.

95. We now proceed to consider "the present water supply to the metropolis."*

We have accounts of the existence, at a very early date, of artificial works for the water supply of London, in the form of certain conduits, some of whose names still survive in *Conduit Street*, *Lambs Conduit*, and *White Conduit*, and the object of which was to bring for the use of the inhabitants the waters of local springs; but about the middle of the sixteenth century the metropolis had so increased in extent that these were no longer sufficient, and attention became directed to procuring supplies, by mechanical means, from the fine river running close to the city walls.

96. The first systematic attempt to supply London from the Thames was made by Peter Morrys, an ingenious Dutchman, who in 1581 obtained the consent of the corporation to erect a water-wheel under one of the arches of London Bridge; this, being turned by the tidal stream, worked forcing pumps, which impelled the water through the leaden or wooden pipes in the streets, and thence by branches into the houses. The *London Bridge Waterworks*, thus established, subsequently increased in magnitude, and kept up a considerable supply for two hundred years.

97. But as London extended, Morrys's mains and pumping power were, in that infant state of hydraulic science, insufficient to supply the higher and more remote parts of the town, and attention became redirected to sources inland. In 1606 an Act of Parliament was obtained to enable the corporation to bring a stream of clear pure water to the metropolis, from certain copious springs in the chalk at Chadwell and Amwell, near Ware; but the corporation, alarmed probably at the magnitude of the plan, hesitated to commence the works, and nothing was done until, in 1609, an enterprising citizen, Mr. Hugh Myddelton (afterwards Sir Hugh Myddelton, baronet) offered to execute them single-handed, on condition that the authority obtained from Parliament should be transferred to him. This offer was accepted, and he at once commenced the work; but through a complication of difficulties, and the refusal of the corporation to aid him (although he had brought his canal to within a few miles of London), he was compelled to appeal to King James I. for the means of completing his work. The King furnished the necessary grant of money on condition that half the property in the undertaking should be ceded to him, and in September 1613, the canal, then dignified with the name of the *New River*, was completed, conveying the pure Hertfordshire spring water into the reservoirs at Clerkenwell. Thus was introduced into the metropolis a true systematic "water supply by gravitation," after the manner of the ancients.

98. The New River and the London Bridge works, aided by the local springs, with many public pumps and shallow wells, kept the greater part of the metropolis well supplied with water for the whole of the seventeenth century; but as buildings began to extend westward new demands arose. Soon after the opening of the New River, the chalk springs had been supplemented by tapping the River Lee, near to them, but parts of London required water where the London Bridge and New River mains did not reach, and again the Thames was resorted to for an increased supply. In 1691 a company was formed, called the *York Buildings Waterworks Company*, for supplying a part of Westminster with water pumped from a point in the river near Charing Cross. These works flourished for some time, but were in 1818 leased to the New River Company, and in 1829 were abolished altogether.

In 1723 a more successful attempt was made in the establishment of the *Chelsea Waterworks* for supplying Westminster and the parts adjacent with water from the Thames at Chelsea Reach. The company first purchased some small works at Millbank, but afterwards removed to a site near the foot of the present Victoria railway bridge, where they erected a pumping establishment.

* The information in this part, where not obtainable from official documents, has been taken from Mathews's "Hydraulia" and Weale's "London in 1851," or gained by communication with the officers of the companies.

99. The portion of the metropolis south of the river was supplied at a very early date by two wheels erected under London Bridge near the Surrey shore, and by separate works not far distant.

In 1785 the *Lambeth Waterworks Company* was established for supplying the parish of Lambeth and parts adjacent with water pumped from the Thames at a site opposite Charing Cross.

100. During the eighteenth century the existing waterworks were gradually enlarged and improved, and iron street pipes were introduced in lieu of wooden ones, a change which not only enabled the old works materially to extend their supplies, but gave a great advantage to new companies entering the field in competition with them.

101. In 1806 the *West Middlesex Water Company* was established for supplying the western suburbs from the Thames at Hammersmith; and in 1811 another company was formed who availed themselves of power granted by a clause in the Grand Junction Canal Company's Act for supplying, to the north-west of London, water brought by the canal from the rivers Colne and Brent, and from a large reservoir supplied by land drainage in the same neighbourhood. These waters were represented to be much superior to that of the Thames; but experience disappointed the hopes of the projectors; the water was found not only bad in quality, but deficient in quantity; and after vain expedients to remedy the evils, the company, which had taken the name of the *Grand Junction Waterworks Company*, resorted in 1820 to the Thames, taking their entire supply from a point near Chelsea Hospital.

102. While these works were going on in the west, the inhabitants of the other part of the metropolis had not been idle. The districts eastward, beyond the reach of the mains of the New River or London Bridge works, had hitherto been dependent on two small establishments at Shadwell and West Ham; but as the population increased, and further supplies became necessary, a company was established under the name of the *East London Waterworks Company*, for supplying water from the River Lee. Their Act was obtained in 1806; they immediately erected works at Old Ford, near Bow, and soon spread their mains over an extensive district.

In the south districts a new company was established in 1805 called the *Vauxhall Waterworks Company;* they took water from the River Effra, and afterwards from the Thames near Vauxhall Bridge. In 1822 the two ancient establishments at and near London Bridge, supplying Southwark, were combined under the name of the *Southwark Waterworks.*

103. By about the year 1820 the various water companies whose rise we have chronicled above had established a firm footing, and rendered themselves necessary to the inhabitants of London, in respect of the supply of this vital element of health. But the records show that no sooner did they become aware of this fact than they began to take advantage of it for their own interest, by combining together to raise their rates. The public complained loudly of this, and in 1821 a Committee of the House of Commons was appointed to inquire into the whole subject. They made a comprehensive report, in which, while they admitted that "a material improvement had taken place in the supply, both in "respect of abundance and certainty," they recommended that the maximum rates to be charged should be settled by Act of Parliament, and other salutary regulations enforced. No legislation followed this, but it seems to have had its effect in inducing the companies to remove the chief causes of complaint.

