Sir Joseph Bazalgette and the Main Drainage of London

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Stephen Halliday, December 1997

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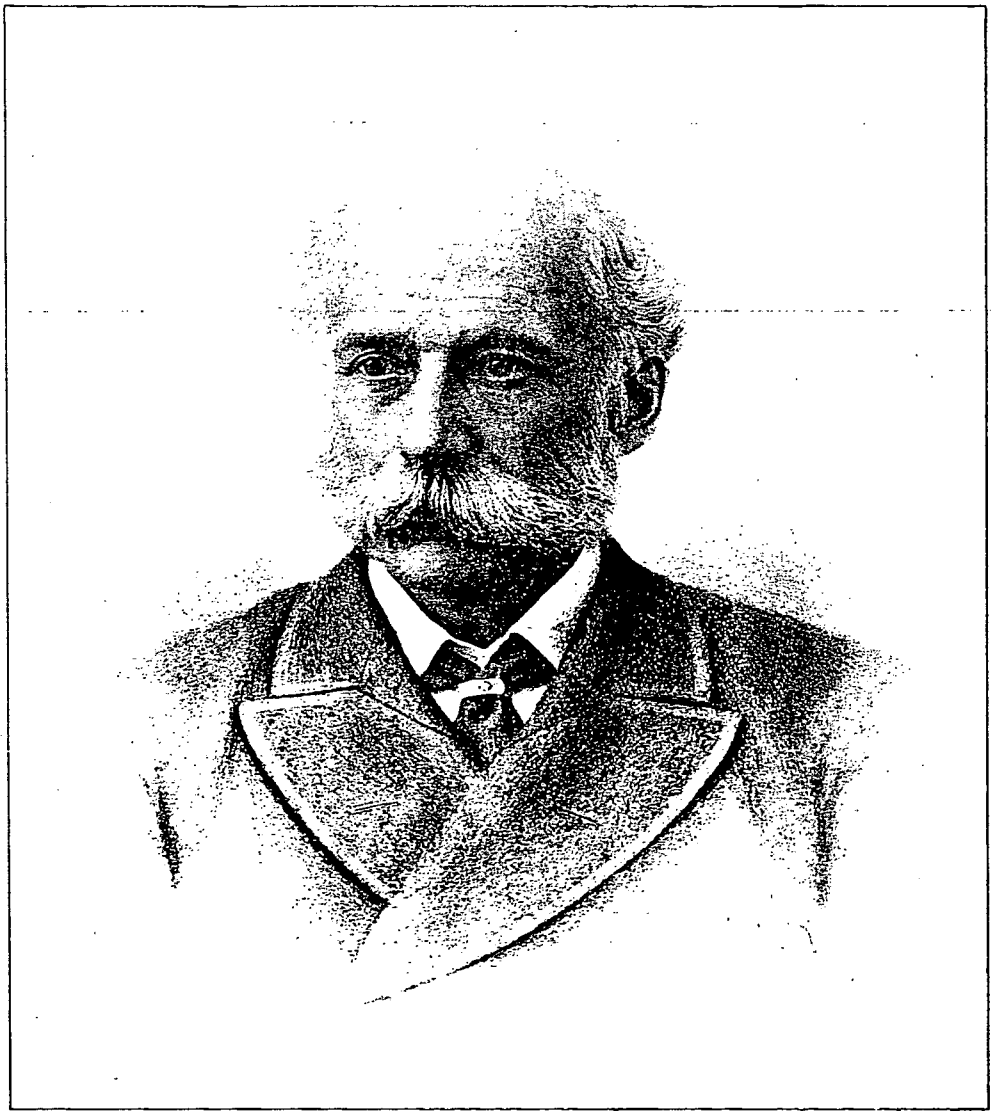
Engraving of Sir Joseph Bazalgette (courtesy of Rear Admiral Derek Bazalgette)



This work is dedicated to the memory of

Edmund Hambly, M.A., Ph. D., F.Eng.,

who encouraged me to undertake it and was

instrumental in helping me, in the early stages,

to find some invaluable contemporary sources

in the archives of the Institution of Civil Engineers

In November 1994 Dr Hambly was elected President

of the Institution of Civil Engineers, an office which

Joseph Bazalgette had himself held in 1883-4

Dr Hambly's unexpected and untimely death in March, 1995, only four months into his presidency, deprived the world of an individual whose distinction as an engineer was outweighed only by his qualities as a man who is greatly missed by his family and by his many friends

Stephen Halliday, November 1997

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Abstract

The thesis submitted examines the work of Sir Joseph Bazalgette (1819-1891), Chief Engineer to the Metropolitan Board of Works, in designing and constructing the system of intercepting sewers, pumping stations and sewage treatment works which was built between 1859 and 1874 and which is still in use, under the management of Thames Water PLC. It also considers those aspects of Bazalgette's work which were directly related to the intercepting sewers, namely the Victoria, Albert and Chelsea Embankments.

The work examines the history of London's systems for disposing of surface water and waste, from mediaeval times, and the reasons for the sudden deterioration in the condition of the Thames in the early nineteenth century. It considers the political and organisational problems which attended early reformers in their attempts to establish an effective regime for the management of London's sanitation and the effects of the consequent delays on the health of the inhabitants. Particular reference is made to the four cholera epidemics which, between 1832 and 1866, are recorded as having killed more than thirty-six thousand citizens.

It examines the engineering problems presented by the need to undertake major engineering work in the most densely populated parts of the world's largest city and the novel solutions that were sometimes adopted to overcome them. It also considers the controversies faced by Bazalgette and the Metropolitan Board of Works during the course of the work, with particular reference to the long and still unresolved debate of how finally to dispose of human waste to the benefit, or at least not to the detriment, of the environment. The thesis concludes by attempting to reach a judgement on Bazalgette's claim to a place in the Pantheon of Victorian Engineers.

The author wishes to record his debt to his supervisors, Professor Roderick Floud and Doctor John Sheldrake of London Guildhall University; to his employers, Buckinghamshire University College for allowing him time to undertake the work; and to the late Doctor Edmund Hambly who helped and encouraged the author in the early stages but who sadly did not live to see the work completed.

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Introduction

> "Though perhaps less remembered than his contemporary, Isambard Kingdom Brunel, this superb and far sighted engineer probably did more good, and saved more lives, than any single Victorian public official". (Taken from The Living Thames: the Restoration of a great Tidal River; John Doxat; Hutchinson Benham 1977).
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> "The engineers have always been the real sanitary reformers, as they are the originators of all onward movements; all their labours tend to the amelioration of their fellow-men". (William Cubitt, 1850, Presidential Address, Institution of Civil Engineers).

The first quotation refers to Joseph Bazalgette, knighted in 1874 for his work as Chief Engineer of the Metropolitan Board of Works throughout its existence (1856-1889). The first claim in the passage quoted, that Bazalgette is less well remembered than Brunel, is uncontroversial. Brunel is perhaps the most celebrated of all engineers, the subject of many biographies, his name associated with railways, bridges, tunnels, stations, steamships, a prefabricated hospital and numerous other achievements of the early Victorian period. His statue is a prominent feature of Paddington Station, the London Terminus of the Great Western Railway which he designed. Brunel even has a university named after him. Bazalgette's contribution to London's fabric is less conspicuously celebrated but has been noted by a more recent historian of London than Doxat in similarly appreciative terms. In writing of Wren's work in the re-construction of London after the fire of 1666 R. Porter writes that "thanks to Wren the reborn City was left more attractive. Alongside Nash and Bazalgette, he stands as one of London's noblest builders".[1]

Brunel and Wren are celebrated. By contrast, Bazalgette is almost forgotten. No biography of him has ever been written. His only public monument is on the Victoria Embankment at the foot of Northumberland Avenue. It takes the form of a bust unveiled in 1901 showing a bewhiskered figure, framed in a circle. Underneath is the Latin text:

Flumini Vincula Posuit

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[1]Porter, R.: *London, a Social History,* Hamish Hamilton, 1994, p.91

The inscription ("He placed chains to the river") and the circle in which the monument is framed modestly represent the achievement for which his fellow citizens were most grateful. The circle represents the sewers which he designed and built and which lie beneath the feet of the few who stop to look at the monument and wonder who he was. The Victoria, Albert and Chelsea Embankments, on each side of the river, were built by Bazalgette to house a small part of the system of intercepting sewers which he designed to prevent London's sewage from running into and polluting the Thames: hence the reference to "The chain on the river". His numerous other responsibilities included over seven million pounds worth of London street improvements, of which the best known are Garrick Street, Queen Victoria Street, Northumberland Avenue, Shaftesbury Avenue, Southwark Street and Charing Cross Road. Twelve bridges across the Thames were acquired and freed from tolls, all were strengthened under Bazalgette's supervision and three were completely re-built to his designs - Putney, Hammersmith and Battersea. He instituted the Woolwich Free Ferry and, in October 1878, he persuaded the Metropolitan Board to experiment with electric lighting on the Victoria Embankment. He even submitted a design for Tower Bridge, though not the one that was chosen.[2]

Although he is now largely forgotten, Bazalgette was celebrated in his lifetime. During the period that the system of intercepting sewers was being constructed he was a major public figure and there are numerous references to him and his work in *The Times, The Illustrated London News, The Builder,* and other contemporary publications. Another indication of his stature may be gained by examining biographical dictionaries of the period. From 1865 until his death in 1891 Bazalgette has a regular entry in George Routledge's *Men of the Time*. The entry ranges in length from about one to one and a half columns. This is comparable with the entries for Matthew Arnold and Cardinals Manning and Newman, rather longer than that of W.S. Gilbert and a little shorter than the entries for Florence Nightingale and Charles Babbage. The entry for Charles Dickens ran to three columns while Gladstone, at the height of his power, qualified for seven.

Bazalgette's contemporaries might well have agreed with Doxat's flattering assessment of him. In August 1890, less than a year before his death on 15th March 1891, Bazalgette was interviewed at his home in Wimbledon for *Cassell's Saturday*

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[2]See M.B.W. *Annual Report*, 1888, pp. 40-50 and p. 97, G.L.R.O., for an account of these works

Journal, one of a series of sketches of "Representative men at home". The writer of the profile began his article with the following paragraph:

> "If the malignant spirits whom we moderns call cholera, typhus and smallpox, were one day to set out in quest of the man who had been, within the past thirty or forty years their deadliest foe in all London, they would probably make their way to St. Mary's, Wimbledon". [3]

In the same interview, Bazalgette himself described the problem which his employers, the Metropolitan Board of Works had been called upon to solve 40 years earlier.

> "At that time, the river at Westminster was in such an abominable condition that they were obliged to close the windows of the Houses of Parliament and there was a talk of Parliament having to shift to other quarters altogether. What was the cause of it? The drains of London were pouring down their filth into the river at low water. There was no outflow from them at high water. The tide kept the sewage up the drains then; but when the tide had been running out for hours and the water in the river began to run low, then the drains began to pour out their sewage and of course when the tide came in again it was all swept up by the stream. When the tide ebbed it all came down and so it kept oscillating up and down the river, while more filth was continuously adding to it until the Thames became absolutely pestilential".[4]

Bazalgette's death was widely reported both in the national press and in engineering publications. The *Illustrated London News* in March 1891 began its Obituary Notice:

> "Londoners who can remember the state of London and of the Thames about thirty-five years ago, before those vast undertakings of the Metropolitan Board of Works, the system of main drainage and the magnificent Thames Embankment, which have contributed so much to sanitary improvement and to the convenience and stateliness of this immense city, will regret the death of the able official chief engineer, Sir Joseph Bazalgette".

The Institution of Civil Engineers, of which Bazalgette had been President, entered a resolution in the *Minutes of Proceedings*[5] which recorded that:

> "His life had been given, to considerations affecting public health and welfare in all the large cities of the world, and his works, as the engineer for many years of the Metropolitan Board of Works, will ever remain as monuments of his skill and professional ability".

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[3] *Cassell's Saturday Journal*, 30th August 1890 pp. 1160-1 "Representative Men at Home; Sir Joseph Bazalgette, C.B.,at Wimbledon"

[4] Ibid..

[5] M.P.I.C.E.: Vol. 105, 1890-1 Part III, pp. 106-7

Celebrated and honoured in his own lifetime, almost forgotten since: Doxat's claim that Bazalgette was "Perhaps less remembered" than Brunel is an understatement. The qualified claim that he "Probably did more good, and saved more lives, than any single Victorian public official" is more controversial. Indeed the claim is astounding when one reflects that the category of public official could be considered to include Edwin Chadwick, Florence Nightingale and John Simon. It may not be possible to quantify with any precision the right of these and others to qualify for such a title. Nevertheless the claim that Bazalgette's work was of this order of importance in improving the health and welfare of his fellow citizens is a useful starting point from which to begin an examination of the significance of the great projects he executed on behalf of the Metropolitan Board: a significance which is reflected in the second quotation, from William Cubitt's Presidential address to the Institution of Civil Engineers. Cubitt was one of the referees who supported Bazalgette's application for the post of Chief Engineer to the Board.

Methodology: identifying the themes

My interest in Bazalgette and his work arose by chance. In 1981 I watched a documentary programme about the River Thames which explained how its waters were freed of industrial pollution in the 1960s and restored to a condition in which salmon, a litmus test of water quality, returned to the river. The documentary briefly referred to the fact that, a century earlier, the Victorians had faced a much more threatening crisis when they were confronted by the problem of ridding the Thames of the sewage which flowed into it daily and which had reduced it to the condition described by Bazalgette in his interview with the *Saturday Review*. Joseph Bazalgette was referred to in the documentary as the engineer who had designed and supervised the construction of the system of intercepting sewers. My interest was immediately aroused. I had read History at Cambridge in the 1960s in a programme of study which had included British Economic History and the Industrial Revolution. I thought I knew of the great Victorian engineers but I had never heard of Joseph Bazalgette. I decided to learn more about him and his work. This proved to be difficult. No biography of him had been written and, with the limited time at my disposal, I was unable to find even an account of the construction of London's drainage works. The standard texts that I consulted on British Economic and Social History made few or no references to the subject. For example the current editions of the three-volume *Economic History of Britain since 1700* (ed. Floud, R. and McCloskey, D., C.U.P.,1994) and the *Cambridge Social History of Britain, 1750-1950* (ed. Thompson, F.M.L., C.U.P., 1990) make many references to the problems of urban

expansion and some references to the wholesome effects of piped water supply but none to Bazalgette or his works which helped to ensure that the water was clean. The *Bibliography of British History, 1851-1914*, (ed. H.J.Hanham, O.U.P., 1976) contains no index reference to Bazalgette or the Metropolitan Board of Works and only one reference to sewage, dating from 1898, eight years after Bazalgette's death.

In 1993 my employers, Buckinghamshire College, agreed to allow me some time to undertake work for a Ph.D. and I chose Bazalgette and his work as my subject. I wrote to Professor Roderick Floud, Provost of London Guildhall University, whom I had known many years earlier and whom I knew to be an economic historian, to ask if he thought the subject suitable and, if so, whether he could recommend a supervisor. Professor Floud suggested that the work could be undertaken at London Guildhall University and he introduced me to Dr John Sheldrake, Reader in History at London Guildhall, who was familiar with aspects of local government history and medical history which, it was becoming clear, would be relevant to the work. I also consulted numerous colleagues who had recently completed, or were completing, Ph.D. work, some on historical subjects and some not, at a wide variety of institutions in order to gain an insight into the approaches that they had found helpful.

I was fortunate in being a personal friend of Dr Edmund Hambly, Vice-President (and later President) of the Institution of Civil Engineers (I.C.E.). Bazalgette was himself President of the I.C.E. in 1884 and in 1991 the Institution had held an exhibition *Sir Joseph Bazalgette: Civil Engineering in the Victorian City* to mark the centenary of Bazalgette's death. Dr Hambly gained me an introduction to the archivist and librarians of the Institution in Great George Street, S.W.1., and it was there that I began my research. The I.C.E. archives were a good place to start. A print-out of materials about Bazalgette was produced by the very helpful archivists and my attention was immediately drawn to a paper prepared by Bazalgette himself and delivered to the membership of the I.C.E. on 14th March 1865, as his works neared completion, *On the Main Drainage of London and the Interception of the Sewage from the River Thames.*[6] The discussion of the paper had continued over four evenings so it was clearly a significant document. The paper gave a brief account of the development of London's drainage since mediaeval times and introduced me to the political as well as the financial and engineering problems which faced the Metropolitan Board as it set about executing its great works. It also hinted at some of the controversies surrounding the effects of the intercepting sewers on the health of

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[6]M.P.I.C.E.: vol. 24, 1864-5, pp. 280-358

the metropolis, besides laying out the technical details of the system. The tone of this, and many of Bazalgette's writings, is dispassionate almost to the point of self-deprecation. Bazalgette laid no claim to originality in his work, simply stating that he had evaluated the many plans drawn up by others who had attempted to solve the problems of London's drainage in the previous thirty years, and had adopted the best features of each.

Having thus formed an impression of the man and the implications of his work I proceeded to read other accounts of it by later writers who, with the advantage of hindsight, were able to take a more dispassionate view. Four were particularly valuable. The first I found with the aid of the Greater London Record Office's (G.L.R.O.) indexing system and is an account of *The Main Drainage of London* written by Sir George Humphreys in 1930.[7] Humphreys, as chief engineer to the L.C.C., which took over the responsibilities of the Metropolitan Board in 1891, was one of Bazalgette's successors and was therefore well placed to judge the extent to which Bazalgette's works had dealt not only with the problems he faced in the middle of the nineteenth century but those of his successors almost a century later. His verdict was re-assuring and Humphreys warned his readers against Bazalgette's tendency to disclaim credit, drawing attention to the fact that "with trifling exceptions, the whole work is still carrying out the function for which it was created."[8]

This short account by Humphreys was particularly valuable because it directed me to a number of primary sources on the early history of London's drainage which were available in the Guildhall Library and in the Greater London Record Office itself. The G.L.R.O. also contained a sketch by John Thwaites, first chairman of the Metropolitan Board of Works, of the *History and Prospects of the Metropolitan Drainage Question*, published in 1855 just before the Metropolitan Board began its work. Thwaites was Bazalgette's chairman and close collaborator in the construction of the main drainage works and his sketch is a valuable and authoritative contemporary record of his experience as a member of the Metropolitan Commissions of Sewers and of the events which preceded the establishment of the Board. I next turned to D.Owen's book *The Government of Victorian London*, (Belknap, 1982) which is an account of the Metropolitan Board of Works for the whole of its existence from 1856 to 1889, during all of which period Bazalgette was its chief engineer. The Board had many responsibilities apart from main drainage, notably the construction of new

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[7]Humphreys, G.: *The Main Drainage of London*; L.C.C., 1930
[8]Ibid., p.11

streets, and only one of fourteen chapters is devoted to the main drainage works. Nevertheless, like Humphreys' monograph, the principal value of Owen's work lay in the fact that it drew my attention to the existence of many contemporary materials, notably in the form of Parliamentary papers, records of the Metropolitan Board of Works and, more surprisingly, an extensive range of accounts in contemporary newspapers and journals. Finally, during my research at the Institution of Civil Engineers I learned of the existence of a paper given by Dr Denis Smith to the Newcomen Society at the Science Museum on 25th March 1987.[9] Besides confirming the value of the sources used by Humphreys and Owen it also contained some information on the origins of the Bazalgette family. The Newcomen Society paper also referred to one of Sir Joseph's many descendants, Rear-Admiral Derek Bazalgette, Sir Joseph's great-grandson, whom I contacted and who not only put at my disposal the records that he possesses relating to Sir Joseph and the family but also gave me permission to examine, in the archives of Coutts Bank, the accounts of Sir Joseph's grandfather, Jean Louis, who arrived in England from France at the end of the eighteenth century and rapidly established himself as a man of substance.

Even at this early stage of the research certain themes were beginning to emerge as being of central importance. First, it would be necessary to give an account of the previous history of London's sanitation and to explain why a city which, in the early nineteenth century, was complacent about the quality of its environment and its water, was confronted in 1858 with the crisis of "The Great Stink". It also became evident that the Metropolitan Board could not do its work until a number of issues had been resolved concerning the extent of its authority, so the second theme was concerned with the early history of London's first "Metropolitan" government. Thirdly, the work would need to assess the nature of the engineering problems posed by a work of this scale in the mid-nineteenth century, comparable in scale with the construction of the railways but executed within the world's largest city, using contracting practices, construction techniques and materials which were either relatively new or completely untried. Fourthly, the effects of the main drainage upon the health of the metropolis had to be evaluated, particularly the effects on deaths from water-borne diseases such as cholera and typhoid. In a sense this was the criterion by which the value of the drainage system would be judged but, besides assessing the effects of the system on the death rate in the capital, which was comparatively easy thanks to the records kept by William Farr, a further and more subtle judgement had to be made: how far did contemporaries *understand* the link between efficient drainage and freedom from

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[9]Smith, D.:"Sir Joseph Bazalgette"; Newcomen Society *Transactions,* vol. 58, 1986-7

disease? The fifth theme which I had in mind from the start was the personal one. What kind of man was Bazalgette, the man who shouldered the burdens of designing the scheme, justifying it to critical Parliamentarians as well as his own Board members, supervising an extensive network of contractors, some of them using novel materials and discharging his numerous other responsibilities as Chief Engineer? Bazalgette proved to be an elusive personality. He left very few personal documents (there is not the briefest diary for example) though there is an abundance of professional papers: almost too many, since I discovered a set of engineering drawings for one of his most famous creations, Abbey Mills pumping station, signed by Bazalgette, in an old desk in a damp, forgotten outhouse at Abbey Mills. His great-grandson, in a discussion on Denis Smith's paper suggested that he was an asthmatic, irascible workaholic who had time only to work on London and beget ten children.[10] Yet his papers do not suggest an irascible man. He was frequently required to spend much of his time reporting on schemes which must have seemed to him to be of very questionable value but in these reports, and in the newspaper correspondence which often accompanied them, the impression that he gives is that of heroic patience supported by a detachment which is at times sardonic and may have been a protective mechanism. Nevertheless Bazalgette never really emerges as a person from these pages. However, reference to his detachment in the face of ill-considered schemes brings me to the final theme, the sixth, which emerged about a year into the research. This concerned the great sewage manure controversy: the belief amongst many influential people that sewage was a mine of wealth which, if properly exploited, would generate sufficient profit to pay for sanitary improvements. This took up so much of Bazalgette's (and the Board's) time that I felt it justified its own chapter.

Methodology: identifying the sources

Having established the key **themes** with which the work would be concerned I proceeded to identify the **sources of information** which would be critical. As observed earlier, Bazalgette and the works he undertook were celebrated during his lifetime and there is an abundance of contemporary records which not only help to give an account of how the works came to be undertaken but also show how they were evaluated by politicians, sanitary reformers, journalists and citizens. The most important of these were as follows.

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[10]Smith, D.,: Newcomen Society *Transactions*, vol. 58, 1986-7, p. 111

Parliamentary Papers.

From the late 1820s the condition of London's sanitation, and its water supply, were a source of almost continuous concern, comment and enquiry by Royal Commissions, Select Committees and a number of statutory bodies who reported to Parliament. Parliamentary Papers of the period are indexed so that it is relatively easy to find references (under headings such as "Sewers" or "Thames" or "Health") to relevant papers in the bound volumes held in Guildhall Library. These were the biggest single source of information on the events which led to the establishment of the Metropolitan Sewers Commissions, their successor the Metropolitan Board of Works, and the progress of the main drainage works for which the Board was primarily established. **Hansard** is similarly indexed and on numerous occasions it was necessary to consult its pages in order to understand the events which preceded the drafting of such documents as the Metropolis Local Management (Amendment) Act of 1858 (22 & 23 Vict. cap. 104).

Documents of the Metropolitan Board of Works

The Minutes of the Metropolitan Board of Works are available in bound volumes in the Greater London Record Office (G.L.R.O.) and within their pages the progress of the main drainage works is carefully chronicled. The indexing, like that of the Parliamentary Papers, is easy to use, particularly since the main drainage occupied such a central place in the deliberations of the Board for the first ten years of its existence that detailed references are easy to find even for such subjects as "sewage utilisation". The G.L.R.O. archives also contain much supplementary material from the Board's records such as records of sub-committees which were a valuable source of detailed information on some of the more complex and controversial issues which the Board had to consider.

Contemporary Newspapers and Journals

It is hard to imagine that, in the twentieth century, the construction of a new sewage system would regularly occupy prime space in the news and leader columns of the principal media of the day, yet such was the case with the intercepting sewers in the mid-nineteenth century. *The Times* and the *Illustrated London News* regularly carried accounts, sketches and comments on the works, both before they were started and as they progressed. Less surprisingly the trade journal *The Builder* also carried frequent detailed accounts of the project. All three of these publications are well indexed and

are readily available in the archives of the Guildhall Library and the G.L.R.O.. Longer articles on the issue of public sanitation were found in the pages of the *Edinburgh Review*, *Quarterly Review,* and *Fraser's Magazine*; and in newspapers such as *The Observer, Morning Chronicle, Marylebone Mercury, The Elector* and *The South London News* which are available in the Newspaper Library, Colindale and the Westminster City archives.