104. In a few years, however, discontent arose on another ground, namely, as to the *quality* of the water. The companies had hitherto pumped it into the districts just as it came to hand, without being over particular as to the state it was in. But it was seen that the water of the river was dirty and turbid, and an alarm arose that it must be unwholesome. Accordingly, in 1828, a Royal Commission consisting of three eminent scientific men—Mr. Telford, civil engineer, Professor Brande, chemist, and Dr. Roget, secretary of the Royal Society—was appointed to inquire into "the description, the quality, "and the salubrity of the water" supplied to the metropolis. They had careful examinations and analyses made, from which it appeared that the Thames water when free from extraneous substances was in a state of considerable purity, containing only a moderate degree of saline contents, and those of a kind which could not be supposed to render it unfit for domestic purposes, or injurious to health; but as it



approached the metropolis it became loaded with a quantity of filth which rendered it disgusting to the senses and improper to be employed in the preparation of food.

It appeared, however, that a very considerable part, if not the whole, of this extraneous matter might be removed by filtration through sand, and the Commission took into consideration various plans for effecting this object, which led them to the opinion that it was perfectly possible to filter the whole supply with the requisite rapidity and within reasonable limits of expense.

The general conclusion of the Commission is expressed in the following paragraph:—

"Taking into consideration the various circumstances to which we have now adverted, together with the details of evidence by which they are proved and illustrated, and also the facts derived from our own observation and experience, we are of opinion that the present state of the supply of water to the metropolis is susceptible of, and requires, improvement; that many of the complaints respecting the quality of the water are well founded, and that it ought to be derived from other sources than those now resorted to, and guarded by such restrictions as shall at all times ensure its cleanliness and purity."

From other passages in the report it is clear that the Commission attributed the pollution of the Thames water to its reception of the sewage and refuse from manufactories in the neighbourhood of London, operating within the tideway; it does not appear that they contemplated the possibility of any such large measure as the removal of the companies' points of intake above the range of the tidal flow.

105. Stimulated by this report, and alarmed probably at the prospect of a sweeping change of the sources of supply, the companies directed their attention to the purification of the water by filtration. This process had been well known on a small scale as a means of separating from water any impurities held in suspension, but its application to large public works was a novelty. It was soon found that the only appropriate material for mechanical filtration on a large scale was fine sand; but the great practical difficulty was to prevent the sand from becoming clogged, and to find an easy, practical, and cheap method for its renewal. After much consideration and long-continued experiments a means was discovered of getting over these difficulties. It was found that by far the greater quantity of the impurities were held in suspension by the agitation and motion of the water, and that if it was allowed to stand for some time at perfect rest, in a reservoir, the heavier and grosser particles were deposited by simple subsidence, leaving only a small proportion of lighter and finer matters to be dealt with by filtration. It was also found that when the water was allowed to filter downwards through a porous bed of sand, held up in its place by underlying layers of coarse gravel, the dirt did not penetrate into its mass, but was stopped at the upper surface, so that the whole cleaning operation necessary was to scrape this surface off to a slight thickness, and when it had become too much diminished to put fresh sand on.

The plan of filtration thus matured was at once carried into practice. The first large filter, of one acre area, was set to work by the Chelsea Company in 1829. It was found to work well, and the principle has since been universally adopted.

The other companies, though they did not all adopt the new principle of filtration, made improvements in some way or other. The New River Company constructed extensive settling reservoirs, as did also the West Middlesex Company; the Grand Junction Company removed their source of supply from Chelsea to Brentford, and formed filters there; the East London went higher up the Lee; and the Southwark and the Vauxhall Companies amalgamated, abolished their old sites, and established new joint works at Battersea. The Lambeth Company also formed elevated reservoirs at Brixton Hill and Streatham, to improve the service generally, and to maintain a supply in cases of fire.

106. It would seem, however, that the public had not full confidence in the improvements thus made, for in consequence of the report of the Commission of 1828 the House of Commons recommended that Mr. Telford should look out for new sources of supply, and he was accordingly instructed by the Government to take steps for the purpose. In 1834 he made his report, advising that the northern part of the metropolis should be supplied from the River Verulam above Watford, and the southern part from the Wandle. This report occupied the attention of the House of Commons in 1834, and of the House of Lords in 1840, but nothing was done.

107. The system of filtration was found to work well, so long as the impurities it professed to remove were only mechanical, and were not too great in amount; but it was found that the state of the river was gradually deteriorating, and, what was more

important, that it was becoming fouled in a way that filtration was powerless to purify, namely, by contamination of a chemical nature.

Drainage and sewage works were beginning to be more developed; ideas of what is now called sanitary science were arising; cesspools were beginning to be abolished; and as a consequence much larger quantities of sewage matter began to be poured into the river on all parts of its passage through London. These impurities were carried backwards and forwards by the tide, and their evil effect on the state of the river was enhanced by another circumstance which took place about this time, namely, the introduction of the small local steam boats plying on the Thames above London Bridge, the agitation caused by which not only kept the infused matter in continual mixture with the water, but washed and stirred up the mud at the bottom, which had before lain undisturbed. It was seen that these evils would go on increasing, and would shortly render the water so contaminated as to be beyond the possibility of purification by ordinary means.

**108.** The first steps towards meeting this difficulty were taken by the Lambeth Company. They had hitherto drawn their water from a site where the bad state of the Thames made itself very obvious, and after well considering the matter, they came to the decision that no measure short of the removal of the source of supply to a point above the highest range of the tide (Teddington lock) would be of any permanent benefit to the quality of the water. They therefore selected a point of the Thames a little above Kingston as their new source, proposing to establish large pumping engines there, and to force the water along a large main of ten miles in length to their existing reservoirs on Brixton Hill. An Act authorizing the works was obtained in 1848, and in 1851 the supply from the new source was delivered to the consumers.

**109.** Meanwhile the subject of the metropolitan water supply had been taken up by a public body who at that time assumed authority on all matters of a sanitary nature—the General Board of Health. In May 1850 this board issued a long report on the subject, which was followed shortly afterwards by numerous appendices and documents in explanation and justification. They pointed out the evils of drawing water from the Thames within the tideway, where it was exposed to sewage contamination; but not content with this, they objected to the Thames altogether, on the ground of its hardness, as they had adopted the idea that only very soft water was fit for public consumption. They therefore made a recommendation in the following terms:—"Whilst we believe "that Thames water, taken up beyond the influence of the metropolitan drainage, and "filtered, may be used without injury to the public health, and may be employed "temporarily until other sources can be laid under contribution, we advise that Thames "water and other water of like quality as to hardness, be as early as practicable "abandoned." The Board further directed their attention to finding other sources in substitution for the Thames, and fixed upon a tract of ground, of 150 square miles area, formed by the Bagshot sands and the lower greensands in Surrey, from the drainage of which they recommended that the supply for the metropolis should in future be taken.

**110.** This report was considered by a Committee of the House of Commons in the same year, but they did not endorse the opinions it contained. It happened that about the same time a company was projected, called the London Spring Water Company, which, on the strength of a favourable report made about ten years before by Mr. Robert Stephenson, proposed to supply the metropolis with spring water from the chalk in the neighbourhood of Watford. The Government, distracted by conflicting opinions, and desiring better evidence than they were yet in possession of, at the beginning of 1851 appointed a commission of three eminent chemists, viz., Professor Graham (now Master of the Mint), Dr. Miller, and Dr. Hofmann, to investigate the quality of the water actually supplied, referring to them also the proposals of the Board of Health and of the Watford Company. The report of this Chemical Commission was given in June 1851. It is a most able document, and as it treats of various matters connected with the subject in a manner which, even at this distance of time, is very pertinent to our inquiry, we shall have occasion often to refer to it hereafter.

The Commission expressed their opinion that the Thames water was perfectly wholesome, palatable, and agreeable; uniform, plentiful, and safe in use; but they recommended that to avoid the liability to contamination by the London sewage, the supply should be drawn at a point above the tidal range. They reported unfavourably of the Board of Health scheme, but drew particular attention to the proposed supply from the chalk at



Watford, which, assuming that the hardness could be got rid of by a softening process suggested by Dr. Clark, they considered much preferable to any other from its greater purity.

**111.** The result of all these investigations was to lead the Government to the opinion that legislation on the subject was desirable, and in 1851 they introduced a Bill to amalgamate all the companies into one great whole, whereby improvements might be introduced more effectively and economically than by dealing with them singly. It was to be one condition that the new company should be compelled to obtain water from such sources as the Secretary of State might direct.

This proposition, which was long and ably fought between its supporters and the companies, also proved too sweeping for the acceptance of the Legislature, and it was modified, the following session, into an Act (15 & 16 Victoria, cap. 84), which, while it did not interfere with the property of the companies, imposed on them many new and important conditions.

**112.** It is this Act which now regulates the general water supply of the metropolis. It is entitled "An Act to make better provision respecting the Supply of Water to the "Metropolis," and it received the royal assent the 1st of July 1852. Its principal provisions are as follow:

Clause 1 provides that it shall not be lawful for any company supplying the metropolis to take water from any part of the Thames below Teddington lock, or from any part of any of the tributary streams within the range of the tide.

Clause 2 stipulates that every store reservoir within five miles of St. Paul's shall be covered; and Clause 3 makes the same provision for aqueducts, unless the water is subsequently filtered.

Clause 4 provides that all water supplied for domestic use shall be effectually filtered, unless it be pumped from wells direct into covered reservoirs.

Clauses 15 and 22 provide for a constant supply at high pressure being given where demanded by four fifths of the inhabitants of any district, on certain conditions being complied with by them.

Clause 16 makes any company liable to a penalty of 200*l.*, and 100*l.* per month in addition, for violation of the Act, or neglect to comply with its provisions.

The other clauses are of minor importance to our present inquiry.

**113.** After the passing of this Act the water companies proceeded to comply with its more important provisions, expending about 2,500,000*l.* in works for this purpose; and in 1856, the Government caused chemical and engineering examinations to be made, under the direction of the General Board of Health, to ascertain the results of the changes. The chemical report was made by Professor Hofmann, and Mr. Lindley Blyth, and it showed that while the hardness and solid contents of the water remained about the same, there was a very positive and considerable diminution in the amount of organic matter. This, though doubtless due chiefly to the removal of the intake above the tideway of the Thames, was also attributed in great degree to the considerable improvement which had taken place in the collection, filtration, and general management of the supply of water. The engineering report made by the inspectors of the Board of Health gave a satisfactory account of the new works of the various companies, and of the manner in which they had carried out the provisions of the Act of Parliament. It was suggested, however, that further inquiry should be made into the removable causes of contamination of the Thames above the new sources of supply, and the inspectors recommended the introduction of the constant service system.