Institution of Civil Engineers

The I.C.E.'s first president, Thomas Telford, established the principle from the time that he took office on 21st March 1820, that the Institution would assume an educational role. He instituted weekly meetings at which a member would be encouraged to read a paper on a matter of engineering practice. This would be followed by a discussion which might extend over several subsequent meetings. The papers and the record of the discussions became the Institution's *Minutes of Proceedings* and these constitute a valuable record of contemporary events as they affected the engineering profession. The library of the Institution contains bound copies of the Institution's *Minutes of Proceedings* and these contain numerous references to the issues of public sanitation including discussions of construction materials and techniques, contracting methods, the possibilities of processing and marketing sewage as agricultural manure and other matters which affected Bazalgette and the construction of the intercepting sewers. The library also contains many texts on the early history of the engineering profession by R.A.Buchanan and others. It was the single most important source of information on the technical aspects of the construction of the main drainage.

Wellcome Institute

The library of the Wellcome Institute for the History of Medicine proved to be a most valuable source of information on nineteenth century perceptions of the relationship between sanitation and disease. It contains an almost complete set of bound volumes of *The Lancet* which carried many articles on theories of disease propagation, together with other contemporary works by writers like John Snow and William Budd. It also contains journals in which commentators such as A.Hardy, C.Hamlin and R.Porter have given their own interpretations of the Victorians' attitudes towards sanitation. The library also holds a copy of Heather Creaton's definitive bibliography of works on London which enabled me to find some texts which had eluded my earlier research. The materials in the Wellcome Institute, with its excellent

computerised indexing system, made a particularly valuable contribution to the chapter on *The Health of the Metropolis*, but to this must be added other sources without which it would not have been possible to write the chapter. The G.L.R.O. contains numerous texts on the health of the metropolis in the nineteenth century and particularly on some of the personalities principally concerned with the subject, notably Edwin Chadwick and John Simon. Finally, in this context, the library of the **Office of Population Censuses and Surveys** in Kingsway holds an excellent stock of materials by and about the statistician William Farr, first compiler of statistics to the Registrar-General. His role as a campaigning statistician gave him a very influential role in the formation of public policy and attitudes towards health issues and his late conversion from a belief in the orthodox "miasmatic" explanation of disease propagation to a conviction that cholera could be water-borne was, I believe, significant in the context of the time.

Presenting the material

In presenting the work I have adopted a partly chronological and partly thematic approach. The first two chapters are broadly chronological and explain how London's sewage disposal problems developed and how the administrative mechanism was established to deal with them. Chapter three examines the role of the intercepting system in ending the scourge of water-borne epidemics, particularly cholera, and considers the paradox that, even after Bazalgette's death in 1891, some eminent authorities were still not convinced that clean water, rather than clean air, accounted for the drop in mortality from this disease. Chapter four examines the sewage manure controversy which began before Bazalgette started to design the system and continued for years after his work was completed. It could be argued that answers are still being sought to-day. The final chapter examines the work involved in actually constructing the system including the problems of financing the project, managing the construction work and choosing the right materials. .

Chapter One examines the origins of London's system of drainage which worked tolerably until the 19th century. It proceeds to examine the factors which, by the 1850s, had pushed the system to a point where its deficiencies were a serious threat to the comfort and health of the population. The chapter draws on Parliamentary Records and contemporary accounts in newspapers and journals such as *The Times* and *The Builder* as well as writers like Leigh, Britton and Wright. These were found mostly in the Guildhall Library and the Greater London Record Office (G.L.R.O.). Edwin Chadwick's *Report on the Sanitary Conditions of the Labouring Population of Great*

Britain (1842, E.U.P. edition, 1965) was also valuable both as a source of information itself and as a pointer to other contemporary works. The accounts of Sir George Humphreys and R.C.Middlemass who succeeded Bazalgette as engineers for the London County Council and Thames Water Authority respectively were valuable sources of background information and the former directed me to a number of accounts of London's sanitation before 1700 which were also held at Guildhall or the G.L.R.O.. John Thwaites's *Sketch of the History and Prospects of the Metropolitan Drainage Question* (1855)[11]is an authoritative account of the events that preceded the establishment of the Metropolitan Board of Works and was supplemented by several documents obtained in the British Library. I have also included in this first chapter a summary of the material I have obtained on the origins of the Bazalgette family and on Sir Joseph himself. For some of this, notably the will of Jean Louis Bazalgette, I am indebted to Rear-Admiral Derek Bazalgette, Sir Joseph's great-grandson. Other sources included the archives of the Lozere Department, held at Mende, Lozere, France; the Surrey County Record Office in Kingston-Upon-Thames; and the records of Coutts Bank. The principal secondary source for this chapter is the seminal work on the Metropolitan Board by D.Owen, *The Government of Victorian London* (Belknap, 1982).

Chapter Two considers the public debate which, in the mid-nineteenth century, attempted to define the role of national government in promoting public health and eliminating the causes of disease. It examines the arguments of the "interventionists" like Chadwick who argued in favour of a strong central authority which would impose solutions to public health problems about which local communities were apathetic; and the contrary arguments of those who argued for local autonomy (and low taxes) like Toulmin Smith. This argument had to be resolved before the Metropolitan Board of Works could gain the authority and the funds needed to carry out its work. Parliamentary Papers, supplemented by *Hansard*, are used extensively to relate the events and debates which preceded the establishment of the Metropolitan Board of Works (M.B.W.) and the amending legislation which was necessary to give it the authority it needed to discharge its responsibilities effectively. The writings of contemporary protagonists in the fierce debates over the claims of centralised authority against local autonomy, such as Chadwick and Toulmin Smith, are quoted as are the views of newspaper commentators in the mid-nineteenth century in such publications as *The Times, The Observer, The Builder,* the *Edinburgh Review* and *The Lancet*. The work of R.A.Lewis (*Edwin Chadwick and the Public Health Movement,*

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[11]Held in the Greater London Record Office (G.L.R.O.)

Longmans, 1952); S.E.Finer (*The Life and Times of Sir Edwin Chadwick* Methuen, 1952); and J.Davis (*Reforming London*, Clarendon Press,1988), were of particular value in preparing this chapter.

Chapter Three examines the effects upon the health of the metropolis of the construction of the intercepting sewers and is, in effect, a judgement on their significance. However, besides evaluating the effects of the system upon the incidence of mortality from epidemics of cholera and typhoid it also questions the extent to which the contribution of the sewers to the eradication of disease was really understood. It examines theories of the causes of disease (especially water-borne diseases like cholera and typhoid) which were prevalent in the middle of the nineteenth century and the extent to which these promoted or obstructed the campaigns for a cleaner environment and better public health. It will focus on the work of a number of particularly influential individuals, notably William Farr, John Snow, William Budd, Edwin Chadwick and John Simon, with particular emphasis on their developing (or in Chadwick's case unchanging) attitudes towards the causes of cholera and towards the role of sanitary reform in ending the four epidemics which affected London between 1831 and 1866. The writings of each of these will be referred to as will the numerous public enquiries to which some of them contributed and which are recorded in Parliamentary Papers. Secondary sources include the works of R.Porter, G.Rosen and M.Pelling (notably the last's *Cholera, Fever and English Medicine* O.U.P., 1978). The biography *Sir John Simon* by R.Lambert (McGibbon and Kee, 1963); S.E.Finer's *The Life and Times of Sir Edwin Chadwick* (Methuen, 1952) and a work published in 1907 by Fisher Unwin, *The Sanitary Evolution of London* by H.Jephson, a member of the London County Council (which succeeded the Metropolitan Board of Works) were helpful starting points for the contents of this chapter. Finally, C.Creighton's *History of Epidemics in Britain*, (O.U.P., 1894), is used as a secondary source for its account of the history of cholera and typhoid in the nineteenth century; and also as a means of evaluating the equivocal nature of contemporary views on the theories of disease propagation. Although the work of Snow, Pasteur and Koch had, by 1895, established to the satisfaction of many observers that cholera epidemics were primarily water-borne, a doubt clearly survived in the mind of a commentator as well-informed and authoritative as Creighton. Although Bazalgette, towards the end of his life, had no doubts about the contribution of the intercepting sewers to public health, it appears that, even in the final decade of the century, the nature of the connection was still not fully understood.

Chapter Four analyses the great "Sewage Manure" controversy which, like the debate over pipe sewers, engaged the attention of Chadwick, of eminent scientists like Justus von Liebig, Parliamentary committees and a collection of hopeful entrepreneurs, each of whom expected to make a considerable fortune by recycling the capital's waste. Parliamentary papers, *Minutes of Proceedings of the Institution of Civil Engineers*, and contemporary journals, notably *The Builder*, were valuable sources of information on this subject. I have also made many references to the contemporary writings of early agricultural chemists such as Justus von Liebig, J.B.Latham and A.Voelcker and, amongst secondary sources, I am particularly indebted to Dr Nicholas Goddard of Anglia Polytechnic University for his recent articles on the subject and for his help in finding some of the contemporary sources to which I have referred.

Chapter Five gives an account of the construction of the system; the early hopes that were invested in it; the technical, financial and political problems which quickly beset it; the acrimony which was heaped upon it when these problems became known; and the enthusiasm which quickly re-asserted itself when the effects of the system came to be gradually felt, attracting praise of a kind most unfamiliar to public officials. It considers the development of materials and of contracting and engineering procedures which were essential for the construction of the intercepting sewers. It considers the weaknesses in the system which became apparent as the growth of the Metropolis exceeded the predictions upon which Bazalgette's designs had been based and it describes the remedies which were adopted before Bazalgette retired. The principal sources for these chapters were the *Minutes of the Metropolitan Board of Works* its *Annual Reports* and the records of many of its committees;the *Minutes of Proceedings of the Institution of Civil Engineers;* and contemporary records of the progress of the works, notably from *The Times, The Builder* and the *Marylebone Mercury.* Amongst secondary sources, the works of R.A.Buchanan were of great value, notably *The Engineers: a History of the Engineering Profession in Britain, 1750-1914,* (Kingsley, 1989) as were a volume edited by R.Church *The Dynamics of Victorian Business: Problems and Perspectives to the 1870s,* (Allen and Unwin, 1980) and J.Summerson's *The London Building World of the 1860s* (Thames and Hudson, 1973).

The Conclusion makes a judgement on the significance of the system of intercepting sewers in the life of the metropolis, with particular reference to health and living conditions and assesses its significance as a feat of engineering. It considers Bazalgette's role in the development of concepts of Metropolitan management and his contribution to the future of the engineering profession by his adoption of new

materials. It will attempt to form a judgement on the truth of Doxat's claim about Bazalgette having "probably done more good and saved more lives than any single Victorian public official".

Note: the words *sewer, drain* and *drainage* are often used as if they are synonyms. In this work the words will be used in the following senses:

Drain:an underground channel used to collect the waste from individual properties or groups of properties; from these the waste flows to a:

Sewer: this collects the waste from properties and channels it, usually beneath the public streets, to a treatment plant, an outfall (usually to sea or river) or:

Intercepting sewer:Bazalgette's principal concern: these intercept the waste from smaller street sewers, thereby protecting natural watercourses;

Main Drainage: this refers to the whole system: drains, sewers and outfalls.

References: throughout this work all sources are referred to by footnotes at the bottom of each page. In the case of books and articles with identifiable authors the name of the author is given, followed by the title of the work, the publisher, date of publication and page number, e.g.: Porter, R.,: *London, a Social History,* Hamish Hamilton, 1994, p.91. Where no author can be identified (e.g. in a contemporary newspaper), the name of the publication is given, followed by the date and page number e.g.: *The Times,* 6th October, 1859, p.6. The following abbreviations are used in identifying a number of primary sources to which frequent reference is made:

P.P.: Parliamentary Papers; followed by the year and volume number; the volumes used are those of the Guildhall Library which are all numbered with Arabic numerals; for this reason the footnotes use Arabic numerals but the bibliography uses the Roman numbers favoured by the British Library.
G.L.R.O.: Greater London Record Office: in 1997 this was re-named the "Metropolitan Archives".
M.B.W.: Metropolitan Board of Works (*Minutes of Proceedings, Annual Reports* and various manuscript sources)
M.P.I.C.E.: *Minutes of Proceedings,* Institution of Civil Engineers
M.C.S.: *Metropolitan commissions of Sewers* records
B.L.: British Library Records

There are several references to Edwin Chadwick's 1842 *Report on the Sanitary Condition of the Labouring Population of Great Britain*; for ease of reference these are referred to in the text as *Report*, followed by a page number which refers to the 1965 edition published by the Edinburgh University Press.

Chapter One: the Early History of London's Drainage.

> "Fifty years ago nearly all London had every house cleansed into a large cesspool...Now sewers having been very much improved, scarcely any person thinks of making a cesspool, but it is carried off at once into the river. It would be a great improvement if that could be carried off independently of the town, but the Thames is now made a great cesspool instead of each person having one of his own". (Thomas Cubitt, in evidence to the Select Committee on the Health of Towns, P.P. 1840, Vol. 11, Q.3452)

> "The Commission promptly required the abandonment of the cesspools in the area, and that all house drainage should be by direct communication to the sewers, causing a drastic alteration in the drainage pattern. These measures radically improved the situation in locations remote from the river but the conditions in and adjacent to the Thames deteriorated further".(R.C. Middlemass: *London's Main Drainage: Historical Background*, Thames Water, 1975, page 2)

This chapter will analyse the factors which, in the early decades of the nineteenth century, precipitated a crisis in London's drainage system which, a few years earlier, had been a source of satisfaction and even some complacency. It will consider the consequences which followed from the replacement of the traditional cesspool by the water-closet. It will examine the development of London's drainage system from the mediaeval period and analyse the effects of Henry VIII's Bill of Sewers, the first serious attempt to create a system of drainage for the capital. This will be followed by an account of the early legislative attempts to improve the living conditions of the urban population, dating from about 1839, and will describe the problems faced by the six Metropolitan Commissions of Sewers which held office from 1848 to 1855. It will also give an account of Joseph Bazalgette's ancestry and early experience.

From Complacency to Anxiety

In 1844 a contemporary journal quoted Professor A. Booth, a Professor of Chemistry, as follows[1]:"The free currents of air which are necessarily in constant circulation from its (sic) proximity to the majestic Thames..... have been considered (and not improperly) as a great cause of the salubrity of the metropolis". This claim is significant for two reasons. First, it is a clear statement of the "miasmic" theory of disease which was prevalent at the time and which held that good and bad health were caused primarily, if not exclusively, by the properties of the air inhaled by the lungs.

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[1] *The Builder*: 18th July, 1844, pp. 350-1

In the same passage Booth expressed a more extravagant version of the theory: "From inhaling the odour of beef the butcher's wife obtains her obesity".The theory long survived the discovery that diseases like cholera were transmitted through water rather than air and Edwin Chadwick, who died in 1890, went to his grave firmly believing in the miasmic theory. The theory bedevilled many attempts by reformers to secure improvements in the water supply and sanitation of London, as will be seen in Chapter three.

However, the greater reason for the significance of Booth's claim about the "salubrity" of London lies in its complacent view of the waters of the Thames. Fourteen years after Booth made this claim, in the hot Summer of 1858, the drapings of the Houses of Parliament were being soaked in chloride of lime to act as an ineffective barrier against the foul odours arising from the river. Despite these precautions the Chancellor of the Exchequer, Disraeli, was seen fleeing from the chamber handkerchief to nose and, as Bazalgette observed in his interview with the *Saturday Review*, there was even talk of moving Parliament elsewhere. Henley upon Thames was considered.

Professor Booth's flattering assessment of the quality of London's air and the condition of its river was not unique in the eighteenth or early nineteenth century. Charles Lucas, an Irishman who qualified as a Doctor in Paris had written in 1756 that London's water "undoubtedly is one of the principal causes why our capital is the most healthful great city in the world"[2] and in 1818, another writer claimed of the capital:

> "Its healthfulness is equal to that of any other metropolis in existence" and suggested that its "plentiful supply of water which is furnished by different water companies, must also have an excellent effect on the cleanliness, and consequently on the health, of the inhabitants of London, while its system of sewers and drains...adds still more to the general causes which conduce to salubrity.[3]

In 1826 John Britton had written:

> "With regard to the diseases and proportion of salubrity usually attaching to London, it is a satisfaction to state generally, that since the complete extinction of the Plague by the Great Fire of 1666, this metropolis has fully

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[2]Lucas, C.: *Essay on Waters*, London, 1756, vol. 1 p.127

[3] Leigh: *Leigh's New Picture of London,* London, 1818, p.33, G.L.R.O.

> deserved to be considered as one of the most healthy on earth; and that in consequence of the open mode of building that now prevails, its increase to an almost indefinite extent is not likely to be attended with additional unwholesomeness". [4]

This reassuring view of the capital's water supply was not universally shared. In 1827 a pamphleteer called John Wright had published *The Dolphin, or Grand Junction Nuisance, Proving that Several Thousand Families in Westminster and its Suburbs are Supplied with Water in a State Offensive to the Sight, Disgusting to the Imagination and Destructive to Health*, which drew attention to the pollution of water supplies by industrial effluent and leakage from sewers. Copies of the pamphlet were distributed to houses in Westminster.[5] Wright had been an associate of William Cobbett and had edited some of the latter's works before his indignation at the quality of the water supplied to his house in Regent Street, and drawn from the Thames near the mouth of the Ranelagh sewer, led him to attack the Grand Junction Waterworks company which supplied it.[6] The pamphlet claimed that the company sent up:

> "to be used daily at the breakfast table...a fluid saturated with the impurities of fifty thousand homes - a dilute solution of animal and vegetable substances in a state of putrefaction - alike offensive to the sight, disgusting to the imagination and destructive to the health".[7]

Sir Francis Burdett, a radical M.P. who was an associate of Wright and to whom the pamphlet was dedicated, raised what a later Select Committee described as "an alarm"[8] which prompted the appointment of a Royal Commission in 1828 whose members concluded that London's water supply became polluted as it approached the Metropolis: "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".[9]

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[4] Britton, John: *The Original Picture of London, Enlarged and Improved,* London, 1826, p.22

[5] See Hardy, A.: "Water and the Search for Public Health in London in the Eighteenth and Nineteenth Century"; *Journal of Medical History*, **28**, (1984) pp. 250-82

[6] An account of the circumstances in which Wright wrote the pamphlet may be found in *The Guildhall Miscellany*, Guildhall Library, No.2, February 1953, pp. 31-4

[7] *The Dolphin*, p.61, T.Butcher, London, 1828

[8] P.P. 1867, vol. 9, p.v: Select Committee on East London Water Bills

[9] P.P. 1828, vol. 8, p.4

The Commission's report was considered by a Select Committee upon whose recommendation Parliament appointed the distinguished engineer Thomas Telford "to Survey and Report his Opinion as to the best Mode of Supplying the Metropolis with Pure Water".[10] His report recognised the pollution problems posed by the Thames and proposed to bring water supplies to London from three unpolluted sources. Aqueducts would bring water from the river Ver at Aldenham and from the Wandle at Beddington while the New River company would augment its supplies by drawing on waters from the upper reaches of the Lee and from wells north of London. The cost was estimated as £1,177,840-16s-5d.[11] A further Select Committee was appointed to consider the matter again in 1834[12] following which no action was taken though, in the same year, another Select Committee reported on the "State of the Law respecting sewers in and near the Metropolis". The Committee drew attention to problems which arose from a lack of uniformity in the design of sewers, the lack of co-ordination between the activities and standards of differing authorities (see page 31, below, et seq.) and the opaqueness of the arrangements by which rates were fixed. There was a brief discussion of means of preventing foul smells from emanating from the sewers and some perfunctory suggestions about how the Commissions which were responsible for building and maintaining sewers should order their affairs. However the deliberations of the Committee, and its recommendations, give no sense of an impending crisis in the sanitary affairs of the capital, or even of a serious problem.

However, by 1853 London's drainage problem was being voiced in the columns of *The Builder*, the journal which had carried Professor Booth's complacent assessment only nine years earlier. A correspondent writing under the name "Quondam" wrote:[13]

> "The flood..... is now, below London Bridge, bad as poetical descriptions of the Stygian Lake, while the London Dock is black as Acheron...where are ye, ye civil engineers? Ye can remove mountains, bridge seas and fill rivers .....can ye not purify the Thames, and so render your own city habitable?"

Since this was written in mid-winter, when the river would have been relatively well supplied with seasonal flood waters, and the temperature low, we may conclude that the condition of the river had markedly deteriorated since Booth's earlier claim. The

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[10]P.P. 1830-1, vol.14, p.51
[11]P.P. 1834, vol.51, pp. 281-90
[12]P.P. 1834, vol. 15
[13]*The Builder*: 19th February 1853, p. 119

problem reached one of its many climaxes in 1855 when *The Times* published the following letter:[14]

> "Sir, I traversed this day, by steam boat, the space between London and Hungerford Bridges, between half past one and two o'clock; it was low water and I think the tide must have been near the turn. The appearance and the smell of the water forced themselves at once upon my attention. The whole of the river was an opaque, pale brown fluid. In order to test the degree of opacity, I tore up some white card into pieces, moistened them so as to make them sink easily below the surface and then dropped some of these pieces into the water at every pier the boat came to; before they had sunk an inch below the surface they were indistinguishable, though the sun shone brightly at the time, and when the pieces fell edgeways the lower part was hidden from sight before the upper was under water. This happened at St. Paul's Wharf, Blackfriars Bridge, Temple Wharf, Southwark Bridge and Hungerford Bridge; and I have no doubt would have occurred further up and down the river. Near the bridges the feculence rolled up in clouds so dense that they were visible at the surface, even in water of this kind.
>
> The smell was very bad, and common to the whole of the water; it was the same as that which now comes up from the gulley holes in the streets; the whole river was for the time a real sewer. Having just returned from out of the country air, I was, perhaps, more affected by it than others; but I do not think I could have gone on to Lambeth or Chelsea, and I was glad to enter the streets for an atmosphere which, except near the sink holes, I found much sweeter than that on the river. I have thought it a duty to record these facts that they may be brought to the attention of those who exercise power or have responsibility in relation to the condition of our river; there is nothing figurative in the words I have employed or any approach to exaggeration: they are the simple truth. If there be sufficient authority to remove a putrescent pond from the neighbourhood of a few simple dwellings, surely the river which flows so many miles through London, ought not to be allowed to become a fermenting sewer.
>
> The condition in which I saw the Thames may, perhaps, be considered as exceptional but it ought to be an impossible state, instead of which, I fear, it is rapidly becoming the general condition. If we neglect this subject, we cannot expect to do so with impunity, nor ought we to be surprised if, ere many years are over, a hot season gives us sad proof of the folly of our carelessness. I am sir, your obedient servant
>
> M. Faraday, Royal Institution July 7th, 1855

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[14] *The Times:* 9th July 1855

Within three years of Faraday's letter, in the hot, dry summer of 1858, the "Great Stink" was on the point of driving Parliament from London. The deterioration in the years since Professor Booth's flattering verdict on the qualities of the river can be explained by reference to changes in London's drainage system which occurred in the early 19th century and which represented a significant change from the arrangements which had prevailed at least since mediaeval times.

London's Natural Drainage System

In order to understand how London's drainage system developed it is important to grasp two principles. The first is that the drainage grew around London's system of natural water courses, notably the following, shown on Map 1.[15]

On the **North** side of the river, West to East:

Stamford Brook:	Wormwood Scrubs to Chiswick
Counters Creek:	Wormwood Scrubs to Chelsea
Westbourne:	Hampstead to Chelsea via Hyde Park (and the Serpentine)
Tyburn:	Hampstead to Westminster (also called the Aye or Kings Scholars Pond)
Fleet:	Highgate and Hampstead to the city
Walbrook:	Islington to Cannon Street
Blackditch:	Stepney to Poplar
Hackney Brook:	Hornsey to the River Lea

On the **South** Side West to East:

Beverley Brook:	Wimbledon to Barnes
Wandle:	Merton to Wandsworth
Falconbrook:	Tooting to Battersea
Effra:	Norwood to Vauxhall
Peck/Earls Sluice/ Neckringer:	Originates in East Dulwich and enters the Thames at Bermondsey and Rotherhithe
Ravensbourne:	Bromley to Deptford

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[15]Trench, R., and Hillman, E., *London Under London,* John Murray, 1984, pp.23-53

Originally, these were open streams but as London grew they were gradually covered over so that now only the Ravensbourne, Beverley Brook and the Wandle are still open streams for much of their length. The covering in of the Walbrook began in 1463 and that of the Fleet in 1732.[16] In 1846 the foetid gases it contained caused it to explode, disgorging a tide of sewage which swept away three houses in Clerkenwell.[17] The remaining streams were mostly covered over with the expansion of London's housing in the 19th century, though part of the Tyburn near its junction with the Thames remained open until the 1970s.