**114.** London is now supplied with water by eight companies, five on the north side of the river, viz.,

The New River Company,
The East London Company,
The Chelsea Company,
The West Middlesex Company,
The Grand Junction Company;

and three on the south side, viz.,

The Lambeth Company,
The Southwark and Vauxhall Company,
The Kent Company.

Each of these companies supplies a certain district, marked by definite boundaries, the whole metropolis being mapped out between them. These districts, together with the sites of the principal pumping stations, filters, mains, and reservoirs, are shown in colours on the map attached to this Report, and marked Appendix AV.

Formerly different companies were often engaged in competition with each other over the same ground; but this course, while it produced no substantial good to the public, was so hurtful to the companies themselves, that it was put an end to by separate limits being assigned to the operations of each company.

115. The *New River Company* supply a very large district, comprehending the whole of central London. The western boundary is a line drawn from Charing Cross by the Haymarket, Tottenham Court Road, and Hampstead Road, northwards to Highgate; the eastern boundary is a line running directly north from the Tower to Stamford Hill.

This company derive the great bulk of their water from sources in the valley of the River Lee, near Hertford, namely,

1. From a copious spring called the Chadwell Spring, situated between Hertford and Ware.
2. From wells sunk into the chalk at Amwell, near Ware, and at Hoddesdon and Cheshunt, a little lower down the valley.
3. From the River Lee itself, in the same neighbourhood.

The waters from these sources are united and conveyed to London by an artificial channel, called the "New River." The distance of the sources from London in a direct line is about 20 miles, but as the New River winds considerably, in order to take advantage of suitable levels of the ground, its course is much longer. The original length was nearly 40 miles, but it has been lately shortened by extensive cuts, leaving its present length only about 28 miles. It is an open river, protected by fencing, for about 25½ miles of its course, the remainder being tunnel or pipe.

The average dimensions of the New River are about 18 feet wide and five feet deep; in its original course it had an average fall of about five inches in each mile of length; but the diminution of length has given a much greater proportionate fall, and has consequently much increased the quantity of water it is capable of conveying.

Leaving Ware, the New River turns southward, and passes through or near Broxbourne, Cheshunt, Enfield, Winchmore Hill, Hornsey, Stoke Newington, Ball's Pond, and Islington, to a site at Clerkenwell known by the name of the New River Head. The water is allowed to subside in reservoirs at Stoke Newington and Clerkenwell, having a joint area of 43½ acres. In addition to the supply brought by the New River, the drainage of a small district, of three or four square miles area, is collected by two reservoirs at Cheshunt of 18½ acres area; this water is admitted into the New River as required. The filtering reservoirs are at Stoke Newington, Hornsey, and Clerkenwell, and occupy 11¼ acres.

At Stoke Newington, Hornsey, and Clerkenwell, there are large pumping engines for forcing the filtered water into store reservoirs at a higher level, situated at Claremont Square and Maiden Lane; and near the Archway, Highgate, is another pumping station, which forces water into still higher reservoirs at Highgate and Hampstead. These reservoirs contain in the aggregate about 20 millions of gallons, and are covered in as required by the Act.

From these reservoirs the district is now supplied, and to meet the varieties of level in the several localities, the district has been divided into several distinct levels, each having its own reservoirs and separate systems of supply. The whole pumping power of the company amounts to nearly 1,700 horses. The length of their mains is about 620 miles.

The company have an engine at Tottenham, by which they can, when necessary, obtain water directly from the Lee, taken at the same point of the river as the water of the East London Company; but this is only intended to be used in case of emergency, such as accident, or stoppage by frost, &c. They have also power to draw water from the Thames below Blackfriars Bridge, to be distributed by separate mains for street watering and sewer flushing, the use of this for the general supply being forbidden by the Act of 1852. It is stated that neither of these supplementary supplies has been used for several years.

The company have further a deep chalk well in the Hampstead Road, and also one formerly belonging to the Hampstead Waterworks, taken by them a few years ago; both these wells, though not at present used, are available to increase the general



supply. They also took to the Hampstead Company's springs and ponds at Hampstead and Highgate, the water of which is used only for street watering.

116. *The East London Waterworks Company* supply also a very large area, comprising the whole of London eastward from the boundary of the New River district, and extending from the St. Katherine's docks to North Woolwich, and from the line of the Shoreditch and Kingsland roads to Woodford.

The supply is derived from the River Lee at Higham Hill, in the parish of Walthamstow, about nine miles above the junction of the Lee and the Thames.

The company have reservoirs at Walthamstow containing about 110 acres of water area, and capable of holding 220 millions of gallons, 170 millions of which can be withdrawn by simple sluices, and the remainder by pumping.

From these reservoirs the water passes by a special private canal about 1¼ mile in length to the filtering beds at Lee Bridge, which are 13 in number, divided into two series, and having a united area of 12 acres on the surface of the sand; and after filtration it passes to large pumping engines established at two stations, Lee Bridge and Old Ford.

From the universal flatness of the district this company have no elevated reservoir, but the supply is afforded by the continuous working of one or more engines, and the pressure is kept up by high stand pipes attached to the pumping mains.

They are now executing works for bringing an additional supply from the Thames, under powers to which we shall allude more particularly hereafter.

117. *The Chelsea Waterworks Company* supply a district extending from Charing Cross westward to Fulham, and from the Thames northwards to the Uxbridge Road, and comprehending Chelsea, Knightsbridge, the whole of Belgravia and Pimlico, and a large portion of Westminster.

The water is taken from the Thames at a point on the right or south bank, at Long Ditton, nearly opposite Hampton Court Palace, three miles above the highest range of the tide. It is first allowed to subside in reservoirs constructed for the purpose, and then filtered through sand and gravel, after which it is pumped by steam engines through two large cast-iron main pipes, six miles long, to elevated covered reservoirs, containing 20 millions of gallons, on Putney Heath. From this the water flows, by its own gravity, through mains passing over the Thames at Putney into the company's district.

118. *The West Middlesex Waterworks Company* supply a district extending west of Tottenham Court Road and north of Oxford Street, as far as the Edgware Road, and in addition a large western suburban area, including Kensington, parts of Fulham and Brompton, Hammersmith, Chiswick, &c., and as far north-west as Hendon.

The water is taken from the Thames on the north bank, at a point a little above the town of Hampton, and 5½ miles above the termination of the tidal range at Teddington lock. From this point it is passed by pumping power, through a cast-iron main 36 inches diameter, and 8¾ miles long, crossing the river to a site at Barnes, from which the company formerly took their supply. Here the water is first allowed to subside in reservoirs of 20½ acres area, and then filtered in five filter beds of about eight acres. It then crosses again under the bed of the river to the north bank at Hammersmith, where the pumping station is situated for supplying the district. There are two elevated covered reservoirs, one at Kensington, containing about 3½ millions of gallons; the other on Primrose Hill, at a high level, containing 4¾ millions of gallons. For some parts which lie higher it is necessary again to pump, from Primrose Hill, into another more elevated covered reservoir, containing 2½ millions of gallons, at Hampstead.

119. *The Grand Junction Waterworks Company's* district comprehends that part of the parish of St. George, Hanover Square, which lies north of Piccadilly, a small portion of Marylebone, the larger part of Paddington, and St. James's to Pall Mall.

They take water from the Thames, close to the point of the West Middlesex supply, and force it along a 33-inch main to Brentford, 7¼ miles distant. It is allowed to subside in reservoirs partly at Hampton and partly at Brentford, covering 8¼ acres, then filtered in beds occupying 5⅙ acres, and then is pumped into the district, there being an elevated covered reservoir on Camden Hill, Bayswater, containing 6,000,000 gallons, with additional engine power for still higher levels.

120. *The Lambeth Waterworks Company* supply a large district on the Surrey side,

extending from the Thames on the north to Croydon on the south, and from Lewisham and Beckenham on the east to Thames Ditton and Esher on the west.

They take their water from the Thames near Long Ditton at the place adopted by the Chelsea Company. Here filter beds and pumping engines are established, forcing the water along a cast-iron main, 10¼ miles long and 30 inches diameter, to elevated covered reservoirs at Brixton, containing 12,000,000 gallons; from these it flows by gravity into the whole of the low-lying district, and is again pumped to supply higher covered reservoirs at Streatham, Selhurst, and Rock Hill, the highest service given being at Norwood, about 350 feet above the Thames.

121. *The Southwark and Vauxhall Water Company* supply a still larger district, comprising the borough of Southwark, portions of Lambeth and Clapham, and the whole of Battersea, and extending east to Rotherhithe, west to Richmond, and south to Camberwell. In some parts supplies are given both by this and the Lambeth Company.

They obtain water from the Thames above Hampton, at the same site as the West Middlesex and Grand Junction, and it is forced along a 36-inch main 13 miles long to their old establishment at Battersea, where it is pumped by large engines directly into the district mains; like the East London they have no elevated store reservoirs. There are large subsiding reservoirs and filters, both at Hampton and at Battersea.

122. *The Kent Waterworks Company* supply the whole of the south-eastern suburbs, their district comprising Deptford, Greenwich, and Woolwich, and extending from Camberwell to Dartford, and from the Thames southward to Bromley, Chiselhurst, and Bexley.

This company was incorporated in 1810, when they took possession of some ancient works on the river Ravensbourne at Deptford, established as early as 1699. Down to 1857 they continued to take water only from this source, but the river proving insufficient, the supply was then supplemented by wells sunk into the chalk, and, this source proving so much more plentiful and so much better in quality, in 1862 the Ravensbourne was entirely abandoned.

The principal station is at Deptford, where there are three wells on the site of the old works, each with a pumping engine, the water being conveyed for distribution to other engines, which pump directly into the district mains. There are also two wells at Charlton, one at Plumstead, one at Crayford, and one at Bromley; at each of these wells an engine is placed which serves both for pumping and for distribution.

In addition to the pumping power at the different wells, there are other engines near Shooters Hill for supplying the more elevated districts, and there are elevated reservoirs in Greenwich Park, on Woolwich Common, and at Plumstead and Chiselhurst, to regulate the pressure, and keep up a supply in case of fire. The water does not require filtration.

The following data refer to the wells furnishing this company's supply:—

| — | Maximum Quantity pumped (Gallons per hour). | Levels with reference to Ordnance Datum, in feet. | | | |
|---|---|---|---|---|---|
| | | Of Surface of Ground. | Of Bottom of Well or Bore-hole. | Of Surface of Water when not pumping. | Of Surface of Water when pumping Maximum Quantity. |
| 3 Deptford wells - | 287,000 | +20 | −230 | +12 | − 44 |
| 2 Charlton wells - | 70,000 | +25 | −225 | +10 | − 45 |
| Plumstead well - | 57,000 | +80 | −420 | +10 | − 20 |
| Bromley well - - | 25,000 | +120 | −130 | +115 | +103 |
| Crayford well - | 38,000 | +30 | −120 | +20 | + 14 |

123. In addition to the supplies of the water companies, there is a considerable quantity of water furnished from wells sunk, in 1844, by Messrs. Easton and Amos, on behalf of the Government, near Charing Cross. They are nearly 400 feet deep, penetrating into the chalk, and they furnish a quantity of about 430,000 gallons per day, which is used to supply the Government offices and several public establishments in Westminster and the neighbourhood, and the fountains in Trafalgar Square.