The second essential point that must be grasped about London's early drainage system is that it was intended for *surface water drainage*, as had been the case with Rome's "Cloaca Maxima", built between 800 and 735 B.C. Foul sewage from buildings was diverted to cesspools which were emptied, at irregular intervals, by "night soil men". Until 1815 it was illegal to discharge effluent from buildings to the sewers. In the words of the First Report on Metropolitan Sewage Discharge, the sewers:

> "were originally intended only to cover or supply the place of natural streams and ditches, and so to carry away the rainfall from the fields, roads and roofs of the houses...at the beginning of the present century it was penal to discharge sewage or other offensive matter into the sewers, which were regarded as the legitimate channels for surface water".[18]

The approved means of disposing of sewage was described by *The Builder* in commenting on the report of the 1884 Royal Commission:

> "At the commencement of the present century it was penal to discharge sewage or other offensive matter into the sewers, which were intended for surface drainage only. The sewage of the Metropolis was collected into cesspools which were emptied from time to time and their contents conveyed into the country for application to the land". [19]

Consequently, until 1815 London's streams, open or covered, were supposedly performing little more than the function for which nature intended them: carrying rainwater into the Thames, though no doubt "enriched" by some of the city's refuse, cast into the streets or surreptitiously dumped in the sewers. The Thames therefore remained a relatively clean river. As late as 1816, 14 salmon weighing 179 pounds

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[16]P.P. 1884, vol.41. p.xi - Historical Note
[17]Trench, R., & Hillman, E.,*London Under London,* John Murray, 1984, p.39
[18]P.P. 1884, vol. 41 p.xi
[19]*The Builder*: 16th August 1884 p.215

were caught at Taplow, though only 4 years later, in 1820, no catches were recorded.[20] By 1828 the Royal Commission on the Water Supply of the Metropolis was drawing attention to "an entire destruction of the fisherman's trade between Putney Bridge and Greenwich" and estimated that the number of fishermen working the river had been halved since 1800. Moreover Metropolitan Brewers were seeking their supplies from wells rather than from the polluted river.[21] The last salmon to be taken from the river was in June 1833. [22] In 1828 the Royal Commission had particularly commented on pollution from industrial waste. It was thirty years before sewage pollution assumed serious proportions.

The Drainage of Mediaeval London

This is not to claim that, before the 19th Century, London had been without its waste disposal problems. It had been a matter of concern for the authorities in the city from mediaeval times. In 1189 the first Mayor of London, Henry Fitzalwyn, in an early attempt at building regulations, proclaimed that the "necessary chamber [cesspool] should be at least 2½ ft. from the neighbouring building if it was made of stone and at least 3½ ft. if made of other materials". The succeeding centuries provide abundant evidence of the need for this and similar measures. Edwin Chadwick in the *Report on the Sanitary Condition of the Labouring Population of Great Britain*, published in 1842, referred to numerous examples of petitions and decrees designed to deal with nuisances. In 1290 the Carmelite Friars of London "petitioned Parliament to abate a nuisance (viz. a great stench) near them which they cannot endure and which prevents them from performing their religious duties".[23] By 1300 according to John Stowe's *Survey of London*, Sherbourne Lane's Sweetwater Bourne had become known as Shiteburn Lane. In the reign of Richard II, in 1379, a statute (12 Richard II Cap.13) decreed that: "None shall cast any garbage or dung or filth into ditches, waters or other places within or near any city or town on pain of punishment by the Lord Chancellor at his discretion".

King Edward III, by ordinance, ordered the city to pay for 12 carts to remove sewage and refuse and he also ordered householders on the banks of the Walbrook to keep rakes with which to intercept refuse which had found its way into the stream. There

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[20]Wood, L.B.: *The Restoration of the Tidal Thames*; Adam Hilger Press, 1982, p.18
[21]P.P. 1828, Vol. 9, pp. 61-2, 122-3, 168.
[22]Fitter, R.: *London's Natural History,* Collins, 1945, p.82
[23]Chadwick, E.,: *Report on the Sanitary Condition of the Labouring Population of Great Britain,* 1842, E.U.P. edition, (1965) p.351

is further evidence that, by the mid 14th century, pollution of the streams, and hence of the Thames, had become a serious problem, judging by the number of times Edward III found it necessary to intervene in the matter. In 1354 he ordered the removal of waste on an appointed day each week by rakers, assistants to Ward Beadles who could levy fines on householders. In 1357 he addressed the mayor and sheriffs of the city in the following terms:[24]

> "Whereas now, when passing along the water of Thames, we have beheld dung and laystalls and other filth accumulated in diverse places in the said city upon the bank of the river aforesaid and also perceived the fumes and other abominable stenches arriving therefrom ..... (we) do command you that you cause as well the banks of the said river, as the streets and lanes of the same city, and the suburbs thereof, to be cleaned of dung, laystools and other filth without delay and the same when cleaned to be so kept."

He followed this with a proclamation in the same year:[25]

> "It is ordered that no man shall take, or cause to be carried any manner of rubbish, earth, gravel or dung out of his stables or elsewhere to throw and put the same into Rivers of Thames and Fleet or into the Fosses around the walls of the city ..... and as to the dung that is found in the streets and lanes, the same shall be carried and taken elsewhere out of the city by carts, as heretofore; or else by the rakers to certain spots, that the same may be put into the dungboats, without throwing anything into the Thames; for saving the body of the river".

The preferred method of disposing of foul sewage was to store it in cesspools (the "necessary chambers" of Fitzalwyn's Assize) whence it was removed by "rakers" or "gong-fermors" who, besides being well paid for their task, were able to dispose of it at a profit to farmers whose fields, in mediaeval times, were close to London's walls. In 1281 thirteen men took five nights to clear the cloaca of Newgate jail at a total cost of £4.7s.8d, each man being paid 6d a night, three times the normal rate. In the sixteenth century a new market was found amongst saltpetremen who dug up excrement for nitrogen to be used in making gunpowder for the Spanish Wars. The Museum of London holds an advertisement for a "chimney sweeper and night man" called Joseph Waller of Islington who kept "carts and horses for emptying bog houses, drains and cesspools". Latrines did exist though from time to time it was found necessary to restrict their effects upon water courses. In the reign of Henry III the first public latrine (and the first water pipes) were constructed since Roman times

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[24] *Memorials of London Life* p. 295, ed. H.T.Riley, G.L.R.O.
[25] Ibid. pp. 298-9

and in 1383 it was recorded that it cost £11 (about a year's wages for a skilled man) to build a latrine on London Bridge.[26] In the same year, an act ordered those with latrines over the Wallbrook to pay the Lord Chamberlain two shillings a year for cleaning it and another, in 1388, made it illegal to "corrupt or pollute ditches, rivers water and the air of London and elsewhere". In 1477 an Act prohibited the construction of further privies over the Wallbrook. [27]

By the fifteenth century, therefore, we may conclude that the pollution of tributaries had become a matter of frequent public concern and the condition of the Thames itself had attracted the critical attention of more than one monarch. Moreover there is evidence that the cesspools, which were supposed to hold the waste until it could be removed, were contributing to the problem. In 1328 William Sprot had complained to the Assizes that neighbours, William and Adam Mere, had let their cloaca overflow his wall.[28] Three hundred years later in his diary for 20th October 1660 Samuel Pepys recorded: "Going down to my cellar ..... I put my feet into a great heap of turds, by which I find that Mr. Turner's house of office is full and comes into my cellar". Many cesspools regularly overflowed or leaked into nearby watercourses, thereby contributing to the pollution of the tributary streams and of the Thames itself whose tidal reaches until the mid 19th century were a major source of drinking water for the population of London.[29] Indeed most cesspools were not designed to retain liquid contents and this practice persisted well into the nineteenth century with consequences described by Cruickshank and Burton:

> "The most common type of cesspool had no outlet. Primitive versions were simply excavated from the earth and most of the liquid matter was expected to percolate into the ground. This was obviously a danger to health when drinking water was drawn from wells, but it persisted well into Victorian years".[30]

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[26]Trench, R., & Hillman, E.,: *London Under London,* John Murray, 1984, p.59

[27]Ibid., p.60

[28]Ibid., p.61

[29]Middlemass, R.C.,: *London's Main Drainage, Historical Background,* Thames Water, 1975, p.1

[30]Cruickshank, D., and Burton, N.,: *Life in the Georgian City,* Viking, 1990, p.94 (with illustration)

The Post-Mediaeval Period: the Bill of Sewers and its Consequences

The 1531 Bill of Sewers (23 Henry VIII Cap. V) represented the first major attempt to regulate London's sewers in a systematic manner, though it also applied to other parts of the Kingdom. "Commissioners of Sewers shall be directed in all parts within this realm from time to time, where and when need shall require". They were to be nominated by the Lord Chancellor and one other official (the Lord Treasurer or the Lord Chief Justice). No further general statute was to be passed until 1848. The Bill of Sewers was intended to be a temporary measure, with each commission lasting three years. In 1548 the Bill was made perpetual and in 1570 the Commissions were extended to last ten years. The Bill specified the qualifications of commissioners, assigned wages to them and gave them authority to survey walls, streams, ditches, banks, gutters, sewers, bridges, dams, weirs and other impediments to water courses; to enquire into annoyances; to fine offenders; to appoint officers; and to enforce their orders.It established eight commissions to regulate London's system of sewers:[31]

The City	Westminster	Holborn and Finsbury	Tower Hamlets
Greenwich	St. Katherine's	Poplar & Blackwall	Surrey & Kent

Each commission was able to adopt its own practices concerning such matters as the size, shape and inclination of sewers and the differences which resulted were to have serious consequences when the need arose for a unified system in the early nineteenth century (see page 31 et seq. below).

The Bill of Sewers was followed by a number of local Acts which amended or extended the powers it conferred, though the Acts were not uniform in the authority that they conveyed. Thus the local Acts for Westminster and Tower Hamlets did not empower their commissioners to build new sewers, though these powers were granted by the Acts governing the City of London, Holborn & Finsbury and Surrey & Kent. Most of the local Acts continued to envisage the sewers as being intended for carrying away surface water and forbade the drainage of house waste into the system. In the words of Thwaites: "The earlier statutes did not in any way contemplate house drainage, and most of the local Acts prohibited its discharge into the sewers and enforced the construction of cesspools".[32]

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[31]Thwaites, J.,: *A Sketch of the History and Prospects of the Metropolitan Drainage Question*, 1855. pp.5-6, G.L.R.O.

[32]Ibid., p.7

The inadequacy of the systems which were constructed following the Bill of Sewers is evident from the anxiety that they continue to cause the authorities. Letters from Burleigh and Walsingham late in Elizabeth I's reign directed the Lord Mayor to clean up the city as a precaution against plague. On the 10th April 1582 the Lords of the Council addressed the Lord Mayor, complaining that improvements to the sewer formed by the Fleet Ditch, made by Richard Matthew, Her Majesty's Cutler and Bailiff of London sewers, had fallen into disrepair through neglect.[33] The same source [34]contains evidence that the problem recurred in following reigns. A letter from the Lords of the Council made known the wishes of Charles I:

> "The king hath noticed that the ways in and about the City and liberties were very noisome and troublesome for passing, in consequences of breaches of the pavements and excessive quantities of filth lying in the streets. They require him, by the king's express command, to take effectual steps for the complete repair of the pavements and the removal of all filth, the fruits of which his majesty expects to see on his return from Portsmouth".

The letter was dated 20th July 1628 and it is to be assumed that His Majesty was disappointed since a reminder was sent on 21st December. Six years later on the 11th June 1634[35] an order in council requested the "Commissioners of Sewers of the City and Inigo Jones Esq." to arch over the Moor Ditch in order to eliminate a great annoyance. Jones recommended a vaulted sewer six feet high by four feet wide and this was authorised by the Council four days later, suggesting a degree of urgency in the matter. Half a century later, on 13th April 1678, Sir Christopher Wren proposed some modifications to the sewers of the Westminster Commission which would have improved their flushing by providing a readier supply of water from a natural watercourse.[36]

Despite occasional criticisms of this kind, the system which had been substantially established by the Bill of Sewers in 1531 had inherent weaknesses which had been contained while London's population was measured in hundreds of thousands and when fields were near at hand to receive the contents of the capital's cesspools. As demonstrated above (pages 16-18) Leigh, Britton and others were describing the

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[33]*Analytical Index to the Remembrancia, 1579-1664,* Corporation of London, 1878, p. 330, Guildhall Library

[34]Ibid., p.482

[35]Ibid., p.483

[36]M.P.I.C.E. vol. 24, 1864-5, p.281

sanitary condition of London in complacent terms as late as 1844, though in the same year, evidence to the Royal Commission on the State of Large Towns was revealing the growing threat to the health of the Metropolis. Joseph Quick, engineer to the Southwark Water Company, told the commissioners that, by 1840, cesspools were being sunk as deep as the first stratum of sand, through which the liquid content of the cesspools could flow into watercourses and wells which were found at a depth of twelve feet. Consequently, he reported, well water was shunned by the local populace who preferred to be connected to the Southwark company's supplies, though travellers passing through the area, unaware of the contents of the wells, continued to drink from them. Quick reported that the deeper cesspools were preferred by householders since the release of their liquid contents into the sand left a smaller solid residue to be removed, thus reducing the cost of emptying the cesspools.[37] However, the rapid growth of London's population after 1800 and a disproportionate increase in its use of water drew attention to shortcomings which had been tolerated or had passed unnoticed. Overcrowded slum tenements, poor workmanship, inconsistent standards and overflowing cesspools combined in the first few decades of the nineteenth century to precipitate a crisis which ensured that the drainage of the Metropolis was a regular subject of critical debate in Parliament, the press and elsewhere for almost thirty years after 1840. These factors, and their effects, will be examined in the pages that follow.

Edwin Chadwick and the Sanitary Movement

Anxiety about the condition of London's system of drainage must be seen in the context of the Sanitary Movement which became active from the 1840s onwards and in which Edwin Chadwick was one of the most influential figures. Chadwick's contribution to social reform in Victorian Britain is too well known to need detailed description here but the drainage problems of mid-nineteenth century London are inseparable from the rising concern about insanitary conditions, of which London's poorer districts were one of the most alarming manifestations. For this reason it is appropriate to consider the origins of Chadwick's best-known work, the *Report on the Sanitary Conditions of the Labouring Population of Great Britain*, and its main themes since these became major public issues at about the time that steps were being taken to improve London's drainage system. Chadwick's *Report* is also a valuable source of contemporary material not only on the condition of London's sewers but on the social and economic consequences of the deficiencies which Chadwick described.

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[37]P.P. 1844, Vol. 17, q. 5891, evidence of Joseph Quick

Chadwick had been a friend and secretary to the Utilitarian Jeremy Bentham and attended upon the philosopher when he died. After Bentham's death in 1832 Chadwick became an active campaigner for social reform and was associated with the new Poor Laws, establishing workhouses, which became effective in 1834. In the same year Chadwick was appointed secretary to the Poor Law Commission and this role led to his involvement in the enquiry upon which his *Report* was based. In 1838 government auditors queried the expenditure by Poor Law unions of public money on measures designed to remove "nuisances" which they believed to be the cause of disease. The disease, in turn, caused expenditure on Poor Law relief so the unions concerned may be judged to have acted prudently. Flinn suggests that the Poor Law Guardians concerned were acting on Chadwick's instructions with a view to testing the government's attitude towards preventive public health measures[38]. The Home Secretary, Lord John Russell, contemplated the introduction of a Bill to amend the Poor Law legislation to permit such expenditure but he first sought an opinion on the matter from the Poor Law Commissioners.

The Commissioners immediately ordered small-scale enquiries in London into the relationship between urban conditions and disease and the short, ten-page report was presented to the Home Secretary on 14th May 1838. This was followed by three reports by Dr Neil Arnott, Dr James Kay and Dr Southwood Smith which were published as appendices to the fourth Annual Poor Law Report in 1838 and a further report by Southwood Smith was appended to the Fifth Annual Poor Law Report the following year. A letter from Chadwick to Russell on 21st June 1838 reminded the Home Secretary of the evidence in the reports of the connection between insanitary conditions and disease and suggested that: "...it would be worthy of your Lordship to bring in a Bill for an Act...to regulate the future dwellings of the labouring classes, providing that none should be built without provision being made for proper drainage, and the width of streets." Russell took no action so, in September 1839, Charles Blomfield, bishop of London, moved in the House of Lords that an enquiry be made into the sanitary conditions of the labouring classes. Blomfield was a friend and admirer of Chadwick and Simon later suggested that Blomfield had been prompted to initiate the measure by Chadwick[39]. The motion was carried and the *Sanitary Report* was eventually published as a House of Lords paper.

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[38]Flinn, M.W.,: Introduction to Chadwick's *Report*, E.U.P. edition, 1965, p.43
[39]Simon, J., *English Sanitary Institutions*, 1897 p. 187, note, G.L.R.O.

Chadwick made use of the machinery of the Poor Law administration to gather the materials required for his report. Letters were sent to Assistant Commissioners for the Poor Law in England, Wales and Scotland and the report itself contains evidence of Chadwick's extensive reading of continental and American works on sanitary questions, with particular attention to practice in France[40]. Chadwick's Report was published on 9th July 1842, under Chadwick's own name, since the three Poor Law Commissioners declined to allow it to appear over their signatures. Copies were sent to every Board of Guardians and Chadwick claimed "upwards of twenty thousand copies of the Report have been sold" (Chadwick to Lord Brougham 24th July 1842). Simon estimated that ten thousand copies were sold or given away[41]. It was extensively and generously reviewed in leading newspapers including *The Times* (29th August 1842) and *The Morning Chronicle* (30th August 1842) as well as influential quarterlies like the *Quarterly Review*[42] and *Tait's Edinburgh Magazine*[43].

The Report was principally concerned with establishing four major themes. The first was the relationship between insanitary living conditions and disease. The second was the *economic* effects of poor living conditions as manifested in the creation of widows, orphans and those rendered by disease incapable of work, all of whom had to be supported by the Poor Rates. The third theme was the *social* effects of poor living conditions - intemperance and immorality as well as disease - under such headings as "Domestic Mismanagement" and "The Want of Separate Apartments". Chadwick's fourth theme was the need for new systems of administration to bring about a reform of the appalling conditions to which the Report bore witness. The chapter reflects Chadwick's distrust of local bodies, operating under Acts which varied from place to place according to the whims of local citizens and often competing with other local bodies which exercised overlapping jurisdictions. He argued that:

> "Whatever additional force may be needed for the protection of the public health it would everywhere be obtained more economically with unity, and efficiency, and promptitude, by a single securely-qualified and well-appointed responsible local officer than by any new establishment applied in the creation of new local boards." (*Report,* page 410)

This was to become a recurring theme as Chadwick campaigned for strong executive bodies, appointed rather than elected and furnished with the authority and the money

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[40]Flinn, M.W.,:Introduction to Chadwick's *Report*, E.U.P. edition, 1965, p.52
[41]Simon, J. *English Sanitary Institutions,* 1997 p.196, G.L.R.O.
[42]*Quarterly Review,* Vol. LXXI March 1843, pp.417-53
[43]*Tait's Edinburgh Magazine* Vol. IX 1842, pp. 649-60

required to undertake the massive task of sanitary reform. It will be analysed in greater detail in chapter two.

Problems of Workmanship and Consistency

The standards of workmanship which applied in the laying of sewers often left much to be desired. In his Report Chadwick was very critical of the qualities of local surveyors. He quoted "a gentleman, a surveyor of extensive practice", as saying: "As regards the appointment of surveyors to the Commissioners of Sewers, I would observe that, in my opinion, very few of them are properly qualified by education or otherwise to perform the important duties entrusted to them in an effective and proper manner". (*Report,* page 374) He also referred to the experience of the Holborn and Finsbury Commission:

> "When the Commission advertised for a person to act as surveyor to the works who understood the use of the spirit level, the candidates, who were nearly all common house builders, were greatly surprised at the novel demand, and several of them began to learn the use of the instrument, in order to qualify for the appointment" (*Report,* page 387)

Further evidence came from Henry Austin, consulting engineer to the First Metropolitan Sewers Commission, who was asked to conduct a survey of the sewers. It was the practice in many areas to construct egg-shaped sewers with the narrow end downwards so that, when the flow was small (for example at night or in dry weather) the liquid would be concentrated in a narrow area and thus speed the flow. However on 16th September 1848 Austin reported to the Commission that the sewer beneath Cumberland Street, Chelsea, was "egg-shaped, with the *broad* end down".[44] In the circumstances Chadwick's verdict on the condition of London's sewers is not surprising:

> "The sewerage of the Metropolis, though it is a frequent subject of boast to those who have not examined its operations or effects, will be found to be a vast monument of defective administration, of lavish expenditure and extremely defective execution". (*Report,* page 127)

Problems of poor workmanship were compounded by the limited authority held by district surveyors to correct faults. In his evidence to the Commissioners for Inquiring into the State of Large Towns and Populous Districts (The "Health of Towns

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[44]B.L. 8776 h.29 Metropolitan Commissions of Sewers Records

Commission", 1844), chaired by the Duke of Buccleuch and including Robert Stephenson among its members, John Roe, surveyor of the Holborn and Finsbury Sewers Commission, explained the difficulties he faced. While he had the authority to *forbid* builders to connect defective drains to public sewers he had no power to *require* them to make connections[45]. He gave an account of a case in which a house drain was laid so that it flowed *towards* the house[46]. Although in the case concerned he could only prohibit a connection this coercive measure was sufficient to make the builder re-lay the drain.

More difficulties arose from the widely differing powers assumed by different commissions of sewers, operating as they did under different Acts of Parliament in London and the other fifty urban areas to which the Health of Towns Commission directed its enquiries. Referring to the narrow question of surface water drainage the Health of Towns Commission Report wrote: "By some commissions it is considered that, even for the above limited purpose, the authority is restricted to the repair and diversion of sewers already in existence".[47] A further problem arose from the fact that Commissioners responsible for one district were under no obligation to co-ordinate their activities with those of the other seven. In the words of Middlemass:

> "While some useful work was carried out, there was little co-ordination, and drainage work was executed regardless of the effect upon neighbouring systems. Levels and sizes were not compatible - for example egg-shaped sewers with point downward met neighbours with point upward. Moreover the outlets to the river were at about low tide level and in consequence solids settled out in the lower sections of the sewers so that when a storm co-incided with a high tide serious flooding of the low-lying levels occurred".[48]

Nevertheless, the condition of London's sewers and of the Thames continued to be tolerated and was even the source of considerable complacency, as illustrated by the quotations at the start of this chapter, as late as 1844. London sewage continued to be collected in cesspools, numbering some 200,000 in 1810 for a population of more than one million. [49]

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[45]P.P. 1844, vol.17 First Report of the Commissioners, Vol. 2 p.150
[46]Ibid. p.170
[47]Ibid. Vol. 1 of Report p.xiii
[48]Middlemass, R.C., *London's Main Drainage: Historical Background,* Thames Water, 1975 p.1
[49]Trench, R. & Hillman, E.: *London Under London,* John Murray, 1984, p.64

Cesspools and their Consequences

Edwin Chadwick in his *Report* drew attention to some of the consequences of London's two hundred thousand cesspools. He observed that the cost of emptying a cesspool was about one shilling and "with a population generally in debt at the end of the week, and whose rents are collected weekly, such an outlay may be considered as practically impossible" (*Report* page 117). He quoted a report by a civil engineer called Howell, who in his capacity as a surveyor for the metropolis, had inspected two houses about to undergo repairs:

> "Upon visiting the latter, I found whole areas of the cellars of both houses were full of nightsoil to the depth of three feet, which had been permitted for years to accumulate from the overflow of the cesspools..... I would mention another case amongst many more in St. Giles's Parish ..... Upon passing through the passage of the first house I found the yard covered in nightsoil, from the overflowing of the privy to the depth of nearly six inches and bricks were placed to enable the inmates to get across dryshod".

Henry Jephson, a member of the L.C.C. who wrote an account of the development of London's drainage system, quotes a Medical Officer in Whitechapel as late as 1858 describing the effects of cesspools in his annual report:

> "No cesspool ought to be allowed to exist in London, for wherever there is a cesspool, the ground in its vicinity is completely saturated with the foul and putrefying liquid contents, the stench from which is continually rising up and infecting the air which is breathed by the people, and in some instances poisoning the water which is drawn from the public pumps." [50]

On page 118 of his *Report* Chadwick remarks upon the difficulty of finding a market for the contents of the cesspools as agricultural manure. As London grew larger, farms became more remote and inaccessible and the transport and use of human waste as manure become less economical, though the records of the Grand Junction Canal company indicate that, as late as 1904, 45,669 tons of manure was being conveyed by barge from Paddington Basin to be applied to the Hertfordshire countryside.[51] Nightsoil men charged more for removing the waste a greater distance and poorer families, unable to afford the expense, allowed it to accumulate until it became a hazard. During the early 1840s the going rate for a load of human and animal waste

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[50]Jephson, H.,:*The Sanitary Evolution of London,* Fisher Unwin, 1907, p.104
[51]Faulkner, A.,: *The Grand Junction Canal,* W.H.Walker, 1993, p. 195

sold by a nightsoil man to a farmer was 2 shillings and sixpence (12 1/2pence) but in 1847 guano from South America became available as a cheaper and more manageable fertiliser and the market for human waste collapsed. [52]The alternative was to empty the waste into the street whence it would, with luck, make its way into the sewers and the river. Pepys, again, records his neighbour, Sir W. Pen, doing this on the 30th May 1660.