A small further addition to the supply of the suburbs of the metropolis is obtained from the chalk springs at Grays, in Essex, described in Mr. Meesom's evidence, and alluded to in Part II. of our Report. A company was incorporated in July 1861 for this purpose, under the name of the South Essex Water Company, and a pumping establishment was formed at Grays, with a store reservoir at Brentwood, and distributing mains ramifying in various directions. The water is now delivered at Brentwood, Shenfield, Warley (including the great barracks there), Grays, and several neighbouring villages. The quantity pumped is about 450,000 gallons per day, and the number of inhabitants supplied between 15,000 and 16,000.

124. The following table gives the statistics of the principal water companies in a combined form:—

Statistics of present London Water Supply.

| —— | Capital. | Approximate Area of District supplied. | Number of Houses supplied, 1867. | Estimated Number of Inhabitants supplied, 1867. | Average daily Supply, 1867. |
|---|---|---|---|---|---|
| *From the Thames.* | £ | Square miles. | | | Gallons. |
| Chelsea Company - - | 785,600 | 6½ | 26,875 | 170,000 | 8,087,258 |
| West Middlesex - - | 798,571 | 10 | 36,881 | 275,000 | 8,816,486 |
| Grand Junction - - | 850,000 | 24 | 27,190 | 245,000 | 9,533,432 |
| Southwark and Vauxhall - | 1,100,440 | 30 | 71,558 | 465,000 | 13,629,758 |
| Lambeth - - - | 736,245 | 25 | 38,320 | 230,000 | 8,975,530 |
| | | | | | 49,042,467 |
| *From the Basin of the Lee.* | | | | | |
| New River Company - | 2,609,418 | 19 | 113,462 | 800,000 | 23,790,667 |
| East London Company - | 1,400,000 | 50 | 92,652 | 675,000 | 19,298,241 |
| | | | | | 43,088,908 |
| *From Chalk wells in Kent.* | | | | | |
| Kent Company - - | 489,240 | 60 | 34,504 | 240,000 | 6,468,873 |
| Total - | 8,769,514 | 224½ | 441,442 | 3,100,000 | 98,600,248 |

In reference to the quantity supplied, it must be observed that the amount in the last column expresses only the average daily supply for the whole year; but a reference to the table in Appendix N will show that, as might be expected, the supply is much greater in summer than in winter. The *maximum* daily supplies in June or July were as follows:—

| | Gallons. |
|---|---|
| Chelsea - - - - - | 9,042,800 |
| West Middlesex - - - - | 9,776,707 |
| Grand Junction - - - - | 11,032,742 |
| Southwark and Vauxhall - - - | 13,975,000 |
| Lambeth - - - - - | 10,257,800 |
| New River - - - - - | 26,710,000 |
| East London - - - - - | 20,321,152 |
| Kent - - - - - | 7,196,708 |
| Total - | 108,312,909 |

This shows that the maximum daily quantity supplied in the summer months is about 10 per cent. in excess of the average of the whole year, and this is an important fact in considerations affecting the quantity of water required.

The following table gives particulars of the reservoirs, filter beds, and pumping engines of the various companies:—

WORKS OF THE COMPANIES.