The consequent pressures on the system, compounded by the lack of co-ordination and standardisation between neighbouring commissions, were illustrated by the evidence of Richard Kelsey and John Daw, surveyors, to the Select Committee on Metropolitan Sewage.[53]

> "It appears by the evidence that a case of this kind occurred not long ago in the City of London, through which a part of the Holborn and Finsbury sewage is conducted to the river. The sewers of the Holborn and Finsbury division having been greatly improved and enlarged, the city sewers became inadequate to carry off their contents, and a number of houses in the vicinity of the river were inundated after each fall of rain, the contents of their own drains ..... being actually forced back into their houses from the volume of water which occupied the main sewer".

Kelsey went on to describe the situation in Cheapside:

> "The inhabitants of Cheapside, generally speaking, have got cesspools:they perforated the yellow clay or loam and got into the gravel, and whatever is thrown into the cesspool mixes with the water in the earth: that is for the benefit of the drinkers!"

Some areas were lacking even in properly constructed cesspools. Hector Gavin was a doctor who lectured at Charing Cross Hospital and, in 1848, wrote an account of the sanitary conditions in Bethnal Green, which fell within the jurisdiction of the Tower Hamlets Sewers Commission. The book was called *Sanitary Ramblings* and was addressed to the Marquis of Normanby as president of the Health of Towns Association of which Gavin was himself a member. He described the situation in Bethnal Green in the following terms:[54]

> "House drainage is nearly entirely wanting in Bethnal Green...The inhabitants, therefore, are compelled to get rid of their fluid refuse by throwing it on the

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[52]Smith, F.B.,: *The People's Health, 1830-1910,* Croom Helm, 1979, p.220
[53]P.P. 1834, Vol 15 pp 602 and 612-15
[54]Gavin, H.,: *Sanitary Ramblings,* January 1848, p.75, G.L.R.O.

gardens, yards, or streets. Sometimes holes are dug in the gardens, or yards, to receive the refuse water. These holes are frequently closely adjacent to the wells whence the occupants derive their supply of water."

Later in the same account Gavin described how the inhabitants dealt with the consequences of these methods of waste disposal."In numerous instances the inhabitants have piled, either in their yards, or in their houses or in the alleys fronting the houses, collections of dust and cinders, to conceal from the eye the soil which has oozed from the neighbouring privies or cesspools". [55]As late as 1900 A.B.Hopkins wrote that "To this day it is not unfrequently discovered, when a health officer is called in to investigate the case of an outbreak of illness in a house, that there is an old cesspool underneath." [56]

The Coming of the Watercloset

Further factors combined to precipitate the crisis which led to the creation of a unified Metropolitan Commission of Sewers in 1848. Of these the first was the growing popularity, from the late eighteenth century, of the water closet. A water flushing device may be seen in the Minoan Palace at Knossos, dating from 1700 B.C., but it was forgotten for over three thousand years before being re-discovered in the late sixteenth century by Sir John Harington who described his invention in his book *The Metamorphosis of Ajax: a Cloacinean Satire* published in 1596. He installed one at his own home at Keston, near Bath and another at the palace of Queen Elizabeth at Richmond. For the next two centuries the invention was virtually ignored until, in 1775, a patent was taken out by a Bond Street watchmaker, Alexander Cumings, for an improved version of Harington's device. Further improvements were made to the valve mechanism by Joseph Bramah, a cabinet maker, who registered his patent in 1778.[57] By 1797 he had made over 6,000 closets and continued to produce them until 1890.[58] In 1844 the London builder Thomas Cubitt, in evidence to the Royal Commission on the State of Large Towns and Populous Districts, estimated that, in the previous twenty years, the number of closets installed in London had increased tenfold.[59] A further stimulus was provided by the Great Exhibition of 1851 when

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[55]Gavin,H., : *Sanitary Ramblings,* January 1848,p.80, G.L.R.O.

[56]Hopkins, A.B.,: *The Boroughs of the Metropolis* Bemrose, 1900

[57]McNeil, I.,: *Joseph Bramah: a Century of Invention,* David & Charles, 1968, p. 30; prior to the registration of this patent the name had been spelt Bramma, as on his birth certificate

[58]Wright, L.,: *Clean and Decent,* Routledge, 1980, p.78

[59]P.P. 1844, vol. 18, q. 181

827,000 people used W.C.s installed for the occasion in Hyde Park by George Jennings, many no doubt experiencing the device for the first time.[60] The effects of the adoption of water closets by wealthier London households was described in the First Report of the Royal Commission on Metropolitan Sewage Discharge:[61] "About 1810 an invention was introduced which had a very important effect on the drainage system, namely the water-closet".

The report proceeds to describe how the greatly increased volume of water used by a WC as compared with an old-fashioned cesspool put further strains on the drainage system. The effect is illustrated by an article published in June 1859 which demonstrated how the volume of water used in London houses almost doubled in the six years from 1850 to 1856. The figures were:[62]

1850	270,581 houses used an average of 160 gallons each per day
1856	328,561 houses used an average of 244 gallons each per day

These figures, taken together, give a daily usage of 43.3 million gallons per day in 1850 and 80.8 million gallons per day in 1856. A contemporary estimate of the pace at which water-closets were introduced to the capital was provided by three engineers who, in 1857, were asked to report on Bazalgette's main drainage proposals. In their report they wrote:

> "We believe that the introduction of water-closets in the metropolis, to any extent, may be dated from about the year 1810, from which time until 1830 their increase was only gradual; but since 1830 the increase has been very rapid and remarkable. The number of cesspools which have been discontinued in London, is stated to be not far short of two hundred thousand."[63]

The effects of the growing popularity of the water-closet were also noted by William Farr, first statistician to the Registrar General of births, marriages and deaths, in his report on the cholera epidemic of 1866. On page 53 of the introduction to the report he wrote:

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[60] *Plumbing and Mechanical Magazine,* July 1989, p.27

[61] P.P. 1884, vol. 41 p.xi

[62] Strang, J., LL.D., City Chamberlain, Glasgow: *Journal of the Statistical Society*; June 1859 p. 233; *On Water Supply to Great Towns*

[63] P.P. 1857 (2), vol. 36, page 4 note 3; *Report to the First Commissioner by Capt. Douglas Galton, J.Simpson, Esq., and Thomas E.Blackwell*

> "Almost co-incidentally with the appearance of epidemic cholera [he is referring to the 1849 outbreak in London], and with the striking increase of diarrhoea in England, was the introduction into general use of the water-closet system, which had the advantage of carrying night-soil out of the house but the incidental and not necessary disadvantage of discharging it into the rivers from which the [water] supply was drawn".

Porter concludes that the sanitation problems thus caused by the coming of the Water Closet was evidence of progress: "Pollution was, ironically, the offshoot of progress. Wider provision of piped water supplied by London's private water companies led to growing use of flushing water closets. Instead of being deposited in cesspits, human waste was now gushing into sewers and so into the Thames".[64] As a result some Victorian cities, including Manchester, discouraged the use of W.Cs among all classes "because of the strain their outpourings imposed on the drainage and sewerage system".[65]

The increasing use of water for the W.C. and other purposes co-incided with other social and regulatory[66] changes which combined to bring about a sudden deterioration in the condition of the Thames. The social factor concerns the growth of London's population which increased as follows in the census years from 1801:[67]

Census Year	Population	Index
1801	959,000	100
1811	1,139,000	119
1821	1,378,000	144
1831	1,655,000	173
1841	1,945,000	203
1851	2,362,000	246
1861	2,807,000	293

The waste disposal problems caused by the growth of London's population in the first sixty years of the century were compounded by the fact that, as the urban area grew, the rural areas retreated to a greater distance, making it more costly to dispose of the contents of the cesspools on the fields.

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[64]Porter, R.,: *London, a Social History,* Hamish Hamilton, 1994, p.260
[65]Best, G.,: *Mid-Victorian Britain* 1851-75, Weidenfeld & Nicolson, 1971, p. 23
[66]See following page for the regulatory change made in 1815
[67]Hollis, J., and Seddon, A.,: "The Changing Population of the London Boroughs" Stat. series No. 5, 1985, O.P.C.S. Library

Thus by the late 1840s a number of factors had combined to turn London's drainage system from a source of satisfaction to writers like Booth, Britton and Leigh to one of well-justified anxiety and criticism for its effects upon the health and comfort of the population. The population had more than doubled in forty years and, as usage of water-closets increased, the volume of waste increased disproportionately. The division of responsibility for the system amongst eight different commissions of sewers (with over one thousand commissioners) created differences in workmanship and standards which meant that, when one part of the system was improved, it was liable to create insupportable pressures elsewhere in the system, causing bursts of the kind described by Kelsey and Daw to the Select Committee on Metropolitan Sewage (see page 34 above). As the fields retreated before the growing urban population the problems of disposing of the contents of the cesspools grew greater and, in the face of guano imports, the market effectively collapsed. As early as 1815, in an attempt to relieve pressure on the cesspools, the prohibition of earlier statutes on connecting house drains to the sewers was lifted[68]. Thomas Cubitt, commenting on the effects of this measure, in evidence to the Select Committee on the Health of Towns observed that:

> "Fifty years ago nearly all London had every house cleansed into a large cesspool...Now sewers having been very much improved, scarcely any person thinks of making a cesspool, but it is carried off at once into the river. It would be a great improvement if that could be carried off independently of the town, but the Thames is now made a great cesspool instead of each person having one of his own".[69]

If further incentives were needed to take seriously the need for improvements in the sanitary conditions of the Metropolis it arrived with the threat of cholera. The first outbreak of this disease had occurred at Sunderland in 1832 and its progress around Europe was anxiously followed in the press from that date. It was understood, though imperfectly, that it was associated with insanitary conditions. Following the Sunderland outbreak a Parliamentary Committee examined a scheme submitted by John Martin to improve London's sewerage. The scheme provided for the establishment of "Grand Receptacles" on the Regent's Park and Grand Surrey canals, whence the sewage would be transported for sale to farmers. It foreshadowed many similar proposals which are examined in chapter four. Nevertheless, when stripped of

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[68]Middlemass, R.C.,: *London's Main Drainage: Historical Background:* Thames Water, 1975, p.1

[69]P.P. 1840, vol. 11, Q.3452

these agricultural embellishments, Martin's scheme bore many of the characteristics of the one eventually devised by Bazalgette[70] and, though nothing came of the scheme (no body existed which could have carried it out) a number of Parliamentary initiatives then followed which led, eventually, to the establishment of the Metropolitan Board of Works.

Early Attempts at Reform through Legislation

In 1839 a Bill was drafted which included four features that are noteworthy in the light of later developments.[71] First, the preamble to the Bill recognised the deficiencies of earlier legislation with regard to house drainage and also as it concerned the authority vested in Commissions of Sewers: "Whereas the general laws of sewers...have no reference to the drainage of houses, or to the removal therefrom of the sulliage and other refuse matters". It goes on to refer to previous statutes from mediaeval times and acknowledges: "whereas doubts have arisen as to the powers given to the commissioners of sewers by the said recited Acts...as to the legal power of Courts of Sewers to decree and order new works to be made..."

Secondly, the Bill proposed to create six new districts:

The City	Western	Finsbury
Poplar	Southern	Tower Hamlets

Thirdly, it proposed an overall authority, the Metropolitan Court of Sewers, to exercise jurisdiction over the six districts, to lay down standards, settle boundary disputes, set rates and authorise the connection of properties to the sewers. Section XI clauses 13-15 empowered the court to *require* properties to be connected to the sewers - the first time this provision appears in any proposed legislation. Finally, the Bill proposed that the City of London would fall within the jurisdiction of the Metropolitan Court: "This Act shall have operation in the City of London and the liberties thereof".

The only concession to the long protected independence of the City was that, in settling boundary disputes, the Metropolitan Court would not have the authority to

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[70]P.P. 1834, vol. 15, pp. 371-5
[71]P.P. 1839, vol. 5, p.161

transfer to other Districts any areas which had previously belonged to the City. MPs would be commissioners in their respective districts, as would the Lord Mayor. The Metropolitan Court, with authority over the Districts, would have as members three commissioners from each district together with MPs, the Lord Mayor, the Presidents of the Royal Colleges of Physicians and Surgeons, certain JPs and the Master General of the Board of Ordnance. This Bill, described in detail in the Parliamentary Papers referred to, contained many features of the Acts which established the Metropolitan Commission of Sewers and the Metropolitan Board of Works nine and sixteen years later respectively, though the later Acts did not confer so much authority over the City of London and it may well have been opposition from the latter which caused the Bill to be lost.

The *Commons Journals* vol. xciv, 1839, records that leave was given on 23rd April 1839 to Mr Henry Ward, M.P. for Sheffield and Mr Benjamin Hawes, M.P. for Lambeth to bring in the Bill which received its first reading on 1st August. The Bill was then dropped. This early attempt at sanitary reform in London came to nothing but it was followed in 1843 by *A Bill for the better regulating the Buildings of the Metropolitan Districts, and to provide for the drainage thereof,* normally referred to as the Metropolitan Buildings Act, 1844. The difficulties encountered by the early sanitary legislation are reflected in the fact that this Act was amended three times in its first year and thrice more over the next eight years. It required (paragraph 37) that no new building be constructed without being connected to the common sewers provided this was within thirty feet of the building. One of the later amendments extended this distance to one hundred feet. The same requirement applied to extensions to existing buildings and to buildings that were substantially re-constructed. Drains had to be at least nine inches in diameter and "must be built of brick, tile, stone or slate, set in mortar or cement".[72]An 1847 amendment specified "all cesspools and privies to be so constructed as to prevent escape save into drain or sewer." [73]This Act ensured that new buildings would be connected to the sewers but had little impact on existing buildings unless they were extended or rebuilt. The *Nuisances Removal and Diseases Prevention Act*, 1846, commonly known as the "Cholera Bill", provided a mechanism whereby existing buildings could be regulated. The preamble to the Bill describes it as: "A Bill for the more speedy removal of certain Nuisances, and to enable the Privy Council to make Regulations for the Prevention of Contagious and Epidemic Disease".It enabled the Privy Council to

[72]P.P. 1844, vol. 3, p. 591, third amendment to original Bill
[73]P.P. 1847, vol. 2, p.473 Schedule H

issue "any such new rules or regulations as to them may appear necessary or expedient" to prevent disease and these provisions were later used by the General Board of Health during the Cholera epidemic of 1848-9, both to compel property owners to clean and whitewash their properties and to encourage them to make connections with the sewers.

The Metropolitan Commission of Sewers

In 1847 a Royal Commission was established to "Inquire whether any, and what special means might be requisite for the health of the Metropolis, with regard more especially...to better house, street and land drainage".[74] The Commission was chaired by Lord Morpeth, Commissioner of Woods and Forests. Morpeth was a close ally of Edwin Chadwick who was appointed to the Commission by the Prime Minister, Russell, along with Southwood Smith, Professor Richard Owen and Henry Austin, all of whom had been previously associated with Chadwick and the movement for sanitary reform.The other members were R.L.Jones, a Common Councillor, who represented the City, and Lord Robert Grosvenor, son of the Duke of Westminster. The Commission, strongly influenced by Chadwick, recommended that the seven commissions of sewers which had been prescribed by Henry VIII's Bill of Sewers be amalgamated into one Metropolitan Commission of Sewers, the Commissioners to be appointed by Royal Warrant. The City Commission ensured its own survival as a separate unit by securing the passage of its own Sewers Bill. The recommendations of the Commission were accepted and the Metropolitan Sewers Act (11 and 12 Victoria Cap. 112) gave jurisdiction over "places or parts in the counties of Middlesex, Surrey, Essex or Kent, or any of them, not more than twelve miles distant in a straight line from St Paul's Cathedral, but not being within the City of London or the liberties thereof".

The recommendations came into effect before the passing of the required legislation. This occurred because the authority of six of the commissions was due to expire on 30th November 1847 and that of the seventh, St. Katherine's, on 4th December. To overcome this short-term problem twenty three commissioners were selected and appointed to all the existing commissions as the old commissions' authority expired. These twenty-three then continued in office as the First Metropolitan Sewers Commission when the Act was passed. Morpeth was the chairman and other notable members included Chadwick, six MPs, three doctors, including the Queen's

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[74]P.P. 1847-8, vol. 32, p.3

physician, Sir Henry de la Beche, (Director General of the Ordnance Survey), John Walter (proprietor of *The Times*) and four who had served on the old commissions. These included John Leslie who, as a former member of the Westminster Sewers Commission, had played an active part in exposing corruption therein.[75] In this work he had been assisted by Hertslet and Phillips, respectively Clerk and Surveyor to the First Metropolitan Sewers Commission. Leslie, "a thoroughly unpleasant man, spiteful, offensive and ungenerous"[76] was to exercise a powerful destructive influence in the first two commissions, of which he was a member and, later, in the Metropolitan Board of Works, to which he was also elected. Hertslet and Phillips were to prove valuable allies to Leslie in his attempts to disrupt the work of the First and Second Commissions.

Thus twenty-three commissioners replaced one thousand and sixty-five commissioners who had nominally served on the former seven district commissions. The commissioners were unpaid and each commission was to last two years. The Act forbade the construction of houses without suitable drains and required them to be connected to public sewers provided there was one within one hundred feet, thus echoing the provisions of the 1844 Metropolitan Buildings Act. In addition, all new houses had to have a WC or privy and ash pit, on pain of a £20 fine. For the first time, Commissioners were given the authority to order that existing properties be connected to the sewers. Having given the Commissioners powers over new and reconstructed buildings Clause 45 prescribed that "if any house built before or after the passing of this Act, within the limits of the Commission, and its appurtenances, shall not be drained to the satisfaction of the Commissioners, the Commissioners shall make the like order for the drainage of the same".

Clause 47 enabled the Commissioners to insist upon the provision of WCs or privies and ash pits in new or existing dwellings and, if property owners failed to carry out the work, the Commissioners could execute the work themselves and levy a charge. Clauses 38 and 42 enabled them to require the City authorities to carry out drainage works where they were considered necessary by the Metropolitan Commissioners. In 1849 these powers were further strengthened by an amendment which prescribed that, if a watercourse were considered by one of the commission's surveyors to be "prejudicial to the health of the neighbourhood" then it might be "abated without

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[75]P.P. 1845, vol. 18, Second Report, Health of Towns Commission, Minutes of Evidence, Q. 211-227

[76]Finer, S.E.,: *The Life and Times of Sir Edwin Chadwick,* Methuen, 1952, p.356

previous notice" and the owner required to pay.[77] The 1848 Act thus created a body which disposed of more power than its predecessors, including considerable influence over the City, though not as much direct authority as the failed 1839 Bill would have conferred. In the words of Thwaites: "All doubts as to the legal rights to construct sewers were removed, all sewers were vested in the Commissioners, and full power was given them over private drainage". [78]

Humphreys, in his account of the development of London's main drainage, is rather dismissive of the achievements of the Metropolitan Commissions: "Numerous designs for improving the drainage system of London and for preventing the discharge into the river Thames were considered but no real advance made."[79]This unflattering judgement does less than justice to the six short-lived and under-funded commissions which sat from 1848 to 1855. The First Commission began by asking the Ordnance Survey to prepare a survey of London's sewers to a scale of five feet to the mile and a survey of house drains to a scale of ten feet to the mile. The request immediately ran into a legal difficulty. On 18th May 1848 the minutes recorded that, in the opinion of the Attorney General and Solicitor General, a general Ordnance Survey could not be commissioned. It would be necessary for separate surveys to be ordered for each of the former districts.[80] This problem having been overcome the First Commission, in the words of the First Report of the Royal Commission on Metropolitan Sewage Discharge "began zealously on the improvement of the house drainage, the abolition of cesspools and the introduction of pipe-sewer communications between the houses and the main drains".[81] This judgement is supported by Middlemass who states that:

> "The Commission promptly required the abandonment of the cesspools in the area, and that all house drainage should be by direct communication to the sewers, causing a drastic alteration in the drainage pattern. These measures radically improved the situation in locations remote from the river but the conditions in and adjacent to the Thames deteriorated further".[82]

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[77]P.P. 1849, vol. 4 p.229

[78]Thwaites, J.,: *A Sketch of the History and Prospects of the Metropolitan Drainage Question,* 1855, p.8

[79]Humphreys, Sir George: *The Main Drainage of London,* L.C.C., 1930, p.10

[80]B.L. 8776 h. 29, Metropolitan Commission of Sewers; also MCS Reports 1848-9, ref. MCS 476, document 17, G.L.R.O.

[81]P.P. 1884, vol. 41, p.xiii

[82]Middlemass, R.C.,: *London's Main Drainage: Historical Background,* Thames Water, 1975, p.2

Bazalgette described the process and its consequences in a paper delivered to the Institution of Civil Engineers:

> "Within a period of about six years, thirty thousand cesspools were abolished, and all house and street refuse was turned into the river.....In times of heavy and long-continued rains, and more particularly when these occurred at the time of high water in the river, the closed sewers were unable to store the increased volume of sewage, which then rose through the house drains and flooded the basements of the houses".[83]

Moreover, since many of the sewer outlets into the river were tide-locked, discharge could take place only at low tide, the consequence of this being that the first movement of the sewage was upstream as the tide turned.[84] The need for the priority which the First Commission gave to promoting the connection of house drains to sewers is attested by Hector Gavin, who described the reluctance of builders and landlords to connect their properties to the public sewers.[85] He related how, in the period 1838-47, 76,386 feet of sewer had been laid and only 750 connections made - less than one property for every hundred feet of sewer. He argued that "This fact sufficiently proves that it is necessary to make it compulsory on owners of houses to form drains in connection with sewers".

In 1847, in an article in *Fraser's Magazine* entitled "The Sanitary Commission and the Health of the Metropolis" W.A.Guy wrote of sanitary reform in the following terms: "The object of the sanitary movement may be summed up in a few words - a sewer in every street of every town and village; a drain for every house; a constant and unlimited supply of good water to every family; pure air at any cost; the application of the refuse of towns to the purposes of agriculture".[86] *The Times*, on 4th October 1849, quoted Chadwick, whose sanitary ideas dominated the Commission, more succinctly but along the same lines as advocating: "the complete drainage and purification of the dwelling house, next of the street and lastly of the river". The weakness of this approach, which was demonstrated in the cholera epidemics, was that, by disposing of human waste in the river, its most harmful elements returned in the capital's water supply: "the systematic drainage of the inner city districts which was undertaken during the sanitary revolution [was] at the short-term cost of a

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[83]M.P.I.C.E., vol. 24, 1864-5, pp. 283 and 287, Bazalgette's paper on the Main Drainage of London

[84]M.B.W.: *Annual Report*, 1888, p. 3

[85]Gavin, H.,: *Sanitary Ramblings,* January 1848, p.75, G.L.R.O.

[86]*Fraser's Magazine,* Vol. 36, Nov. 1847, pp.505-17

deterioration in water supplies drawn from river sources which were still too close to major sewer outlets".[87] Nevertheless the First Commission, though it drew up no plans for a system of intercepting sewers to protect the Thames, had taken the first steps towards cleaning the dwellings of the population as advocated by the sanitary reformers. It had also begun the Ordnance Survey which would be used by the future designers of the intercepting system.

The Second Commission, which took office on 1st January 1849, was strengthened by the addition of new members who included three army engineers - Sir John Burgoyne, Captain Vetch (a member of the tidal harbour commission) and Captain Dawson of the Ordnance Survey. Other new members included Cuthbert Johnson, an authority on manure. His addition to the membership reflected Chadwick's interest in the use of sewage as manure (see Chapter Four below). The new commission began experiments with different types and sizes of sewage pipe and addressed the question of an intercepting system. The commissioners asked their consulting engineer, Henry Austin, to prepare a design. Austin's proposal was for a "converging system" in which sewage would be conducted to four reservoirs which would converge on a pumping station in Belgravia from which the sewage would be pumped for use in agricultural areas. Austin claimed[88] that the system could be built:

> "at a cost fully 30% below that of the most improved and economical arrangements under the present system" because "the cost of engine power and of the suction and distributing pipes, together with the annual expense of working, would not be a charge upon the public, as it would be borne by the parties to whom the application of the refuse to agriculture would be entrusted".

John Phillips, Chief Surveyor to the Metropolitan Commission, produced a rival plan for intercepting tunnel sewers running nineteen and a half miles from Eel Pie island, Twickenham, to Plumstead marshes. It would cross the Thames eleven times. It would be for sewage only, not for surface water, which could continue to run into the river via the old watercourses. The sewage would be made available for agricultural use along the route of the intercepting sewer and Phillips, like Austin, made some generous claims for the revenue that could be expected from this course. He estimated that the total cost of the sewer, with its associated machinery, would be £634,991 12s

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[87]Woods, R., and Woodward, J., (eds): *Urban Disease and Mortality in Nineteenth Century England*, Batsford, 1984, pp.112-13

[88]B.L. 8776 h.29 Metropolitan Commission of Sewers 9th February 1848

10d.[89]What Thwaites described as "a warm controversy" [90] followed as Austin and Phillips criticised each other's plans. Chadwick, who enjoyed a majority on the Commission, favoured Austin's plan. The controversy reached its height when on 21st June 1849, Phillips addressed a letter to the Commission whose insulting tones suggest to Finer that it may have been influenced by Leslie.[91] The letter included the following sentence:

> "Instead of limiting the attention of the Court to minor matters and piecemeal work.....to the advantages of a three inch over a four inch pipe, or to the shape of a water-closet pan, the energy of the Commission and its officers should, in the first instance, have been concentrated on the selection of a sound and thoroughly practicable and intelligible plan for providing an outfall entirely independent of the Thames for the complete and permanent drainage of the whole of the districts within the jurisdiction of the Metropolis".

Leslie's other protege, Hertslet, announced his resignation as secretary to the Commission over Chadwick's preference for Austin's plan. *The Times*, whose proprietor John Walter was in the minority which supported Phillips, also criticised the Commission for using sub-committees, working in private, to transact important business and demanded independent scrutiny of the rival plans by engineers unconnected with the Commission, though the latter had already appointed its own assessors, headed by Robert Stephenson.

The Commissioners could not agree on either plan so, on 20th August 1849, they issued a general invitation to engineers to submit their own schemes. At this time, 16th August 1849, they appointed Joseph Bazalgette Assistant Surveyor to the Commission at an annual salary of £250. They subsequently received one hundred and thirty-seven proposals in response to their invitation but the Commission left office before evaluating them. Acrimony descended into farce when the Commission attempted to organise meetings which excluded the dissenters[92]. The atmosphere had become so charged with distrust that Morpeth decided that a new Commission was essential and wrote to Chadwick to tell him so on 29th September 1849:"...neither of the prominent parties in the late disputes and differences should re-appear in the new

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[89]Ibid., no. 78 23rd July 1849

[90]Thwaites, J.,: *A Sketch of the History and Prospects of the Metropolitan Drainage Question,* 1855 p.9

[91]Finer, S.E.,: *The Life and Times of Sir Edwin Chadwick,* Methuen, 1952, pp.369-70

[92]Ibid., p.376

[Commission]...the government and public will require the sanction of the highest engineering authority that can be procured".

The Engineers' Commission: a Plan Devised

Chadwick and Leslie were thus excluded from the new, (Third) Commission which took office on 8th October 1849. It became known as "The Engineers' Commission" because the commissioners included a number of eminent members of that profession. Robert Stephenson agreed to join the Third Commission and he insisted on bringing with him, as fellow commissioners, Samuel Morton Peto, J.M.Rendel and Philip Hardwicke, all of whom had worked with Stephenson on railway projects. Frank Forster, who had also worked with Stephenson on railway construction, was appointed Engineer to the Commission. A sub-committee was set up to examine the one hundred and thirty-seven plans which had been submitted in response to the Second Commission's invitation for proposals. It included five commissioners: Stephenson, Vetch, Burgoyne, Rendel and Harness who delegated the work of scrutinising and classifying the schemes to Bazalgette and another Assistant Surveyor called Edward Cresy. Their report was read by Woolrych, secretary to the Commission, at a special meeting held on 15th March 1850. The degree of public interest in the matter may be gauged from the fact that the commissioners' deliberations were described at length not only in professional publications like *The Builder* but also in *The Times* which devoted four columns to the subject on 16th March 1850.[93] Bazalgette and Cresy divided the schemes into seven categories:[94]

1. Portable cesspool systems; using little water to reduce bulk and to avoid weakening properties of the sewage as agricultural fertiliser

2. Systems which discharged into the Thames

3. Intercepting tunnels or culverts adjacent to the Thames

4. Several tunnels or culverts at different levels

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[93]*The Times,* 16th March, 1850, page 7 cols 1-4
[94]M.P.I.C.E.: vol. 24, 1864-5, p.513

5. Cesspools by the Thames from which sewage would be conveyed to rural areas

6. Converging reservoir systems, like Austin's earlier proposal.
7. Systems described as "almost exclusively confined to the consideration of processes and expedients for infiltrating, de-odorising and solidifying the sewage for the purposes of the market gardener".

One hundred and sixteen proposals were allocated to the above seven categories while a further twenty-one were dismissed in the following terms:

> "Numerous communications have come under our notice which may for the most part be described as vague, speculative, disquisitious or collateral...few of which can be said to possess any practical value."

One proposal, which was presented under the name "Onalar" was described as "a long, unconnected and unintelligible paper".

In evaluating the proposals the commissioners were governed by three principles. First, they believed that surface drainage and house drainage should be united, an assumption that was to be challenged later. Second, the commissioners believed that high level drainage should not be brought to lower levels where this could be avoided. Rather, natural gradients should be used to convey sewage to a common outfall, thus reducing the need for pumping. Finally, and consistently with the latter aim, natural gravitation was preferred to mechanical means of conveying the sewage. Several of the plans, including a proposal from W.H.Smith, involved conveyance of sewage by rail while a variant of this was a proposal from J.Bethel for sewage pipes laid along railway lines. Another, submitted under the pseudonym "Pontifex" proposed conveying solid manure by barge along the river and canal system while liquid would flow along a tunnel in the bed of the Thames.

After debating the matter the committee announced, on 8th March 1850, that none of the schemes submitted was entirely satisfactory though the system submitted by J.B.M'Clean was chosen as the best. It was an intercepting system which involved conveying sewage by an iron syphon beneath the Thames above Vauxhall to drain the lower districts of Westminster but it neglected the North banks of the Thames between Charing Cross and Shadwell. The plan of Nasmyth and Statham was also commended, though confined to the South side of the river as was that of J.Bayley

Denton. This plan proposed to convey sewage from the high levels to agricultural reservoirs while the low level sewage would be piped to the Thames at Deptford and Barking. Phillips had re-submitted his plan for a tunnel from Twickenham to Plumstead and Austin submitted his proposal for a "converging" system.

The commissioners decided to ask the Engineer to the Commission, Frank Forster, to design a new proposal. On 1st August 1850 he submitted plans for the South side drainage which involved building one intercepting sewer which was served by pumping stations at Ravensbourne Creek and Woolwich Marshes before discharging into the Thames at Plumstead. On 31st January 1851 he submitted plans for the North side which he had developed in conjunction with Colonel William Haywood, the City Engineer. These consisted of two sewers, each with branches leading to a pumping station at the River Lea. *The Builder*, in commenting on the scheme, wrote that sixteen square miles of Fulham and Hammersmith had been omitted from the system because: "The Metropolitan Sewage Manure Company's works is in the heart of the district, which is eminently adapted for the application of sewage water as manure and offers grounds for the belief that the whole of the sewage produced in the district may be profitably applied."[95] This area was also difficult to drain since it was low lying and would require special arrangements in the scheme eventually devised by Bazalgette.

Some work for the system on the Northern side had in fact already begun, in the form of the Victoria Street sewer which would run from Pimlico to Percy Wharf, Westminster (near Scotland Yard) via Parliament Square. The Metropolitan Commission of Sewers Report for 1850, written by Woolrych, secretary to the Commission, includes a reference to the Victoria Street Sewer:[96]

> "This length of sewer constitutes a portion of the main low level intercepting line...and is intended to be continued eastward along the bank of the Thames to Blackfriars Bridge and thence by the course specified in that report [i.e. Forster's report of 31/1/51] to the pumping station on the bank of the River Lea".

The Victoria Street Sewer was to be the source of great embarrassment to the Commission as a result of difficult terrain (quicksand), poor workmanship, changes in

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[95] *The Builder*: 8th February 1851, p.95

[96] P.P. 1851, vol. 48, Metropolitan Commission of Sewers Report, p. 3 (followed by correspondence on the problems in constructing the sewer)

specifications, catastrophic collapses of work in progress and damage to nearby properties. The original estimate for the two construction contracts had been £12,300. The final cost of the sewers was £54,866 2s 5 3/4d.[97] In the same report Woolrych wrote that the Ordnance Survey of the Metropolis, requested by the First Commission in 1848, was nearing completion at a cost of £23,630 7s 11d. Difficulties over the Victoria Street Sewer and over the final choice of an intercepting system provoked much criticism from Metropolitan MPs, local Vestries and *The Times* and the critical climate was also manifested in Parliamentary debates.[98] In the face of this criticism the chairman, Lord Ebrington, who was one of the few survivors from the Second Commission, resigned along with the other commissioners. They were immediately re-appointed, still as the Third Commission. A barrister called Lawes was designated chairman and upon his death shortly afterwards the engineer Morton Peto assumed the chairmanship. Nevertheless in June 1852 the Third Commission (The "Engineers" Commission) resigned. It had lasted longer than either of its predecessors and had been responsible for devising schemes for intercepting sewers north and south of the River which bore many of the characteristics of the scheme later implemented by Bazalgette. The Commission resigned because its revenue from the sewer rates was inadequate for the task it had to perform.

The Fourth Commission, which held office from July to October 1852, was divided over whether to support Forster's plan or a rival scheme promoted by Captain Vetch. During the Fourth Commission's brief term of office Forster died, the victim of "harassing fatigues and anxieties of official duties".[99] Some idea of the pressure on the Commissioners and their officers at this time is conveyed by Forster's obituary notice which commented that:

> "A more general and hearty support from the Board he served, might have prolonged a valuable life, which as it was, became embittered and shortened, by the labours, thwartings and anxieties of a thankless office".[100]

The Appointment of Joseph Bazalgette

Bazalgette was appointed as his successor. Joseph Bazalgette, like several other prominent Victorian figures, including John Simon and Isambard Brunel, was of

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[97]P.P. 1854-5, vol. 53 p.283
[98]*Hansard* 16/5/51 vol. cxvi col. 1063; 24 and 29/7/51, vol. cxviii cols 1468 and 1700
[99]*Civil Engineer and Architect's Journal,* 1852, vol. 15, page 160
[100]M.P.I.C.E., vol. 12, 1852-3, p. 158

French extraction. His grandfather, Jean Louis Bazalgette, was born in the small town of Ispagnac, Lozere, near Mende, on 5th October 1750.[101] Lozere is the most sparsely inhabited of France's Departments and has long been a stronghold of Protestantism though the account in the *Almanach Cevenol* claims that Jean Louis was baptised the day after he was born in the Catholic church at Ispagnac. A village on the moorland nearby, now largely deserted, is called Bazalgette, its existence being recorded as early as 1270 in an official document held at the departmental archives in Mende.[102] The name is unusual even in France and several explanations have been offered of its origins, none of which has been proved beyond doubt. One account claims that the name derives from the Sultan Bajazet who defeated the last crusaders at Nicopolis in 1396. Another suggests that the name was brought to France in the late eighth century by a Spaniard fighting in the army of Charlemagne and that this ancestor settled in the Gevaudan area at this time, just North West of Mende. By the thirteenth century the family had acquired a coat of arms, Pierre Bazalgette being appointed a judge in Ispagnac, near Mende, by King Philip the Fair in 1298 while another member of the family was commemorated in the church of Aigues Mortes as having accompanied Louis IX on crusade in 1270. In 1604 Martin de Bazalgette left the Gevaudan area to settle in the Vivarais, on the patrimony of his new wife. They lived in the chateau de Charneve, near the town of Bourg St Andeol, on the Rhone just South of Montelimar, where a substantial residence *L'Hotel de Bazalgette de Charneve* is still to be found. Raymond Bazalgette de Charneve was amongst the noblemen nominated to the Estates-General in 1789. Other members of the family remained in the Ispagnac area where the name is still common. One of them, Antoine Bazalgette, was appointed to the office of consul (magistrate) in 1663[103] and about 1770 his great grandson, Jean Louis, aged twenty, left France for the Americas, an act which may, according to the account in the *Almanach Cevenol*, have been prompted by a desire to escape conscription into the French Army. What is certain is that he acquired property in Jamaica.[104]

Jean Louis later claimed to have arrived in England in 1775 though the first definite record of his presence is his marriage to Katherine Metivier on 14th August 1779 at St George's, Hanover Square at which time, according to contemporary rate books, he was living in South Moulton Street. Jean Louis prospered. By 1786 he was living in

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101 *Almanach Cevenol,* 1970, pp.169-76:Archives Departmentales,Mende.

102Lease dated 25th June 1287 held in the departmental archives

103An account of the Bazalgette family compiled by Jean Bazalgette, Cardet, Gard, from family records and others held in the Lozere archives

104Jean Louis Bazalgette's will, in the possession of the Bazalgette family.

Grosvenor Street, and by 1789 he had established himself as a merchant in Little Grosvenor Street (now Grosvenor Street) an address at which he remained trading for at least the next twelve years,[105] in an area where there was had been a substantial number of French emigre merchants, including many tailors, for almost a century.[106] During this time he occupied houses in Turnham Green and Gloucester Place. By this time he was a very wealthy man. On 11th May 1787 the Prince of Wales, (later George IV) writing to William Pitt about his debts, disclosed that he owed £16,744 - 3s -2d to Bazalgette, whom he described as a tailor. The debt was paid off by May 1788. An examination of the archives of Coutts Bank, of which Jean Louis had become a client, reveals that, from 1794 onwards, he continued to advance substantial loans to prominent members of the royal family including the Prince of Wales and the Prince's brothers: the Dukes of York, Clarence and Kent, the last being the father of the future Queen Victoria.[107] In 1795 a statement to the Parliamentary Commissioners who had been given the task of examining the Prince of Wales's debts revealed a claim from Jean Louis for a total of £24,593 - 14s - 0d of which almost £21,000 was for loans, over £3,000 was for clothes and the rest was interest. He was finally paid off in July 1806, the sum amounting to £28,462.[108] On 18th October 1792 he had been "denizened" (acquired British citizenship).[109]

In 1809 Jean Louis purchased the estate of Eastwick Park near Great Bookham in Surrey, together with the Lordship of the Manor of Great Bookham. This was a substantial, sixteen-room property which became a school before being demolished in the nineteen fifties to make way for a housing estate. In Jean Louis' lifetime it was the home of the Surrey Union Foxhounds and, apart from the parkland surrounding the house itself, exercised rights over two thousand two hundred and eighty acres of cultivated land and seven hundred and eighty five acres of Bookham and Ranmore Commons.[110] When Jean Louis died, in 1830, his will bequeathed not only these estates but "also the manors and other hereditaments and real estate whatsoever and wheresoever situate in Great Britain, Ireland, Jamaica and elsewhere".[111]

105London Directories: *(Lowndes, 1789; Universal, 1790-1;Holden's, 1797-1800)*
106Gwynn, R.D.,: *Huguenot Heritage*, Routledge & Kegan Paul, 1985, p.71
107Coutts Bank: archives
108Ibid.
109*Letters of Denization and Acts of Naturalisation for Aliens in England and Ireland,1701-1800*; Guildhall Library
110Particulars of Sale of the Estate sold on the death of Jean Louis: Surrey County Record Office
111Jean Louis Bazalgette's will: in the possession of the family.

By his first marriage Jean Louis had three children. One of them was a son, Joseph William, born in 1783. He entered the Royal Navy in 1796, attended Nelson's funeral, was wounded in action in 1809, retired from the Navy in July 1814 with the rank of Commander and died in 1849[112]. This Joseph William was the father of the engineer, his only son, who was born on 28th March 1819 at Enfield and privately educated. At the age of seventeen Joseph the younger became an articled pupil of (later Sir) John MacNeill, formerly one of Telford's principal assistants in road and bridge building. He was employed by MacNeill as a resident engineer on land drainage and reclamation works in Northern Ireland, for which purpose he visited Holland[113] and these works were the subject of his first paper to the Institution of Civil Engineers[114] of which he had become a graduate member on 6th March 1838, MacNeill acting as his proposer.[115] He became a full member of the Institution on 17th February 1846 when he had, according to his membership certificate, "Served a regular period of pupillage under Sir J.MacNeill, was for 2 years Resident Engineer on works in Ireland, 1 year laying out lines for the Railway Commissioners and has been upwards of 2 years in business for himself as a civil engineer".[116]He was to become President of the Institution in 1884.

In 1842, aged twenty-three, Joseph had set up his own civil engineering practice and by 1845, the year in which he married Maria Keogh of Wexford, he was leasing an office for the purpose at 24, Great George Street, close to the headquarters of the Institution itself. This part of London was the "Harley Street" of the engineering profession and Bazalgette's office had itself previously been occupied both by the Stephensons and by George Hudson, the railway entrepreneur. In the year 1847 he suffered a complete breakdown in his health which was attributed in a short account written during his lifetime to his involvement in the "railway mania" of the previous two years:

> "In November of the year in which the railway mania began [1845] he found himself at the head of a large staff of engineering assistants, designing and laying out schemes for railways, ship canals and other engineering works in various parts of the United Kingdom and preparing the surveys and plans for Parliamentary deposit, which had to be accomplished by the last day of

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112O'Byrne, W.R.,: *Naval Biographical Dictionary,* John Murray, 1849, p.59

113M.P.I.C.E.: vol. 105, 1891, pp. 302-8, Bazalgette's obituary

114M.P.I.C.E.: vol. 1, 1837-40, p.41:"*On Reclaiming Land from the Sea, with Plans Illustrative of Works in Loughs Swilly and Foyle*".

115J.W.Bazalgette's Graduate Membership Certificate, I.C.E..

116J.W.Bazalgette's Transfer to Membership Certificate, I.C.E.

> November. While his remarkable success was most encouraging, its effects soon began to tell upon his health, which completely gave way in 1847; he was compelled to retire from business and go into the country, where a year of perfect rest restored him to health".[117]

The experience that he gained in preparing plans under the pressure of deadlines and in dealing with Parliamentary requirements during this testing period was to be repeated in his later work as Chief Engineer to the Metropolitan Board of Works.[118] Upon emerging from his convalescence he sought other work and in March, 1849, he applied for the post of Assistant Surveyor to the Second Metropolitan Sewers Commission. In support of his application he wrote a letter from 24, Great George Street, proposing the establishment of sixty public urinals for London, at a cost of £96 - 2s -10d each. He drew attention to the discomfort and pollution that arose from the absence of such facilities and believed that it would be possible to make them pay by renting them out to "tenants":

> "It is proposed to farm these establishments like turnpikes, requiring the tenant to be constantly at his post within certain hours...the profit would arise from the sale of papers and the hire of private WCs to those persons preferring them to the free use of the public ones".

He further proposed the establishment of four large reservoirs in the North, South, East and West suburbs where urine would be collected "and where it would be increased in value as a manure by fermentation, from whence it could be conveniently distributed to the surrounding farmers and market gardeners".[119]

Bazalgette's application for the post was successful but it is paradoxical that proposals for the use of human waste as manure, which he thus advocated, were to cause him endless problems at the Metropolitan Board of Works where he spent much of his time examining and rejecting such plans put forward by others. He was certainly well connected within the engineering profession and apparently well regarded by some of its most distinguished practitioners since his application to succeed Forster as General Surveyor of Works to the Metropolitan Commissioners of Sewers was supported by

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117 *Men of the Time*; pub. George Routledge, 1887; *Joseph Bazalgette*

118 Buchanan, R., In *Government and Expertise: Specialists, Administrators and Professionals, 1860-1919,* C.U.P., 1988, R.A.Buchanan argues that the use of engineers to defend railway bills in the 1840s was a significant influence in preparing the profession for the later exercise of this role in connection with other great public works.

119 B.L.Ref. 8776 h 29 no. 59: *reports of the Metropolitan Commissions of Sewers*

"flattering testimonials from Mr Robert Stephenson and Sir William Cubitt", two of the most distinguished engineers of the nineteenth century.[120]

Very little is known of the personality of the man who was to have such a decisive influence on the sanitation of Victorian London and the health of its inhabitants. One of his pupils, H.P.Boulnois, who became Bazalgette's pupil at the Metropolitan Board on 1st January 1865, gives the impression in his few references to Bazalgette that he was above all meticulous, with a sharp eye for detail. Bazalgette had specified the use of the recently developed Portland Cement in the construction of the intercepting sewers, the first large scale public work in which it was so used. He adopted it because it was stronger than other kinds of cement owing to the vitrification process which occurred during manufacture but, if over-heated, it was liable to fail.[121]Boulnois was required, with other engineers and pupils, to carry out tests on each batch of Portland cement supplied to the Board in order to ensure that it was sufficiently strong. Boulnois also records that Bazalgette complimented him on a drawing he had prepared but criticised its lettering on the grounds that "an engineer should be able to do his own lettering and printing in a neat manner, even if it were only block printing".[122]It was commonplace at this time for established engineers to take as articled pupils young men who wished to gain entry to the profession by working under the guidance of an experienced master. Bazalgette had learned his trade in the same way as a pupil of MacNeill and seven of Bazalgette's pupils eventually passed into the service of the Metropolitan Board of Works, two of them being graduates and one of them being Bazalgette's son, Edward. Each articled pupil paid a fee of several hundred pounds, Boulnois paying £420[123]. Bazalgette's salary upon appointment was £1,000 so the fees thus received represented a significant source of additional income.

The few surviving photographs of Bazalgette show that he was a small man and his great-grandson, Rear-Admiral Derek Bazalgette, recorded that he suffered from

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120*The Builder*: 4th December 1852, Vol.10, p.773

121Rolt, L.T.C.,: *Victorian Engineering,* Penguin, 1970, pp.145-6

122Boulnois, H.P.,: *Reminiscences of a Municipal Engineer,* St Bride's Press, 1920, pp. 29 and 31.

123Ibid., p.29

asthma.[124] His published correspondence on the main drainage, notably in *The Times*, and the doggedness with which he confronted the numerous interest groups and other obstacles which stood in the way of the completion of the intercepting sewers suggest that he was a man of heroic patience and exemplary persistence in the face of frustrations and opposition which many would have found daunting and which had in fact brought about the early death of Frank Forster whom Bazalgette succeeded at the Metropolitan Sewers Commission in 1852. He certainly made a strong impression on a young man who joined the Board of Works in 1882 and later became Comptroller of the Board's successor, the London County Council. In an account written after his retirement Sir Harry Haward, commenting on the more prominent figures working at the Board in the year he joined, wrote that:

> "The most prominent figure among the officers of the Board was the distinguished Chief Engineer, Sir Joseph Bazalgette, the designer of the main drainage system of London and of the Victoria Embankment - two monumental works entitling him to a niche in the temple of fame".[125]

The Fifth Commission: Financial Constraints

In late 1852 the Fourth Commission was succeeded by the Fifth which was, for a considerable time, distracted by a private Bill, promoted by John Morewood, for a private company called the Great London Drainage Company, which proposed to make a profit from Metropolitan Sewage by applying it to agriculture. Morewood had first proposed the scheme as early as 1848 but the Great London Drainage Bill did not come before a Select Committee until 6th June 1853. It proposed two tunnel sewers, one on each side of the Thames, and guaranteed the promoters 3% per annum on an investment of one million pounds, to be paid out of the sewer rate. Any profits from the application of sewage to agriculture would be shared with the ratepayers[126]. The prospectus for the scheme describes it as being designed:

> "To Afford Means for Effectually Draining the Metropolis
> To preserve the Thames from impurities at present passing into it and
> To collect all the produce of the sewers for application to agricultural purposes
> (*Plans for Metropolitan Drainage* 1848-65 Greater London Record Office)

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[124]Smith,D.,: Newcomen Society: *Transactions,* Vol.58,1986-7,Discussion of paper
[125]Haward, Sir Harry,: *The LCC from within*, Chapman and Hall, 1932, p.5
[126]Thwaites, J.,: *A Sketch of the History and Prospects of the Metropolitan Drainage Question,* 1855 p.10

Bazalgette was called to give evidence to the Select Committee which considered the Bill and the opinions he expressed are interesting in the light of his later work in constructing the intercepting sewers. He left the Committee in no doubt that, in his view, the priority should lie with constructing an additional thousand miles of drains to draw off the waste from houses and streets rather than with cleaning up the river, thus reflecting the view expressed by Chadwick four years earlier (see page 44 above). Referring to suggestions that the smell from the Thames was offensive Bazalgette replied:

> "The Commissioners of Sewers receive deputations, and memorials, and complaints of the want of sewers and drainage, at every court they hold, and I do not remember one complaint (with one exception; I remember one complaint, and only one) of the offence of the sewers in the river...I think that evil has been very much exaggerated, and I think it is very much less than the benefit; not to be compared with the benefit which will be conferred on the public by the drainage into the Thames...I have not a word to say against the interception; I simply state, however important it may be, or however desirable, I think it much more important to drain those localities that are now without drainage, where the people are really suffering from a want of it".[127]

The Bill was finally rejected after examination by a Select Committee in 1853. In the meantime Bazalgette, in his capacity as Forster's successor as engineer to the Commission, had worked with Haywood and prepared a modified version of Forster's plan which was approved by Robert Stephenson and William Cubitt, consulting engineers to the Commission, in 1854.