| Subsiding Reservoirs. | | Filter Beds. | | Store Reservoirs. | | | Pumping Engines. | |
|---|---|---|---|---|---|---|---|---|
| Number and Situation. | Area in Acres. | Number and Situation. | Area of Sand Surface in Acres. | Number and Situation. | Available Contents in Gallons. | Height of High-water Line above Ordnance Datum. | Number and Situation. | Horse Power. |
| | | | | CHELSEA COMPANY. | | Feet. | | |
| 3 at Seething Wells, near Kingston, with vertical rough filters attached. | 4½ | 2 at Seething Wells, near Kingston. | 2 | 2 for filtered water, situate on Putney Heath. | 10,000,000 | 132½ | 8 at Seething Wells, near Kingston. | 1,025 |
| | | NOTE.—Two additional filter beds similar to the above are in course of construction at Seething Wells. | | 1 for unfiltered water, situate on Putney Heath. | 1,000,000 | 132½ | | |
| | | | | WEST MIDDLESEX COMPANY. | | | | |
| 3 at Barnes, Surrey - | 20½ | 5 at Barnes, Surrey - | 8 | 1 at Kensington - | 3,672,000 | 124½ | 2 at Hampton - | 210 |
| | | | | 1 at Barrow Hill - | 4,750,000 | 190 | 5 at Hammersmith - | 900 |
| | | | | 1 at Kidderpore - | 2,500,000 | 323 | 2 at Barrow Hill - | 85 |
| | | | | | | | 1 at Barnes (for sand washing machines). | 6 |
| | | | | GRAND JUNCTION COMPANY. | | | | |
| above Hampton - | 2 | 3 at Kew Bridge - | 5¼ | 1 at Campden Hill - | 6,000,000 | 132½ | 2 at Hampton - - | 220 |
| at Kew Bridge - | 5½ | | | 2 „ „ - | 12,000,000 | | 4 at Kew Bridge - | 660 |
| „ - | 3½ | | | | | | 2 at Campden Hill - | 300 |
| | | | | SOUTHWARK AND VAUXHALL COMPANY. | | | | |
| 2 above Hampton - | 2 | 5 at Battersea - - | 8 | None - - - | None - | None. | 3 at Hampton - - | 400 |
| 2 at Battersea - - | 6½ | 3 at Hampton - - | 3 | | | | 6 at Battersea - - | 915 |
| 1 at Hampton - - | 3½ | | | | | | 2 at Hampton - - | 450 |
| | | | | LAMBETH COMPANY. | | | | |
| at Long Ditton, near Kingston, with vertical rough filters attached. | 3 | 4 at Long Ditton, near Kingston. | 1½ | 2 at Brixton - - | 12,000,000 | 115½ | 7 at Long Ditton, near Kingston. | 970 |
| | | | | 1 at Streatham - | 3,750,000 | 197½ | 5 at Brixton - - | 210 |
| | | | | 1 at Rock Hill (Sydenham). | 500,000 | 362½ | | |
| | | | | 1 Ditto ditto | 115,000 | 385½ | | |
| | | | | 1 at Selhurst (near Croydon). | 2,500,000 | 218½ | | |
| | | | | 1 at Coombe (near Kingston). | 1,150,000 | 192½ | | |
| | | | | NEW RIVER COMPANY. | | | | |
| 2 at Stoke Newington | 42½ | 7 at Stoke Newington | 7 | 1 at Claremont Square | 3,500,000 | 139 | 8 at Stoke Newington | 1,080 |
| 1 at New River Head | ¾ | 3 at New River Head | 2½ | 2 at Maiden Lane - | 15,000,000 | 233 | 2 at New River Head | 200 |
| 2 at Hornsey - - | 8 | 3 at Hornsey - - | 2 | 1 at Highgate - - | 1,000,000 | 432½ | 1 at Hornsey - - | 75 |
| 2 at Cheshunt - - | 18½ | | | 1 at Hampstead - | 500,000 | 447½ | 2 at Highgate - - | 75 |
| 13 at Highgate and Hampstead (for street watering only). | 30 | | | 1 at Camden Park Road (uncovered, for unfiltered water). | 900,000 | 171½ | 1 at Amwell End - - | 50 |
| | | | | | | | 1 at Amwell Hill - | 25 |
| | | | | | | | 1 at Hoddesdon - | 50 |
| | | | | | | | 1 at Cheshunt - | 20 |
| | | | | | | | 2 at Tottenham - | 125 |
| | | | | EAST LONDON COMPANY. | | | | |
| 5 at Walthamstow, Essex. | 110 | 13 at Lea Bridge - | 12 | 1 at Old Ford - - | 7,000,000 | 12½ | 6 at Old Ford (steam) | 640 |
| | | | | | | | 4 at Lea Bridge (ditto) | 600 |
| | | | | | | | 2 Ditto (water) | 65 |
| | | | | | | | 1 at Walthamstow (steam). | 100 |
| | | | | | | | 1 at Walthamstow (water). | 30 |
| | | | | KENT COMPANY. | | | | |
| None. | | None. | | 1 on Woolwich Common. | 325,000 | 314 | 7 at Deptford. | 740 |
| | | | | | | | 2 at Charlton. | 238 |
| | | | | 1 on Plumstead Common. | 750,000 | 170 | 1 at Plumstead. | 63 |
| | | | | | | | 1 at Bromley. | 33 |
| | | | | 1 on Chiselhurst Common. | 450,000 | 306 | 1 at Crayford. | 54 |
| | | | | | | | 2 at Dover Road. | 47 |
| | | | | 1 in Greenwich Park (uncovered). | 1,125,000 | 163 | | |
| | | | | 1 on Woolwich Common (uncovered). | 1,600,000 | 240 | | |



125. The distribution of the water is on what is called the *intermittent* system. The supply pipes to the houses are not attached to mains in which the water is always under pressure, but to smaller service pipes, into which the water is "turned on," as it is called, during only one or two hours each day, the consumers receiving during this short time the whole quantity required for the day's consumption, and storing it for use in cisterns provided by themselves. On Sundays, as a general rule, no supply is given, but exceptions are made by many of the companies in poor neighbourhoods where the receptacles are insufficient.

126. We may now allude to the more recent public proceedings affecting the water supply of the metropolis.

In 1865 a Royal Commission was appointed to inquire into the best means of preventing the pollution of rivers, embracing also the question of water supply. In March 1866 they reported on the River Thames; and their report, so far as bears on our present inquiry, was to the effect that the river was at present fouled by various causes, but principally by the sewage of towns, villages, and houses on its banks, but that this sewage might be so utilized on land as to be rendered innocuous. They recommended that the whole river should be placed under the superintendence of one governing body, who should amongst other duties take steps to ensure its freedom from pollution.

This recommendation bore immediate fruit, for on the 6th of August in the same year an Act (29 & 30 Vict. cap. 89) was passed, altering the constitution of the existing Conservancy Board of the Thames, and considerably enlarging their powers. It extended their jurisdiction up to Cricklade in Wilts, and made two important provisions for ensuring the purity of the water:—

1. The surface of the river was to be effectually scavenged, in order to the removal therefrom of substances liable to putrefaction.
2. The admission of sewage or any other offensive or injurious matter into the Thames, or into any tributary stream or watercourse within three miles of its junction with the Thames, was declared illegal, the Conservators giving due notice to all offending parties to discontinue the practice under heavy penalties.