The Fifth Commission also began a campaign to reform the finances of the Commissions. On 5th January 1853 the new chairman, Richard Jebb, wrote to the Home Secretary, Palmerston, reminding him that the Commission's income was limited to about £200,000 a year from the sewer rates whereas Forster's plan for the North side alone had been estimated to cost £1,080,000 excluding the purchase of land and houses for a pumping station and compensation for other landowners along the line of the sewer.[128] On 13th October 1853 Jebb wrote again to Palmerston to inform him that the Commissioners would shortly be ready to enter into a contract for a portion of the High level Sewer but that their attempts to raise the necessary capital sum on the money markets in the form of a loan against the sewer rates had been unsuccessful.

127P.P. 1852-3, vol. 36, Bazalgette's evidence, 10th June 1853
128P.P. 1852-3 vol.96

Palmerston did not respond sympathetically to the Commission's financial difficulties and in the meantime a further difficulty had emerged in the form of an objection to the proposed scheme from the General Board of Health. Chadwick, who had been a member of the First Metropolitan Sewers Commission, had long advocated separate systems for sewage and surface water. In 1849, as a member of the General Board of Health, he had successfully advocated a policy of flushing London's sewers into the Thames in an attempt to combat the Cholera which had re-emerged after a respite in the winter of 1848-9.[129] This policy was described by *The Times* as "no filth in the sewers, all in the river". Every two to three months the engineers reported to the Commissioners the volume of filth that had been flushed into the Thames in the previous months: 29,000 cubic yards in March-May 1848 and 80,000 yards from September 1848 to February 1849[130]. The Thames was at this point the capital's principal supply of drinking water but at this time water was not recognised as a vehicle by which cholera was transmitted.

In 1850 Chadwick had supported the General Board of Health's proposal to pipe drinking water from Farnham in Surrey to supply London's population with a constant supply of clean water, thereby reducing dependence on the nine water companies supplying the Metropolis, most of which drew their supplies from the Thames. The water companies combined to frustrate this proposal, settling instead for the Metropolis Water Act, 1852, which gave the companies three years to move their intakes to a point above Teddington Lock where the tidal river ended. Chadwick was also a strong advocate of pipe sewers rather than brick sewers on grounds of cost and effectiveness and was to become one of the strongest critics of the Metropolitan Board. He criticised the Fifth Commission's plans on the grounds that a "unitary" system which proposed to convey both sewage and surface water in the same sewers was unnecessarily expensive and would dilute the sewage to a point at which its agricultural value would be severely reduced. Palmerston was receptive to these criticisms and this prompted the resignation of the Fifth Commission.

The Sixth Commission, which took office on 22nd November 1854, differed from its predecessors in one significant detail. Evidence taken by the Committee on the Great London Drainage Bill had convinced the MPs that the membership of the Metropolitan Commissions should be altered. In the words of Thwaites:

129Finer, S.E., *The Life and Times of Sir Edwin Chadwick,* Methuen, 1952, p.347
130B.L. 8776 h. 28/29: *Reports of the Metropolitan Commissins of Sewers*

> "The information obtained during the examination of witnesses, had considerably enlightened Parliament, as well as the Metropolitan Constituencies on the subject, and so much opposition was evinced to intrusting (sic) the execution of works of such magnitude and cost, to a limited Crown appointed Commission, that Government, yielding to the expression of the general sentiment, infused a new element by the nomination to the New Board of one local representative for each of the Metropolitan Boroughs".[131]

The new commission recognised the urgency of the problems it had inherited, particularly as they affected the Southern bank of the Thames, much of which lay below high water. On 23rd January 1855 the Commission carried a motion to the effect that: "This Court therefore resolves that immediate steps be taken to carry into effect the plans as set out by the late Mr F.Forster, with such alterations or improvements, and extensions or curtailments of the branches, as may be suggested to the Commission, as far as it relates to that part of the Metropolis South of the Thames."[132] The Commission then discovered that it lacked the power to purchase land beyond its area of jurisdiction which was essential if the sewer outfall was to be at Plumstead marshes as Forster's modified plan required.

On 17th August 1855 the Metropolis Management Act received the royal assent. Under its provisions the Metropolitan Board of Works would take over all the responsibilities of the Metropolitan Sewers Commissions with effect from 1st January 1856. Thwaites, who was to become chairman of the Metropolitan Board, therefore moved the following resolution at the Commission's meeting on 21st August 1855.

> "That whereas the Metropolis Local Management Act will shortly come into operation, by which this Commission will be superseded, it is the duty of this Court immediately to provide plans, showing the existing sewers, for the use and guidance of the several District Boards to be formed under the said Act; that the proper officers of this Commission do with all diligence prepare such plans, that the same may be ready to be handed over to each of the said District Boards on or before the first day of January next".[133]

The motion was carried.

131Thwaites, J.,: *A Sketch of the History and Prospects of the Metropolitan* Drainage Question, 1855, p. 11

132Ibid., p.13

133Ibid..

Six Commissions had, between them, held office for eight years. What had they achieved? They had brought into being the Ordnance Survey of the Metropolitan area without which no comprehensive drainage plan could be devised. Their engineers, first Forster and later Bazalgette, had prepared a scheme which, for the first time, included two critical features of the plan which would eventually be adopted by the Metropolitan Board of Works: a *unitary* system combining sewage and surface water; based upon the principle of *interception* which would conduct the sewage to a tidal outfall beyond the limits of the Metropolis. Finally, the principle that the body responsible for executing the works should include an element which was *representative* of the population of the Metropolis rather than Crown appointees had been accepted in the constitution of the Sixth Commission. These developments foreshadowed both the constitution of the Metropolitan Board and the scheme it adopted, though only after many diversions into sewage manure, more distant outfalls and controversies over finance and methods of sewer construction. Nevertheless they were considerable achievements given the limited powers, duration and revenue of the Commissions and to that extent Humphreys' dismissive judgement on the Commissions' achievements may be contested.

Chapter Two: the Triumph of Authority: Establishing the Metropolitan Board of Works

> "We may really say that there is no such place as London at all, the huge city passing under this title being rent into an infinity of divisions, districts and areas". (*The Times*, 20th March 1855).

> "The administrative history of the Metropolis, outside the City, may be regarded practically as having originated in the year 1855. Prior to that date a condition of utter chaos everywhere prevailed".(A.B.Hopkins *The Boroughs of the Metropolis,* Bemrose, 1900, page 3)

Local Administration and the Health of the Population

Before an effective sanitary regime could be introduced to the Metropolis, to deal with the problems described in the previous chapter, it was first necessary to set in place an organisation with the wide-ranging powers and the substantial financial resources which would be required to execute the work. The six sewers commissions which had struggled with the problem from 1848 to 1855 had been wanting in both authority and money. The creation of the Metropolitan Board of Works, which eventually completed the project, was attended by fierce arguments over the wisdom of creating a body which was seen by some commentators as authoritarian and by others as weak and ineffective. The debate engaged some of the most influential polemicists of the period including Edwin Chadwick, Benjamin Hall and Toulmin Smith. They based their arguments upon such concepts as economy, liberty and utilitarian philosophy. The issues had to be resolved before London could be given the organisation it needed to attend to its pressing need for better sanitation. Many of the arguments surrounding the establishment of the Metropolitan Board of Works were rehearsed in the debates over the passing of the Public Health Act, 1848 which established the General Board of Health, particularly in the work of Toulmin Smith.

The problem was not confined to London, whose conditions may be considered in the wider context of the urbanisation of the population which characterised the late eighteenth and nineteenth centuries. Mitchell and Deane estimate that, by 1851, thirty-three per cent of the population of Great Britain lived in seventy-two urban communities, of which London was by far the largest with 2,363,000 inhabitants and Liverpool the second largest with 376,000. In 1801, at the first census, twenty-two per cent of the population had lived in such communities.[1] A broader definition of urban

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[1]Mitchell, B.R., & Deane, P.,: *Abstract of British Historical Statistics,* C.U.P 1962,

communities, used by Morris and Rodger, estimates that, by the same year (1851) fifty-four per cent of the population was urbanised, compared with thirty-four per cent in 1801.[2] The process of urbanisation was not accompanied by any corresponding effort to plan for its consequences. G.M.Trevelyan described the process as characterised by "A rampant individualism, inspired by no idea beyond quick money returns...Town planning, sanitation and amenity were things undreamt of by the vulgarian makers of the new world".[3] The consequences are succinctly described by Walvin: "The British people seemed to become collectively more sickly as they became a nation of town dwellers"[4] while Hamlin refers specifically to the institutional context of the problems by suggesting that "to a large degree counties, boroughs and parishes were responsible for their own affairs, each conducting these with its own traditions, institutions and ineptitude".[5] Dyos describes the process in more measured tones:

> "No emergent society ever proceeded so far in urbanising itself with such little established fact about its implications, nor ever will; the rate of urbanisation among the emergent countries of to-day rests substantially on the control of crude death rates first demonstrated when the major advances in public health were being pioneered in the nineteenth century...However, within another generation sanitary reform had been so completely accepted within the canon of municipal improvement that the only real issue was, not what men should do to stay alive, but who should pay."[6]

MacDonagh, in discussing the impact of urbanisation on the health of the population, argued that "The problem of Public Health, as it was presented by the agitations in this field, was essentially the problem of nineteenth century urbanisation and industrialisation" and proceeded to postulate that "The transformation took place while local and national government was still incompetent to undertake remedial measures, and while engineering and medical science were only beginning to take their modern shape" [7] This chapter will examine the process by which the need for

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tables 7 & 8.

[2]Morris, R.J., & Rodger, R.:*The Victorian City, a Reader in British Urban History,1820-1914*, Longman,1993

[3]Trevelyan, G.M.,: *English Social History,* Longman, 1942, p.463

[4]Walvin, J.,: *Victorian Values*, Andre Deutsch, 1987, p.25

[5]Hamlin, C.,: *State Medicine in Great Britain* in D.Porter (ed.) *The History of Public Health and the Modern State*, p. 134, Editions Rodopi, 1994

[6]Cannadine,D. & Reeder, D.,(ed,)*Essays in Urban History by H.J. Dyos*, C.U.P., 1982, pp.16-17

[7]MacDonagh, O.,: *Early Victorian Government 1830-70* Weidenfeld & Nicolson

authoritative bodies to impose sanitary reform came to be accepted by that generation of Victorians, with particular emphasis upon the government of the Metropolis.

As early as 1837 the Second Report of the Royal Commission on Municipal Corporations had drawn attention to the difficulties which arose from the fragmentary character of London's administration. In commenting upon the separate status of the City the commissioners wrote:"We are unable to discover any circumstance justifying the present distinction of this particular district from the rest, except that *in fact* [their italics] it is, and has long been, so distinguished". The commissioners proceeded to argue for a single authority: "With respect to sewage, indeed, there is an obvious absurdity in placing the City, and any large district which drains into it from a higher level, under different superintendence".[8] Such attempts as were made to create a unitary authority including the City came to nothing (see above Chapter One and P.P. 1839 Vol. 5). Seven years later, in the First Report of the Royal Commission on the Health of Towns, the Commissioners drew attention to the legal and administrative causes of sanitary problems they had identified. The Commission, chaired by the Duke of Buccleuch, and including amongst its membership engineers like Robert Stephenson and William Cubitt, had sent questionnaires to fifty provincial towns, and had visited many of them, in order to assess their sanitary condition. In many cases, they discovered, local Acts of Parliament applied to areas which were found to be inappropriate for topographical or engineering reasons. In other areas householders were either required to pay prohibitive charges for the privilege of connecting their properties to the sewers or, in some cases, the local Acts specifically forbade such connections.[9] In their Second (and final) Report the commissioners commented that "there are only eight of the fifty towns visited in which even a tolerably favourable report could be given in respect to drainage and cleansing" and they went on to add: "We recommend that the necessary measures for drainage, paving, cleansing and an ample supply of water (the most important matters conducive to health) should be placed under one administrative body". Indeed the only question in the minds of the commissioners was how far these matters "could be placed in the hands of a Metropolitan Municipality, or how far they should be entrusted to the officers of Your Majesty's Government".[10] The doubt the commissioners thus expressed over the wisdom of conferring significant powers upon a municipal body foreshadowed the original Metropolis Local Management Act by which responsibility for devising a

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1977, p. 133.

[8]P.P. 1837, vol. 25 pp. 4-5.

[9]P.P. 1844, vol. 17, p.ix

[10]P.P.1845, vol. 18, pp. 1 & 5-6.

scheme of sewerage would lie with the Metropolitan Board of Works while the Chief Commissioner of Works, on behalf of Parliament, would exercise a power of veto over the proposals.

The Administration of London

If the conditions in the fifty towns visited by the Royal Commissioners was unsatisfactory, then in the capital itself the situation was confusing in the extreme. J.Dunbabin, in a discussion of Nineteenth Century Local Government Reform, characterises London vestry government in the following terms:

> "Only in the London area - always largely *sui generis* - did vestries survive as significant bodies. For there, problems of urban overspill had been met in the eighteenth century by the development (under local Acts) of the powers of vestries which, by the turn of the century, often governed populations the size of cities".[11]

Some critics questioned what the word "London" meant, if it meant anything at all. Cobbett's "Great Wen" had been described in unflattering terms in the 1820s as if it was a recognised entity and in 1829 the establishment of the Metropolitan Police recognised the existence of a "Metropolis", with defined boundaries (and excluding the City) as a coherent unit for the purpose of policing. By 1830 the word *Metropolis* began to appear in map titles. Yet as the Metropolis Local Management Bill made its way through Parliament *The Times* could comment:

> "there is no such place as London at all..[it is] rent into an infinity of divisions, districts and areas...Within the Metropolitan limits the local administration is carried on by no fewer than three hundred different bodies, deriving powers from about two hundred and fifty local Acts".[12]

Sir Benjamin Hall described the situation to Parliament when he introduced the Metropolis Local Management Act. Outside the boundaries of the City itself, about two million people were governed by the vestries of more than ninety parishes, precincts and liberties, ranging in size from the Liberty of the Old Artillery Ground, Bishopsgate, with fifteen hundred inhabitants, to the parish of St. George's Hanover Square with sixty thousand. Some of these vestries were "open" and elected by ratepayers, while others were "close" or "select" vestries. In these the vestrymen were

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[11]Dunbabin, J.,"Local Government Reform: the Nineteenth Century and After", *The Historical Journal*, October 1977, p. 781.

[12]*The Times*: 20th March, 1855, p.9

put forward by thirty or more "principal inhabitants" whose forbears had been nominated for this purpose in the Act of Parliament which set up the vestry.

St. George's Hanover Square and St. Marylebone, two of the largest parishes, were "select" vestries.[13] One of the largest and most chaotic areas, St Pancras, had re-constituted its vestry from an "open" to a "close" form by a local Act of 1819. One hundred and twenty-two vestrymen were created of whom seven were noblemen, two thirds were parishioners with parish property valued at £150 or more and the remainder were parishioners with parish property valued at £56 or more[14]. Overlaying this fragmented apparatus was a system of about three hundred different boards for paving, lighting, drainage and other amenities which had been established by over two hundred and fifty Acts of Parliament, creating some ten thousand commissioners for the purpose. F.O.Ward, a sanitary engineer, writing in the *Quarterly Review* in 1850 referred to correspondence between the rector of Christchurch, Regent's Park, and the General Board of Health. The rector had enquired what steps he could take to improve sanitation in his parish and had been told:

> "In the parish of St. Pancras, where you reside, there are no less than sixteen separate paving boards, acting under twenty-nine Acts of Parliament, all of which would require to be consulted before an opinion could be pronounced as to what might be practicable to do for the effectual cleansing of your parish as a whole".[15]

Hall claimed, in his speech to Parliament when he introduced the Metropolis Local Management Bill, that St. Pancras had *nineteen* separate boards on which served four hundred and twenty-seven commissioners of which two hundred and fifty-five were self-selecting. In the Strand, nine different paving boards served three-quarters of a mile of road.[16] *The Times*, commenting upon the need for the reform of London's government in the period leading up to the introduction of the Bill, observed that London had "a greater number and variety of governments than even Aristotle might have studied with advantage" and commented that, within St. Pancras, the *seventeen* paving districts "have no more to do with each other than the pavement of our St.

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[13]Owen, D.,: *The Government of Victorian London,* Belknap, 1982, p. 24.
[14]Porter, R.,: *London, a Social History,* Hamish Hamilton, 1994, p.243
[15]Public Record Office: M.H. 13: *General Board of Health & Local Government Act Office Correspondence*; vol. 261, 15th November 1848 quoted also in *Quarterly Review,* 1850, Vol. 88, p.455
[16]*Hansard*,Vol.137,c.703-7,Sir Benjamin Hall's speech,16th March, 1855.

Paul's with that of St. Peter at Rome" [17]. It is significant that the General Board of Health, Sir Benjamin Hall and *The Times* could not even agree *how many* paving boards served the beleaguered inhabitants of St. Pancras.

Some commentators wished to preserve these distinctions, basing their arguments on such well-defended grounds as civil liberties, the rights of property and the need for rigid economy in public expenditure. Others opposed them, citing public health, the philosophical principles of Bentham and J.S.Mill and, again, the need for economy in public expenditure. Dyos has described the campaign for the centralisation of administrative controls as "a campaign beside which the battles over comprehensive schooling or the London ringways are a sideshow"[18]. Other commentators have placed the conflict between "centralisers" and their opponents in the context of an eighteenth and early nineteenth century economy that was firmly rooted in private enterprise and low taxes.[19] Porter has specifically attributed the growth of private night soil collection services and similar enterprises to the private enterprise economy of the eighteenth and early nineteenth century economy.[20] An insight into the nature of the conflict which arose when reformers began to propose legislative remedies can be gained by examining the views of two of the principal protagonists, Edwin Chadwick and J.Toulmin Smith, both of whom learned the art of advocacy from their training as barristers.

The Debate over Autonomy: Philosophy or Expediency?

Chadwick's experiences in preparing and writing his *Report* had convinced him that strong central administration was essential if the problems he had uncovered were to be solved (see above, Chapter One, page 28 et seq.). In 1831, while aged thirty-one, Chadwick had become secretary to the ageing philosopher of Utilitarianism, Jeremy Bentham, who died the following year. For the rest of his life, as a campaigner for social reforms, Chadwick based his arguments on utilitarian principles, against the libertarian" or "de-centralising" position of advocates like Toulmin Smith. Royston Lambert, the biographer of Sir John Simon, wrote of Chadwick that "he had been

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[17] *The Times*, 7th November 1854, p.7

[18] Cannadine & Reeder,(ed.):*Essays in Urban History by H.J.Dyos*,C.U.P.1982,p.27

[19] See, e.g., Jones, E.C., and Falkus, M.,: *Urban Improvements and the English Economy in the Seventeenth and Eighteenth Century*: Research in Economic History, iv, (1979) pp. 193-223

[20] Porter, R.,: *Cleaning up the Great Wen: Public Health in Eighteenth Century London*: in W.F.Bynum & R. Porter (eds.) *Living and Dying in London*, Medical History Supplement No. 11, Wellcome Institute, 1991, pp. 61-75

intimate with the philosopher Bentham and possessed a utilitarian hatred of waste, a love of efficiency and a belief in the social necessity and potentiality of legislative and administrative intervention"[21] Chadwick accepted the first principle of Bentham's Constitutional Code, that "Self-interest is predominant" but his life's work was devoted to remedying the ills that could result from it. Chadwick once wrote: "Self-interest is the most constant - the most uniform - most lasting and most general feeling; and it appears, when traced in its ultimate actions, to be really one of the most beneficent".[22].Yet the biographer of Chadwick, R.A.Lewis, has written: "Chadwick started from the simple proposition that the great bulk of the social ills ....uncovered by his investigation was preventable; and that since it was preventable there was a plain duty resting upon the state to prevent it".[23]Dorothy Porter places the reform movement firmly in the tradition of utilitarianism:

> "The mantle of health reform was, however, inherited by utilitarian political economy. It was the economic value of preventing premature mortality to the expanding industrial state which was ultimately responsible for public health reform in early nineteenth century Europe...Led by Jeremy Bentham's successor and most ardent disciple, Edwin Chadwick, public health reform in England was a crusade to reduce the financial burden of destitution through a campaign against epidemic infections caused by 'filth'".[24]

In the same volume Chrstopher Hamlin further argues that Chadwick deliberately linked sanitary reform to the poor rate because he thereby "sought to put preventive medicine on the agenda of what was probably the most active of local government institutions in early nineteenth century Britain".[25] Christine Bellamy has suggested that Chadwick was also influenced by J.S.Mill's *Essay on Representative Government* with its distinction between functions in which central government should be dominant, like the administration of justice; those in which it has an interest, but should take into account local conditions, including sanitary regulation; and purely local functions, which included house drainage. In Bellamy's words "The principle is, says Mill, that localities should be legally allowed to mismanage their own affairs, but the law should intervene to prevent the violation of the interests of others".In

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[21]Lambert, R., *Sir John Simon,* McGibbon & Kee, 1963, p.60

[22]Chadwick, E.,: *Papers Read Before the Statistical Society of Manchester,* Charles Knight, 1846,p.18

[23]Lewis, R.A.,: *Edwin Chadwick and the Railway Labourers,* Economic History Review, 2nd Series, Vol. iii, No.1, 1950, pp.107-18

[24]Porter, D. (ed.): *The History of Public Health and the Modern State*: Editions Rodopi, 1994, pp. 8-9

[25]Hamlin, C.: *State Medicine in Great Britain* in Porter, D. (above) p. 144

Chadwick's mind these principles are translated into the idea that "Local government is equated with particularism and ignorance; national organisation with the application of general principle and knowledge; local control with corruption and favouritism; national control with consistency and justice".[26]

Chadwick, and other Utilitarians, reconciled the apparently conflicting principles of self-interest and centrally-directed reform by reference to Bentham's "means-prescribing or junction-of-interest-prescribing principle" which enjoined that laws should be so framed that, in furthering his own interests, the citizen should promote the welfare of his fellows.[27] Mill, in his essay "On Liberty" developed this into the principle that "the only purpose for which power can be rightfully exercised over any member of a civilised community, against his will, is to prevent harm to others. His own good, either physical or moral, is not a sufficient warrant"[28]. Finer, another biographer of Chadwick, has argued (in "The Transmission of Benthamite Ideas, 1820-50"), that such ideas influenced social reformers as has Alan Ryan in "Utilitarianism and Bureaucracy: the view of J.S.Mill", an essay on the influence of utilitarian ideas on administrative machinery.[29] Hamlin attributes Chadwick's utilitarian concern with sanitary reform to his earlier experience with the poor law:

> "The poor law provided the initial context for his concern with sanitary engineering, which was predicated on the argument that preventing pauperism by preventing disease was cheaper than supporting paupers".[30]

The legal commentator, A.V.Dicey, suggested that there was a "close dependence of legislation, and even the absence of legislation, upon the varying currents of public opinion" and formulated the hypothesis that a period of "legislative quiescence" gave way to "Utilitarian" reform from about 1840 to 1865, under the leadership of Chadwick, and that this in turn was followed by a period of state intervention or "collectivism" which gathered pace after that date and remained the pattern thereafter[31]. This view of Chadwick as "England's Prussian Minister" (a quotation

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[26]Bellamy, C.: *Administering Central-Local Relations, 1871-1919*; Manchester U.P., 1988, pages 7 & 10

[27]Bentham, J.,: *Constitutional Code* in *Collected Works* Vol. 9 pp. 5-8

[28]Mill, J.S.: *On Liberty*, Dent, 1972, p. 73

[29]Ryan, A. and Finer, S.E., in Sutherland, *G.*, (Ed.),: *Studies of the Growth of Nineteenth Century Government* , Routledge & Kegan Paul, 1972, pp. 11-62

[30]Hamlin, C.,: *Edwin Chadwick and the Engineers, 1842-54:Systems and Antisystems in the Pipe-and-Brick Sewers War*: Technology & Culture,xxiii, 1992, p. 683

[31]Dicey, A.V.,: *Lectures on the Relation between Law and Public Opinion during the Nineteenth Century,* Macmillan, 1905, p.1 et seq.

attributed to Lord John Russell) is shared by other writers.[32] The critics of this interpretation, who include O.MacDonagh, R.J.Lambert,C.Hamlin and E.C.Midwinter suggest rather that the reforms which occurred in the mid-nineteenth were incremental and administrative rather than philosophical and Midwinter made a comparison with the supposedly similar bureaucratic reforms in the Tudor period. In the words of Midwinter: "the prim doctrines of laissez-faire were overrun by the enormity of the difficulties and, in empirical, piecemeal fashion, first one and then another device was hastily shaped to meet needs as they forced their attention upon administrators"[33]. MacDonagh chronicles the development of "bureaucratic" government in five stages in the mid-Victorian period and presents it as a logical development of utilitarianism,[34] while Anthony Wohl has suggested, in a study of the work of Dr Buchanan, medical officer in the St Giles district of London, that the activities of medical officers assisted the development of centralised administration and the erosion of local liberties.[35] Hamlin argues that Chadwick was not a centraliser in the continental or "Prussian" sense since he was prepared to work through local boards in order to implement his ideas, though he may have done this from necessity rather than choice.[36]

The American Historian A.L.Lowell developed these arguments by suggesting that the quality of local administration was directly proportional to the amount of influence that salaried officials (as distinct from elected representatives) were allowed to exercise. This judgement is reflected in Owen's view of the steadying influence of Thwaites and Bazalgette in the sometimes turbulent debates with the Metropolitan Board and in Clifton's description of the Board as "one of the first local authorities in England to develop an extensive bureaucratic administration"[37]. If this view is correct then the 'professionalisation' of administration did not occur without setbacks. In 1841 Battersea employed a salaried surveyor but abolished the office four years later as an

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[32]Brundage, A.,: *England's "Prussian Minister": Edwin Chadwick and the Politics of Government Growth, 1834-54,* Penn State University Press, 1988

[33]Midwinter, E.C.,: *Seminar Studies in History: Victorian Social Reform,* Longman, 1968, p.19

[34]MacDonagh, O.,: *The Nineteenth Century Revolution in Government: a Re-appraisal*: Historical Journal, 1, 1958, pp. 52-67

[35]Wohl, A.S.,: *Unfit for Human Habitation*, in *The Victorian City, Images and Realities,* ed. H.J.Dyos, and M.Wolff, Routledge & Kegan Paul, 1973, p.615

[36]Hamlin, C.,: *State Medicine in Great Britain*: in *The History of Public Health and he Modern State,* D.Porter ed., pp. 146-7

[37]Clifton, G.,: *Professionalism, Patronage and Public Service in Victorian London: the Staff of the Metropolitan Board of Works, 1856-86,* Athlone Press, 1992,p.160

economy measure and replaced him with a committee of ratepayers while the vestry of St James, Westminster, reduced the salary of its medical officer from £200 to £150 in order to check his enthusiasm[38] .

Midwinter postulates the existence of a "Tutelary State" consisting of administrative agencies like the Poor Law Guardians and the General Board of Health whose aim was to guide individuals towards self-help, in line with Utilitarian doctrine and he argues that Chadwick "threw his considerable, if doctrinaire energies into constructing the Victorian Tutelle".[39] Chadwick's "interventionist" or "centralising" stance found expression in the General Board of Health and the Metropolitan Sewers Commissions, on both of which he served and from both of which he was removed when his centralising views conflicted with those of other powerful figures, including Sir Benjamin Hall. Referring to these two organisations Lambert argues that "each of these bodies was Chadwick's creation, was dominated by him, and both seemed to represent the anti-representative, anti-medical, "centralising" properties of their creator."[40] Chadwick based his arguments for active measures by the state both on precedent and public interest. In Section seven of the *Report* (page 339 et seq.) he drew attention to recent (1842) legislation governing safety in mines and the prohibition, in 1840, on the use of chimney boys. He also wrote at length on the economic effects of poor sanitation among the labouring classes:

> "It is a depressing effect on that which most distinguishes the British people, and which it were a truism to say constitutes the chief strength of the nation the bodily strength of the individuals of the labouring class. The greater part of the wealth of the nation is derived from the labour obtained by the application of this strength".

This argument would be much used and developed by Chadwick and others in the debate that followed.

Evidence that state intervention would be necessary before any reforms could occur became available from a survey carried out by the Health of Towns Association in 1848. A questionnaire was sent to towns which asked "Have the authorities of the town given any indication of their knowledge of the kind and degree of influence

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[38]Porter, R.,: *London, a Social History,* Hamish Hamilton, 1994, pp. 247 & 262

[39]Midwinter, E.C.,: *Seminar Studies in History: Victorian Social Reform*, Longman, 1968, p.19

[40]Lambert, R.J.,: *Sir John Simon,* McGibbon & Kee, 1963, p.72

which the condition of suburban districts exercises over the health of the town?" The reply from Canterbury was:

> "A few of the town council are quite aware of the influence which defective drainage has upon the public health but a large number will not acknowledge it and the greater number are so much opposed to public expenditure for any purpose that there is no hope of effectual means being resorted to by them for the public good"[41].

A question to Oxford about its plans for obtaining a clean and economical supply of water drew the answer "never, and not likely to until compelled by Parliamentary interposition".[42] Nor were these attitudes confined to the early part of the century. A.S.Wohl, in commenting on the effects of the Public Health Act of 1848 has argued that:

> "The inadequacy for much of the second half of the nineteenth century of the medical officers' staff reflects the vestries' attitudes towards the novel concept of preventive medicine and their determination to obey cherished precepts of low rates and laissez-faire".[43]

It was such attitudes that had led Chadwick, in 1840, to express the view that "The affairs of the parish are best governed in the absence of its representatives"[44] and to write on 10th April 1845: "the evidence almost goes so far as to establish this, that the worst company would be better than the best corporate municipality". His views on the relative importance of the various elements that could promote or obstruct the cause of better sanitation are expressed in a letter that Chadwick wrote to Macvey Napier in 1842:

> "The chief remedies consist in applications of the science of engineering, of which the medical men know nothing; and to gain powers for their applications, and to deal with local rights which stand in the way of practical improvements, some jurisprudence is necessary, of which the engineers know nothing". [45]

At this stage, therefore, Chadwick assigned a humble position to the medical profession and a paramount position to engineering, though he later fell into

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[41]Briggs, A.,: *Victorian Cities*, Pelican, 1968, p. 376

[42]Ibid..

[43]Wohl, A.S.,: *Unfit for Human Habitation*: in *The Victorian City, Images and Realities*, ed. H.J.Dyos and M.Wolff, Routledge & Kegan Paul, 1973, p.607

[44]Finer,S.E.,: *The Life and Times of Sir Edwin Chadwick,* Methuen, 1952, p.92

[45]Chadwick to Macvey Napier, 11th October 1842, quoted in *Finer,* p. 218.

controversy with the engineering profession, and particularly with Bazalgette, over the relative merits of tunnel sewers and pipe sewers. Local rights, in Chadwick's opinion, were something to "deal with". Dr. John Snow, who hypothesised that cholera epidemics were water-borne, expressed similar sentiments while addressing the Social Science Congress in Bristol in 1849. He stated that "our present machinery must be greatly enlarged, radically altered and endowed with new powers" above all with the power of "doing away with that form of liberty to which some communities cling, the sacred power to poison to death not only themselves but their neighbours".[46]

Chadwick and many other advocates of strong central administration (and accompanying public expenditure) based their arguments on economic grounds: the effects of poor sanitation upon the Poor Rates. Chadwick had referred to these consequences in his *Report* (see above Ch. 1) and in his earlier capacity as secretary to the Poor Law Commissioners. In Appendix A to the Fourth Annual Report of the Commissioners in 1838 he wrote: "In general, all epidemics and all infectious diseases are attended with charges, immediate and ultimate, upon the poor rates". The case for sanitary reform as sound economics was strengthened by the Report of the Select Committee on the Health of Towns which observed that "large sums of money must be expended year after year for the support of families afflicted with fever"[47].The Select Committee recommended Boards of Health in Towns to be appointed by Poor Law Guardians, Town Councils or ratepayers. The Committee's recommendations led eventually to the establishment of the General Board of Health by the Public Health Act of 1848, a measure which was too "centralising" for some critics but too weak for the most active sanitary campaigners like Chadwick. From an early stage Chadwick had recognised that improved house sanitation was of no value unless it was associated with effective sewerage, street cleaning and water supply. In MacDonagh's words:

> "from a very early stage he saw that better house sanitation would not remove, but might even aggravate, the evils...He was therefore led to take the revolutionary step of considering house drainage, street drainage, main drainage, water supply, street cleaning and paving as all necessarily interconnected, indissoluble constituents of one great general problem" [48].

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[46]Briggs, A.,: *Victorian Cities*, Pelican, 1968, p. 20.
[47]P.P. 1840, vol. 11, p.vi.
[48]MacDonagh,O.,:*Early Victorian Government,*Weidenfeld & icholson,1977,p.136-7

Vested Interests

Such a comprehensive prescription was certain to bring Chadwick and his supporters into conflict with every kind of vested interest: commissioners of sewers, vestries, local paving boards, private water companies, each with its own agenda and means of influence. Hennock draws attention to the fact that, prior to about 1848, the Local Act was the predominant influence upon local government, each creating its new interest group and proceeds to argue that the Poor Law Reforms with which Chadwick was strongly associated weakened the hands of later advocates of administrative reforms. Centralisation of authority "occurred first in the sphere of Poor Law Administration and there took a form which raised much opposition and thereby probably hindered the adoption of similar detailed control in other fields of administration"[49] Ruth Hodgkinson regards Chadwick as a precursor of the welfare state but also recognised that his unpopularity was inseparable from his effectiveness:

> He was a man of great vision, prodigious energy and courage...He believed implicitly in rationalisation, and that strong, centralised control with efficient administration could alone combat the ineffectiveness of private enterprise and effete local authorities. He was loathed by all those with vested interests and who believed in personal liberty or freedom from state control".[50]

Porter's judgement is harsher. He suggests that, as secretary of the Poor Law Commission "Chadwick became the most hated man in England, detested alike by the poor, by vestrymen and by local boards of Guardians for his "Prussian" style of operation"[51] He proceeds to conclude that Chadwick's enthusiasm for sanitary reform was caused in part by his belief that the failure of the workhouse system to reduce the number of paupers was caused not by the shortcomings of the system itself but by the insanitary conditions in which they lived.[52]

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[49]Hennock, E.,: *Fit and Proper Persons: Ideal and Reality in Mid-Victorian Government*, Edward Arnold, 1973, pp. 4 & 6

[50]Hodgkinson, R.: *Science and Public Health*; Open U.P., 1973, p.37; see also the same author in *The Origins of the NHS*, Wellcome, 1967

[51]Porter, R.,: *London, a Social History,* Hamish Hamilton, 1994, p. 247

[52]Ibid., p.260.

An article in *Fraser's Magazine* in 1847,[53] by W.A.Guy entitled "The Sanitary Commission and the Health of the Metropolis" made an explicit connection between sanitary administration and sound economy. He wrote that "Sanitary reform... is, from first to last, a grand scheme of preventive charity; a practical application, on a large scale, of the soundest principles of humanity and economy". The article went on to call for "the destruction or reconstruction of every form of local administration which does not work well towards these righteous ends". The same writer, the following year, drew an even more optimistic picture of the results of intervention by an enlightened central government. He was applauding the decision by the House of Lords to insert in the Public Health Act a clause which gave the General Board of Health the authority to set up a local Board, regardless of the wishes of the local community, in areas where annual mortality rates exceeded twenty-three persons per thousand population - one of Chadwick's "centralising" moves. Guy wrote:

> "We may now look forward with confidence to the time when England shall possess real towns...with perfect mechanical appliances for removing all things which can offend taste or endanger health and conveying them, suspended in the waters of a mimic Nile, to the surrounding agricultural districts, where they will cover cultivated lands with unwonted verdure".[54]

The following year the *Edinburgh Review* joined the debate in reviewing a series of sanitary measures proposed by the General Board of Health and rehearsed the arguments for enlightened interventionism. The author, in support of taxes for sanitary reform, wrote that "the tax for sanitary reform should be set down as a cheap forestalment of poor rates" and referred also to the phenomenon of "the cholera widow":

> "A 'cholera widow' is a significant expression occasionally used by the General Board of Health to indicate one who has been thrown on the parish by the death of that husband who, if he had not been prematurely cut off, might have supported her for years".[55]

Yet even the allegedly 'centralising' Public Health Act conferred strictly limited powers upon the General Board of Health who were charged with the responsibility of administering it. During the 1849 cholera outbreak the Board had the greatest difficulty persuading local boards to take the measures necessary to contain the outbreak. *The Times* drew attention to the fact that "The Board of Health is an

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[53]*Fraser's Magazine*, Vol. 36 pp. 505-17
[54]Ibid., October 1848, Vol. 38, p.444
[55]*Edinburgh Review*, 1849, Vol. 91, pp.210-28

absolute nullity without the assistance of a judge in Chambers",[56] referring to the fact that the Board had had to make use of powers under the *Nuisances Removal and Diseases Prevention Act,* 1846 (The "Cholera Bill" see Chapter One) to compel local boards to cleanse and whitewash infected properties. Later in the month *The Times* returned to the controversy over central as against local authority. In reference to a confrontation between the Board and the City Poor Law Guardians the paper noted that "Every Briton is cock on his own dunghill, no doubt; but on this indispensable condition - that his dunghill offends no-one else's nose". [57]

The view of Chadwick and others that strong sanitary measures were justified on philosophical, humanitarian and economic grounds was not, however, unopposed. The contrary beliefs that such measures would be ineffective, or would require burdensome taxes, or would require an unacceptable degree of interference with personal liberty, found many eloquent advocates. Guy, writing in *Fraser's Magazine* had applauded the Public Health Act as an enlightened measure but in the same year, 1848, *The Economist* criticised the Act in the following terms:

> "Suffering and evil are nature's admonitions; they cannot be got rid of; and the impatient attempts of benevolence to banish them from the world by legislation, before benevolence has learned their object and their end, have always been more productive of evil than good".[58]

Other commentators viewed the processes of sanitary reform as an interference with personal freedom and, particularly, with property. Jephson makes numerous references to the difficulties which beset those who attempted to improve the living conditions of the inhabitants of London. Following a public meeting in 1850, presided over by Blomfield, Bishop of London, the bishop, Lord Ashley and others went as a deputation to the Prime Minister, Lord John Russell, to press for reform. Russell told them that "In this city there is very naturally and properly great jealousy of any interference either with local rights or individual will and freedom from control" and Jephson comments that "Never had there been a time in which the rights of property had been more insisted upon and expressed...and throughout this period the people in their daily lives and circumstances were absolutely unprotected by any public authority, or by any local governing body". [59]

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[56]*The Times,* 13th September 1849 p. 3 cols 3-4
[57]*The Times,* 26th September 1849, p. 4 col.3
[58]*The Economist*, May 1848
[59]Jephson, H.,: *The* Sanitary *Evolution of London*, Fisher Unwin, 1907, pp. 66 & 78

Russell may have been complacent but he was not unrepresentative. On a previous occasion, when contemplating a reform of London's government which would have involved intruding upon the authority of the City, he had been warned by the Lord Mayor that his position as M.P. for the square mile could be jeopardised. Moreover he probably knew that he was reflecting the views of voters like the one who signed himself "A.Ratepayer" in a letter to the *Morning Chronicle* about the "centralising" tendencies of the Public Health Act: "Even in Constantinople or Grand Cairo where plague and cholera are decimating the population, it is doubtful whether such a Bill would be desirable".[60] Support for such views came, also, from more surprising quarters. Three eminent civil engineers, I.K.Brunel, William Cubitt and James Walker were asked to prepare for the General Board of Health a paper on sanitary improvements for the Metropolis, with particular reference to the provision of an adequate water supply. Commenting upon the possibility of replacing cesspools with sewage pipes they wrote of the idea that "we believe [it] to be impracticable without enormous expense, and to an extent of interference with private property that would hardly be submitted to".[61] This judgement was the more surprising since the civil engineering profession would be one of the chief financial beneficiaries of any large-scale programme of sewer construction.

Russell and the engineers may have been apprehensive about the effects of sanitary measures upon private property but the local vestries which constituted London's government in the early nineteenth century were more interested in taxes. Owen describes the attitude of vestrymen towards administrative reform:

> "From the tradesmen class that dominated London vestries as a whole, opposition was strong and continuous. This group, like French peasants, regarded spending money for public services as wasteful and unnecessary...the greatest triumph that a vestry could record was a reduction in the rates".[62]

Porter argues against judging mid-Victorian vestries by the standards of the post-1945 Welfare State and places the attitudes of the vestrymen in a broader economic context. Writing of "vestry government" he suggests that:

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[60] *Morning Chronicle*, 29th April 1848

[61] *The Supply of Water to the Metropolis*, General Board of Health report, 1850, pages 209-10 quoted in *Early Victorian Water Engineers*, G.M.Binnie, Thomas Telford Press, 1981 G.L.R.O.

[62] Owen, D.,: *The Government of Victorian London,* Belknap, 1982, p.38

> "Cheapness was seen as a cardinal virtue. If myopic as an approach to the metropolis's social and sanitary needs, this pinpointed an important fact: the Victorian growth miracle depended on a low cost, nil inflation economy. The burden of local government was to be reduced wherever possible". [63]

Nor were these attitudes confined to the Metropolis. In Newcastle-under-Lyme in 1853 two ratepayers candidates were elected after describing the town's first sanitary improvements as "injudicious and uncalled-for expense".[64] In Birmingham, a proposal to give the local corporation the power to borrow funds to construct a scheme of sewerage for the city was defeated in a ratepayers' poll by 3402 votes to 170. In 1861 a similar motion was passed by the ratepayers by 6351 votes to 3802. In the meantime a local landowner and Member of Parliament, C.B.Adderley, had obtained an injunction from the Chancery Court restraining the council from polluting the River Tame.[65] A similar situation occurred as late as the 1880s in Farnham, Surrey. In 1880, following an unfavourable report by the medical officer concerning the pollution of wells by sewage, a drainage scheme was prepared by a local engineer, James Lemon. An election followed which was "fought on the issue of sewage disposal".[66] One of the Farnham councillors elected in 1881, John Lorimer, who had intended to propose the adoption of Lemon's scheme "saw in the result of the election that it had been fought on the issue of drainage or no drainage, and that it was obvious that a majority verdict was for no drainage". Lorimer withdrew his motion. As with Birmingham twenty years earlier, it took the intervention of the law to persuade the councillors to invest in a sewerage scheme. The case of *Bateman vs Farnham Local Board* in January 1883 at Aldershot County Court led to the court issuing a judgement "to restrain the defendants from allowing solid or liquid sewage matter to fall or flow...into the River Wey". Birmingham and Farnham had both behaved in the way that Oxford and Canterbury had predicted when questioned by the Health of Towns Association. No money would be spent until the councils were compelled to do so.

The most ardent critic of centralisation, for sanitary reform or for any other purpose, was J.Toulmin Smith, a barrister of Lincoln's Inn, who wrote a series of pamphlets criticising all legislative measures which he regarded as directed to that purpose. In 1849, in a document of three hundred and eighty pages entitled "Government by

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[63]Porter, R.,: *London, a Social History,* Hamish Hamilton, 1994, pp. 240 and 242

[64]Bealey, F.W.,: *Municipal Politics in Newcastle-Under-Lyme,* Part I, 1835-72, in *North Staffs Journal of Field Studies,* Vol. 3 1963, quoted in *Briggs, Victorian Cities,* p.41.

[65]Briggs, A.,: *Victorian Cities,* Pelican, 1968, pp. 211-15

[66]Smith, E., *Victorian Farnham,* Phillimore, 1971, pp. 111 et seq.

Commissions Illegal and Pernicious" he invoked Magna Carta, Sir Edward Coke and the Common Law in attacking the centralising tendencies of commissions, referring to the Metropolitan Commission as "one of the best illustrations of the vices of the system" and proceeding to compare such institutions unfavourably with older traditions of local government: "Under existing things, and especially under such Commissions as the Metropolitan Commission of Sewers and the Public Health Board, many of those engaged know, and will in private tell you, of the folly and waste and inadequacy of certain means prescribed" whereas "under true institutions of local self-government, every opportunity is given for the development of every man's own energy".[67] He founded a journal, *The Eclectic Review* to publicise his "Anti-Centralisation Union" which called on Anglo-Saxon traditions " to take its stand on our historical constitution, not on any novel theories" and which declared itself opposed to "that sweeping experimental legislation to which there is now so great a disposition".[68] At a meeting of the Institution of Civil Engineers in 1852 he argued that nature should be left to carry away rainfall, sewers being an unnecessary expense for this purpose, and he attacked both the engineering profession and the General Board of Health for suggesting otherwise.[69]

The Creation of the Metropolitan Board of Works

In 1853, sixteen years after the Second Report on Municipal Corporations had drawn attention (without effect) to the advantages of a unitary Metropolitan authority, especially for drainage (see above, page 63), the Royal Commission on the Corporation of the City of London returned to the theme. The Commission was set up by Aberdeen's ministry and its members were Mr. Justice Patteson, Sir George Cornewall and Henry Labouchere. The evidence taken by the commissioners on the subject of drainage revealed a degree of satisfaction amounting to complacency amongst the City authorities concerning sanitary matters. On 19th January 1854 evidence was given by Joseph Daw, principal clerk to the City Commissioners of sewers. He was asked: "Does any inconvenience arise from the separation of the City Commission from other Commissions North of the Thames?" and he replied:

> "I do not conceive that any inconvenience has arisen at any time, and it can hardly arise now, because there is the best possible feeling between the two

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[67]Toulmin Smith, J.,: *Government by Commissions, Illegal and Pernicious*, Henry Sweet, 1849, p. 340.

[68]*Eclectic Review*, August 1850, p.146

[69]M.P.I.C.E., vol. 12, 1852-3, pp. 70-71

> commissions. The powers of our Act of Parliament and theirs are made to dovetail in such a manner that no difficulty can arise".[70]

Daw was referring to the powers conferred by the Metropolitan Sewers Act, in which clauses 38 and 42 authorised the Metropolitan Sewers Commission to require the City to carry out drainage works deemed necessary by the commissioners. Daw also referred, in the same evidence, to the City's "Ancient and prescriptive right of self-taxation" and argued that, since the City had an almost complete network of sewers, it would be wrong to tax the inhabitants for the drainage of surrounding districts. Later the same day the City Engineer, William Haywood, gave the Royal Commission a favourable account of the condition of the City's sanitary arrangements:

> "The sanitary police of the City is in a very satisfactory condition. I am not prepared to say that, as necessities develop themselves, during sanitary progress, it may not be capable of improvement, but it is the only section of the Metropolis that I am aware of at the present time which can be said to have any special sanitary staff conducted upon any complete system." [71]

The Royal Commission, in its final report, gave twenty-seven recommendations concerning the internal organisation of the City, followed by two recommendations which suggested a government for London outside the City based on the seven Parliamentary Boroughs:

Tower Hamlets	-539,111 inhabitants	Westminster	- 241,611
Finsbury	- 323,772	Marylebone	- 370,957
Lambeth	- 251,345	Southwark	- 172,863
	Greenwich - 105,784		

Each of these, except Greenwich, contained more inhabitants than the City itself, which registered 129,128 inhabitants at the 1851 census. The twenty-ninth recommendation was: " We further suggest the creation of a Metropolitan Board of Works composed of members deputed to it from the Council of each metropolitan municipal body including the Common Council of the City. The public works in which all have a common interest should be conducted by this body".[72] When Sir Benjamin Hall introduced the Metropolis Local Management Bill to Parliament on 16th March 1855, (18 & 19 Vict. cap. 120) Hansard records that he briefly considered

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[70]P.P. 1854, vol. 26, p.533
[71]P.P. 1854, vol. 26 p 534
[72]Ibid., page xxxviii.

but then dismissed the Royal Commission's proposals to base London's administration on the seven Parliamentary Boroughs, though his arguments against this structure appear to be based upon peripheral considerations. His reasoning is recorded in the following words:

> "Another suggestion was that there should be charters of incorporation granted to the present boroughs. He thought the greatest inconvenience would arise from that. The Tower Hamlets contained 550,000 inhabitants; Finsbury 330,000; Marylebone about 400,000. They were too large, and would probably be larger and they must not legislate merely for the present, but for some time to come. Moreover they would be imposing on the inhabitants of London that to which they were apparently much disinclined, in imposing on them municipal corporations, with the necessarily expensive staff of mayors, aldermen and councillors".[73]

Having dismissed the suggestions of the Royal Commission on the grounds that the boroughs were too large and, conversely, that he did not wish to burden them with the expenses of mayors and their retinues, he turned instead to his own proposal which was that the Metropolis be divided into administrative areas based upon existing parish boundaries, without creating corporations. Davis suggests that Hall's motive for adopting this fragmented structure was a concession to the "de-centralisers". "Sir Benjamin Hall's Metropolis Local Management Act rewarded the vestries for their opposition to Chadwick", (referring to the vestries' opposition to Chadwick's interventionist stance at the General Board of Health during the 1849 cholera epidemic).[74] Owen also describes Hall as one who "still represented the hopes of the anti-centralisation party...As the Member for Marylebone, he had carried the anti-centralisation torch in the House - partly, one suspects, because he disliked Chadwick's principles and partly because he disliked Chadwick.[75] The Bill, as presented to Parliament, certainly represents an attempt to balance the need for a powerful Metropolis-wide body with the authority to execute the drainage and other works of common interest with other considerations concerning intrusion on local interests. Some of these anxieties were expressed in the course of the Parliamentary discussion of the measure.