To enable towns and villages more easily to comply with the requirements of this law, there was passed in August of the next year an Act (30 & 31 Vict. cap. 113) for facilitating the distribution of sewage matter over land, and otherwise amending a law previously passed with the same view.

127. In May 1867 the Rivers Pollution Commission made a report on the River Lee, which they found liable to pollution from sewage and refuse from manufactories, and beset with peculiar difficulties as to its purification and general management; they recommended certain measures with a view to improvement.

During the same session, the East London Waterworks Company, who were requiring to increase their supply, applied to Parliament for powers to enlarge their works; and having been led by the experience of the extreme dry season of 1864 to distrust the capability of the River Lee to afford all they wanted, they promoted a bill for enabling them to draw 10,000,000 gallons per day from the Thames at Sunbury. Both these bills were passed, with certain controlling provisions.

It had happened, however, that in the previous year there was a severe outbreak of cholera in the east of London, and, from certain peculiarities in the phenomena exhibited, suspicion was entertained that it might be connected with the water supply. The suspicion was strengthened by the circumstance that the Registrar General for the metropolitan districts had established a monthly analysis of the water supplied, and that his reports had produced an impression unfavourable to the quality. When therefore the East London bill was referred to a Committee of the Commons, the House took the opportunity of instructing them to inquire generally into the operation and results of the Metropolis Water Act, 1852, of which, as it came into full operation in 1856, ten years' experience had been gained.

128. This committee, of which Mr. Ayrton was chairman, inquired fully into the whole subject, and reported at the end of June 1867.

As to the main question, they declared they were satisfied that both the quantity and quality of the water supplied from the Thames were so far satisfactory that there was no ground for disturbing the arrangements made under the Act of 1852, and that any attempt to do so would only end in entailing a waste of capital and an unnecessary charge upon the owners and occupiers of property in the metropolis.

The water of the Lee they found naturally not only wholesome, but comparing favourably with that supplied to other places. They agreed with the Rivers Commission that it was liable to serious contamination, but they suggested certain alterations in the remedial measures proposed, and expressed their opinion that when these were carried out the water supplied by the companies would be of unquestionable character.

They also approved the North Kent water, and considered this company had an adequate command of quantity for many years to come.

They went elaborately into the question of constant supply, and recommended that it should be enforced, under strict provisions to prevent waste, and to ensure the suitable condition of all the house fittings.

They finally recommended that the duty of seeing that the water companies properly fulfilled their obligations should be imposed on the Metropolitan Board of Works; and that a new Act should be passed consolidating all the laws at present in force as to the metropolitan supply, and introducing the new measures they had proposed.

**129.** In 1868 an Act (31 & 32 Vict. cap. 154) was passed to make better provision for the preservation and improvement of the River Lee and its tributaries. It was analogous to the Thames Conservancy Act of 1866, altering the constitution of the managing body, and rendering illegal the admission of sewage or offensive matter into the river, except in the case of certain towns where measures had been adopted for its purification.



# PART IV.

## ON THE SUPPLY OF WATER AVAILABLE FROM THE BASIN OF THE THAMES.

**130.** We have now to consider the eligibility, for the future service of the metropolis, of the great source from whence its supplies have hitherto been drawn, namely, the basin of the River Thames.

The gigantic schemes proposed for supplying London with water gathered in the distant mountain ranges of the country have been projected on the assumption that the nearer and more natural supply derived from the Thames valley was either deficient in quantity or unsuitable in quality, or both. It becomes, therefore, our duty to inquire whether there is sufficient justification for either of these suppositions; and we will consider them each in turn.

### Section I.

### AS TO QUANTITY.

**131.** At the end of Part II. of this Report we have endeavoured to give a general view, scientifically considered, of the most important natural features of this great basin, having reference particularly to its underground storage, and the nature and distribution of its springs. It will be here our object more practically to consider the evidence as to the quantity of water actually obtainable from the rivers and wells in this district.

On this point we have received a large amount of information from a great number of witnesses, who, from their position, experience, and knowledge, are most competent to judge of the subject.

**132.** The portion of the basin first to be considered is that above Hampton and Ditton, where the water companies have their intake. This portion extends over a length and breadth of 80 or 90 miles, its superficial area being given as 3,676 square miles.

The Thames first assumes importance near the small town of Lechlade in Wilts, where a number of small streams, forming the head waters of the river, unite. From this point down to Ditton it follows a tortuous course of about 120 miles in length, and is joined on either bank by several important tributaries.

**133.** The rainfall in the Thames basin has been determined with considerable accuracy by many years' observations by numerous persons at various localities from London to Cirencester. It is found to vary, on an average, from about 25 inches at the former place to 30 inches at the latter. Taking the mean of the whole area, Mr. J. T. Harrison estimates the average rainfall to be 27¾ inches, and of this it is estimated that one-third flows down the Thames. 4671. 6838. 2966. 3036.

**134.** It is desirable, however, to investigate the volume of the stream more particularly; taking our data at the point most important for our purpose, namely, at the intake of the companies, a little above the highest point reached by the tide, and where the natural fresh water stream has its maximum volume.

It has been shown that the total discharge at Kingston for eleven years was 5,432,418 millions of gallons, which is equal to an average of about 1,350 millions of gallons per day, or equivalent to about nine inches of rainfall. If this were the constant flow, no question could arise as to its sufficiency; but we need hardly say that it varies very widely at different times. In floods the stream is so large as scarcely to admit of accurate measurement; but in dry seasons it is much reduced; and it is in reference to the volume in these seasons that the doubt has arisen. It is therefore to this that we must direct attention. 3904.