The Bill is a long one, running to a hundred and twelve pages, but the critical provisions as they affected the drainage works may be briefly summarised(18 and 19 Vict. Cap. 20). For the purposes of the Act the Metropolis would be defined as the area covered by the Registrar-General's thirty-six metropolitan registration districts,

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[73]*Hansard*, Vol. 137, 16/3/55 col. 717
[74]Davis, J.,: *Reforming London,* Clarendon Press, 1988, p.12
[75]Owen, D.,:*The Government of Victorian London,* Belknap, 1982, p 31

as used in the 1851 census so that "London as a governmental unit began as a statistical area".[76] Owen suggests that the choice of this area, rather than the larger area covered by the Metropolitan Police, was simply that it was the area chosen by the 1853 Royal Commission into the City.[77]A later controversy over the positioning of the outfalls into the Thames (see below page 94 et seq.) would question whether this was the most appropriate topographical area. Within this area the local government of London would continue to be based upon vestries, as in the past, but henceforward all vestries would be "open": that is, elected by all ratepayers whose properties were rated at forty pounds or more in most areas, though a lower figure of twenty-five pounds was substituted for those areas where less than one sixth of dwellings would have qualified at the forty pound level. One third of vestry members would retire each year. Vestries would then elect members of a central Metropolitan Board of Works according to the following formula (Clauses 44-47):

Six large vestries would elect two members each (St. Marylebone; St. Pancras; St. George's Hanover Square; Lambeth; Islington St. Mary; and Shoreditch St Leonard)

Seventeen smaller vestries would elect one member each

Twelve District Boards (consisting of groups of between two and nine small vestries) would each return one member

Plumstead District (five parishes) and Lewisham District (two parishes) would elect one member between them.

Rotherhithe Parish and St Olave's District (three parishes) would elect one member between them.

The City would elect three members

This gave a total of forty-six members, of which one third would retire annually. The chairman of the Board would be elected by the other members though Hall had originally suggested that the Home Secretary should choose the chairman from three candidates proposed by the Board, suggesting a desire on his part to maintain a degree

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[76]Gibbon, C., & Bell, R.W.,: *History of the LCC,* 1939, pp. 22-3
[77]Owen, D.,: *The Government of Victorian London,* Belknap, 1982, p. 32

of control over the Board's affairs from Westminster. The chairman would receive a salary of fifteen hundred to two thousand pounds. No other member would receive payment for his services. There would, under this formula, be no direct election to the Board by ratepayers. Clause 58 permitted the Board to appoint committees to which it could delegate its business and this provision would cause difficulties with the press during the early days owing to accusations of secrecy on the part of these committees whose deliberations, unlike those of the Board itself, were not necessarily open to public scrutiny.

Vestries and District Boards would be responsible for the construction and repair of local sewers, subject to the approval of their plans by the Board; and no house could be built without drains approved by the vestry (Clauses 68-89). The Board was given the power to raise rates for the construction of the intercepting sewers, for which it alone was responsible, a rating power which also extended to the City despite Daw's protestations on the matter to the Royal Commission; but some concessions to local interests were made in Clause 170 which enjoined that the rating power was to be exercised "having regard, in the case of expenditure on Works of Drainage, to the benefit derived from such expenditure by the several parts of the Metropolis affected thereby". To strengthen this restraint upon the exercise of its rating powers, Clauses 177 to 179 gave those thus assessed the right to inspect the basis of the assessment and, in case of dissatisfaction, to take the matter to the Court of Quarter Sessions. This arrangement, which amounted to a right of appeal, appears to have been a further concession to local conditions and it was to cause the Board much trouble in the first two and a half years of its work. The Board was empowered to borrow against the security of the rates (Clause 183).

Clause 135, concerned with the powers and duties of the Board, instructed that:

> "The Main Sewers now vested in the Commissioners of Sewers of the City of London and in the Metropolitan Commissioners of Sewers...shall be vested in the Metropolitan Board of Works and such Board shall make such sewers and works as they may think necessary for preventing all and any part of the sewage of the Metropolis from flowing into the River Thames in or near the Metropolis and shall cause such sewers and works to be completed on or before the thirty-first day of December 1860".

But it was the following clause, 136, that was to dominate the first three years of the Board's existence and prevent it from taking any active steps to carry out this instruction:

> "Before the Metropolitan Board of Works commence any sewers and works for preventing the sewage from passing into the Thames as aforesaid, the plan of the intended sewers and works ....shall be submitted by such Board to the Commissioners of Her Majesty's Works and Public Buildings; and no such plan shall be carried into effect until the same has been approved by such Commissioners."

It seems that, having created a body which would be rooted in local interests in the form of the vestries; and having further protected local interests by making it easy for ratepayers to inspect and appeal against the basis of their rating assessments; that Parliament was still unwilling to confer upon the Board the powers necessary to design and execute the system of intercepting sewers. A power of veto was retained. This arrangement is reminiscent of the 1848 Public Health Act by which, after some fierce debates about the relative powers of the Board of Health and local authorities, the House of Lords had amended the Bill to give the General Board what amounted to powers of veto over the proposals of local Boards and is further evidence of a reluctance to make a clear choice between central and local authority. Further constraints upon the Board were inserted in Clause 144, which stated that expenditure upon improvement works of over fifty thousand pounds had to be approved in advance by the Commissioners of Public Buildings and Works while expenditure in excess of one hundred thousand pounds had to be approved by Parliament. Finally, the Act protected another interest, that of the Metropolitan Sewage Manure Company which was engaged in plans (eventually fruitless) to put the sewage to agricultural use. Clause 243 stated that "Nothing in this Act shall extend to or affect any of the rights...vested in the Metropolitan Sewage Manure Company." Clause 152 gave the Board what was, in effect, power of compulsory purchase, with the agreement of "one of Her Majesty's principal Secretaries of State".

This curious, and ultimately unsatisfactory compromise between the powers of the Board to take action and the powers of the central government to veto the Board's plans may be seen as part of the continuing debate over the relative virtues of strong central authority and local autonomy. MacDonagh has described the Public Health and Sanitary conflicts of 1842-54 which preceded the establishment of the Metropolitan Board as "in many ways the most complex and illuminating of all the phases of administrative reform...they also produced perhaps the last major victory of individualist over collectivist principles.[78] Chadwick had only recently (1854) been removed from the General Board of Health for his supposedly authoritarian

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[78]MacDonagh, O.,:*Early Victorian Government,* Weidenfeld, 1977, p. 133

tendencies and as late as 1858 *The Lancet* was criticising Chadwickian centralisation in uncompromising terms:

> "A few doctrinaires, nursed in the narrow conceits of bureaucracy, scornful alike of popular knowledge and of popular government, seized upon the sanitary theory as a means of exercising a central power of domiciliary inspection and irresponsible interference with the conduct and property of Englishmen...the truth is we do not like paternal governments ...this is another reason why the CHADWICKIAN sanitary regime so signally failed".[79]

The debates on the Bill were poorly attended. Only five members spoke in the debate on the first reading, the first being Fitzroy who complained that proposals for the government of nineteen twentieths of the Metropolis were based on the recommendations of a Royal Commission which had been appointed to consider the other twentieth (i.e. the City). Lord Ebrington objected that "there was a danger that the proposed local Parliament...would discuss politics instead of sewerage questions, and threaten to overshadow the authority of the Speaker and that of the Imperial Parliament." Similar anxieties were voiced in later readings and in committee by Major Baring (M.P. for Marlborough), Spencer Walpole (Midhurst) and J.W.Henley (Oxfordshire). Porter compares the misgivings of these Victorian M.Ps about conferring power upon a powerful Metropolitan body with similar anxieties felt by the governments of the 1980s concerning the power of the Greater London Council.[80] Later readings were nevertheless also poorly attended. During the second reading on 16th April 1855 Apsley Pellatt, M.P. for Southwark, asked Hall to delay the reading because of the sparse attendance caused by the visit of Napoleon III, but the reading proceeded nevertheless. On 3rd July, during the Committee stage of the Bill, Ebrington observed that only twenty-five members were present.

Outside Parliament the debate was conducted with more vigour. On 14th August, following the passage of the Act, *The Times* published a leader welcoming the new body and, commenting on its powers over the City, wrote that "a very large handful of feathers has been plucked from the civic bird". Prominent amongst the opposition to the measure was Toulmin Smith who, in 1857, published a clause by clause commentary upon the Act in which he placed it in a long and dishonourable line of authoritarian measures which "sought to extend the system of Functionarism and to destroy the traces of every principle which characterises English institutions and

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[79]*The Lancet* 13th February 1858

[80]Porter, R.,: *London, A Social History,* Hamish Hamilton, 1994, p. 246

responsible government". Commenting on the clause (46) which required Plumstead and Lewisham to share one member of the Board he declared that "This section affords a striking illustration of the unfitness of the arrangements of the present Act as to Districts and representation".[81] Some contemporary commentators were critical of the principle of indirect election, by which vestrymen, elected by the ratepayers, then elected the Board, with no direct influence from the ratepayers, thereby creating what Davis has called "The world's first Metropolitan two-tier administration".[82] In fact it was a three-tier administration in those areas where small vestries elected District Boards who in turn elected the Metropolitan Board. A contemporary critic, J.T.Dexter, calculated that this three-tier arrangement meant that it could take twelve years to change a single member of the Metropolitan Board. [83]Another contemporary, J.F.B.Firth, argued that the dependence of the Board on Vestry representatives led to second rate people serving on it and he produced a hostile analysis of the background of its members.[84] The democratic, representative credentials of the system were not strengthened by the very low votes in vestry elections. Davis calculated that, in Camberwell, in the first ten years of the Board's existence, the highest vote recorded for a vestryman was sixty-seven votes while many elections were uncontested and, on three occasions, a candidate topped the poll with votes in single figures.[85] Firth claimed that "frequently the number of persons electing is less than the number to be elected, and frequently there is no contest". [86]

Later critics have taken a similarly harsh view of the lower tiers of administration, the vestries and districts, which Hall created in an attempt to create a balance of power. Robson, writing in 1939, claimed that "There is almost unanimous agreement among those who have enquired into the subject that the minor authorities created in 1855 [i.e. the vestries and districts] failed miserably to fulfil with credit or efficiency the tasks which Parliament had assigned to them".[87] Davis's verdict is that "The two-tier system of 1855 was an experimental attempt to solve the problems which happened not to be very successful".[88] Dyos's judgement of the Board was that "London, though fit for a province in itself, was saddled for more than a generation with a kind

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[81]Toulmin Smith,J.,:*The Metropolis Local Management Act*, Henry Sweet, 1857, p.85

[82]Davis, J.,: *Reforming London*, Clarendon Press, 1988 p. 13

[83]Dexter, J.T.,: *The Government of London,* Stanford, 1875

[84]Firth, J.F.B.,: *London Government and How to Reform it,* London, 1882, p. 63

[85]Davis, J.,: *Reforming London*, Clarendon Press, 1988, p. 28

[86]Firth, J.F.B.,: *London Government and How to Reform it*: London, 1882, p. 63

[87]Robson,W.A.,:*The Government and Misgovernment of London*, 1939, pp. 66-9

[88]Davis, J.,: *Reforming London*, Clarendon Press, 1988, p. 15

of vastly inflated vestry, in the shape of the Metropolitan Board of Works"[89] though it may be argued that, judged by its later achievements, this verdict is harsh. Dunbabin's more balanced judgement is that "The Board had, in many ways, a constructive record, but its prestige was low; and the system was too complex to attract the interest of voters and too anomalous to have the same pretensions to finality as the Municipal Corporations re-modelled in 1835".[90] Chadwick's view of the Metropolis Local Management Act and its author, Hall, was harsher and remained so thirty years after its passing. In 1884 he wrote:

> "When the measure of disunity was passed, agitation ceased; all for a time appeared in Parliament to be working satisfactorily and the author of the measure [Hall] ...claimed a peerage for what he did and obtained it".[91]

Long after the Board was established a number of powerful vestries continued to question the need for its existence. In 1859 the Vestry of St. James, Westminster, called for the implementation of the original recommendations of the 1853 Royal Commission Appointed to Enquire into the Existing State of the Corporation of the City of London. Hall had rejected the recommendation to create the seven corporations in favour of a Vestry-based system but this proposal was now revived by the St James Vestry one of whose members, James Beal, formed the Metropolitan Municipalities Association in 1865, to campaign for the purpose. Beal was a friend of the philosopher John Stuart Mill who, as a Member of Parliament, made several attempts in the period 1867 to 1870 to introduce Parliamentary Bills which would secure Beal's ends. In May, 1872, an article in the *Pall Mall Gazette* advocated the de-centralisation of London Government at the expense of the Board of Works though the *Metropolitan* was quick to reply, mounting a strong defence of the Board in a leading article.[92] The issue thus continued to excite controversy seventeen years into the Board's existence and long after its success in constructing the main drainage had been acknowledged and applauded.[93]

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[89]Cannadine, D. & Reeder,D., (ed.),: *Essays in Urban History by H.J.Dyos*, C.U.P., 1982, p.42

[90]Dunbabin, J.,: *Local Government Reform:the Nineteenth Century and After* The Historical Journal, October 1977, p. 782

[91]Chadwick, E.,: *London Centralised*: Contemporary Review, June, 1884, p.80

[92]*Pall Mall Gazette,* 1st May, 1872, p.3; *Metropolitan*, 4th May, 1872, p.200

[93]An account of the work of Beal is to be found in K.Young and P.L.Garside: *Metropolitan London - Politics and Urban Change, 1837-1981,* Edward Arnold, 1982, pp. 28-9

The Metropolitan Board of Works: Character of the Membership

Hall's careful judgement in creating a body over whose plans he had, in effect, a power of veto in his capacity as Chief Commissioner of Works, was put to the test as the Board began what Jephson, in the words of the Hackney Medical Officer in 1860, characterised as "a war of the community against individuals for the public good",[94]a phrase which effectively summarises the debates between centralisers and de-centralisers which had preceded the creation of the Board. The Board took office on 1st January 1856. Instead of forty-six members it had forty-five since John Thwaites, soon to be elected chairman, had been returned as representative for two vestries, Southwark and Greenwich. Given the disparaging judgements of the Board and its members by contemporaries and later commentators, noted above, it is instructive to examine the personalities and backgrounds of some of its early members.Appendix 1 contains some information about the experience and credentials of those members who were the subjects of a series of "Pen and Ink Sketches" and "Pen and Ink Portraits" which respectively appeared in *The Elector* and *The South London News* in 1857, the second year of the Board's existence. Twenty-nine of the members were featured and there follows a brief account of some of the more prominent members, together with a classification of the occupations and experience of local administration of all the members whose details in these respects are available.

On 13th June 1857 appeared a sketch of the chairman, Thwaites, in *The Elector.*[95] Thwaites had been born at Meaburn, Westmorland, in 1815 and was educated at a school in Reagill, in the same county. He left Westmorland for London in 1832, aged 17 and became a partner in a draper's business after first serving an apprenticeship. The business was situated first at 18, Blackman Street, Borough and later at 61-2 Borough High Street. Thwaites was knighted on 18th May 1865 for his work as chairman of the Board and died at Meaburn House, Upper Richmond Road, Putney on 8th August, 1870.[96] A portrait of him in the *Illustrated London News*, which appeared in July, 1858, revealed that his experience of local administration included the role of Poor Law Guardian in the parish of St. Paul, Deptford, where he resided.

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[94]Jephson, H.,: *The Sanitary Evolution of London,* Fisher Unwin, 1907, p. 96

[95]An account of the numerous applications for the office of chairman, many from persons who were not members of the Board, may be found in *MBW Presented paper 212,* G.L.R.O.

[96]Boase, Frederick (ed.),: *Modern English Biography*; Frank Cass (1868) p.782

He had also been chairman of a gas consumers' committee which had been instrumental in exerting control over gas prices in the area.[97] He had represented Southwark on the former Metropolitan Sewers Commission. *The Elector* described him in flattering terms:

> "Mr. Thwaites is a type of the time we live in. He is the natural product of London matter-of-factism...In the celebrated Guildhall of the most important city on earth you may see, enthroned in the highest Metropolitan authority a man who, a short time ago, was the vendor of broadcloth".

Referring to his role as chairman of a Board whose discussions were often acrimonious *The Elector* wrote:

> "The frequent use of his hammer proves how active his mind must be in balancing the merits of every statement, and the amount of disorder he has to check...He bears with great calmness the odium of actions he has done all he could to prevent, and the charge of inaction he has made every effort to avoid".

In 1889 the London County Council (L.C.C.) succeeded the Metropolitan Board of Works and in the early years of the twentieth century the *LCC Staff Gazette* published two brief mementos of Thwaites, written by members of the L.C.C. staff who had worked with Thwaites at the M.B.W. In June 1906, in an obituary notice following the death of a Mr Delahooke, the writer observed that "during the reign of 'king' Thwaites, first chairman of the Board and a thoroughly capable despot, no-one else had much chance".[98] A further commentary on Thwaites appeared the following year, in April 1907, in an article by Edgar Doggett, written on the retirement of the latter as Comptroller of the L.C.C.. Doggett had joined the Metropolitan Board in 1863 as an assistant bookkeeper and reported the nicknames attached to some of the Board's more prominent personalities. Of Thwaites he wrote:

> "Even that solemn and lofty person, the Chairman, with a strong gaze and sepulchral voice,did not escape, and was generally known as 'The Stiff 'Un' "[99]

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[97] *Illustrated London News*, 24th July 1858, p.74

[98] *L.C.C. Staff Gazette*, Vol. 7, June 1906, p.85; the volume is the property of Mr John Adamson, the joint author of *The London Town Miscellana*: see following footnote.

[99] Adamson, J., & Hudson, L., (ed.): *The London Town Miscellana*: Alexius Press, 1992, p.23.

On the same day as its portrait of Thwaites, 13th June, *The Elector* sketched Alderman William Cubitt, M.P. for Andover and later Lord Mayor of London. As a successful builder in partnership with his brother, Thomas, he had been responsible for constructing many of London's buildings. *The Elector* portrayed him as one of those "who sit down calmly, whilst the tempest of debate is raging...He never wastes his ardour, neither at the Board nor in Parliament in a heated debate. He is quite content to act." The clerk to the Board, Woolrych, (former secretary to the Metropolitan Commission of Sewers) was described as one trained for the bar who was unable to use his oratorical skills in expediting the Board's business. On 27th June the paper's sketchwriter turned to John Leslie who had succeeded in disrupting the first two Sewers Commissions (see above Ch. 1) by his intemperate opposition to Chadwick and who was soon to be a similar influence on the work of the Board. *The Elector's* view of him was plain enough:

> "Whilst others are rounded off like pebbles, by constant friction of the fellowship of each other, he retains his natural angularities, just as nature blew him out of her quarry...The dependence of one idea upon another, and the parental connection of a first thought with a second, we should say, had never been objects of his special solicitude...He does not take the trouble of explaining to others the thread of causation and sequence which may exist in any statement he may make. His forte is to startle with apparently random hits. He has smashed out of being several commissions for the improvement of London."

Alderman Humphrey (11th July 1857) had been M.P. for Southwark from 1832-51 and Lord Mayor of London in 1842. A prominent businessman, he was described as a wharfinger of Hay's wharf who had spent half a million pounds on business premises in Tooley Street. On 21st March the *South London News* published a much less re-assuring "Pen and Ink Portrait" of Mr. Crellin, a member who was noted for his lack of energy: "None but a totally indifferent class of men to all that is energetic could have elected him to be a member of the Board of Works". Crellin was presumably one of the people Firth had in mind when he criticised the quality of the members who emerged from the vestry system. Yet Crellin, and in a different way Leslie, were the only Board members whose portraits could be regarded as hostile despite the fact that, when they appeared, the Board was already the subject of critical press comment as it struggled to prepare a scheme for intercepting the sewage which was acceptable to Hall.

Of the twenty-nine members portrayed in the two papers three were M.Ps and nearly all had some experience in local administration as magistrates, Guardians or, in two

cases, as Lord Mayors of London. Three were involved with Mechanics' Institutes either as lecturers or, in one case (Irvine), as a collaborator of Birkbeck in establishing such institutes. Eleven were identified as businessmen and one of these, Dennis, had experience in the construction of sewers. Five were lawyers, one an accountant and one was a captain of artillery. Two had been elected to the Metropolitan Board without being members of a District Board or Vestry. It is hard to reconcile these admittedly brief biographical details with the severe judgements of Dexter, Firth and more recent commentators on the qualities of the Board's members. With the exception of Crellin there is not much evidence here that it was dependent upon nonentities though one commentator has attributed the success of the Board in executing great projects to the fact that the modest capacities of the Board members removed from them the temptation to interfere with the work of the professionals like Bazalgette:

> "The mediocrity of many of the members, together with their willingness to leave the staff to get on with the job, meant that projects were designed and completed, and were not delayed by in-fighting between powerful interest groups, such as had thwarted the efforts of the Metropolitan Commissions of Sewers".[100]

The members certainly worked hard, particularly so since none of them received a salary except the chairman, Thwaites, who was paid fifteen hundred pounds a year. Owen, while acknowledging some of the weaknesses of the organisation attributes much of its success to the steadying influence of Thwaites and Bazalgette:

> "However much chattering there may have been in the meetings of the Board, and there was an enormous volume of bad oratory sprayed around in "the Parliament of the Parishes" - at least two essential officers, the chairman and the engineer-in-chief, were diligent and alert. To their indefatigable labour London, in large measure, owes its intercepting sewers".[101]

Owen's judgement is at odds with the interpretation which some contemporary commentators placed upon Bazalgette's appointment. *The Observer* believed that it represented an attempt by sectional interests within the Board, notably those of the City, to exercise control over the chairman, Thwaites, who had no connections with the City. In 1853, during the course of a dispute within the Fifth Metropolitan Sewers

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100Clifton, G.,: *Professionalism, Patronage and Public Service in Victorian London: the Staff of the Metropolitan Board of Works, 1856-86*,Athlone Press,1992,p.163

101Owen, D.,: *The Government of Victorian London,* Belknap, 1982, p. 57

Commission over the relative merits of sewers built of brick or cast in pipe. Bazalgette had produced a report for the Commissioners which was highly critical of pipe sewers as used in the Metropolis and in five other towns. Subsequent enquiries suggested that Bazalgette's investigation had been hurried, biassed and far from thorough and Thwaites, in his account,[102] was not only critical of Bazalgette's methods but implied that his task had been to assemble evidence to support decisions already taken by his masters, the Commissioners, rather than to carry out an objective appraisal of the merits of each system. Bazalgette did not emerge from the episode with credit and feelings on the matter ran so strongly that one of his critics, Ebrington, in his speech to Parliament on the Metropolis Local Management Bill, went so far as to claim that one of the advantages of the Bill was that it would end Bazalgette's career at the Commission of Sewers:

> "Mr Bazalgette, engineer to the Commission had latterly made himself conspicuous by his opposition to [pipe sewers]...the utter disingenousness of Mr Bazalgette's report...He rejoiced to feel that one of the operations of the present Bill, when it became law, would be to cut short this officer's tenure of office".[103]

Bazalgette's application for the post of Chief Engineer to the Board appears to reflect some anxiety that he felt from this earlier episode. He wrote two letters, one of which referred to his extensive engineering experience in the service of the Metropolitan Commissioners of Sewers while the other dealt with the earlier controversy:

> "In the course of my official duty I have been required by the Commissioners under whom I served to make reports and to give my professional opinion upon several matters which were, or became, subjects of controversy amongst persons holding a contrarity of opinion respecting such matters. But in the performance of this duty... I have always studiously abstained from offering any remarks uncalled for by the strict line of my duty upon the systems favoured or pursued by other persons or bodies whose views happened to differ from mine".[104]

In support of his application Bazalgette also enclosed testimonials from numerous eminent engineers including I.K.Brunel, Robert Stephenson and William Cubitt.

102Thwaites, J.,: *History and Prospects of the Metropolitan Drainage Question*, 1855, pp. 15-18

103*Hansard*, 9th August 1855, cols. 2067-9

104M.B.W.: *Presented Papers*, 212, G.L.R.O.

Building upon the hostility between Thwaites and Bazalgette which it supposed to have arisen from the pipe sewers controversy, *The Observer* suggested that Bazalgette had been appointed as Chief Engineer with the support of City representatives on the Board because "they calculate that it will place Mr. Thwaites in an unpleasant position if the Chief Officer appointed holds views diametrically opposed to the chairman.[105] A fortnight later the newspaper went so far as to suggest that the City had supported the appointment of Bazalgette in order to secure Thwaites's resignation.[106] Despite these predictions Bazalgette and Thwaites were to enjoy an excellent working relationship in the many difficulties they faced together, particularly in the early years of the Board's existence, despite the despotic tendencies, referred to above, which others noted in Thwaites.[107]

A False Start

The Board, from its earliest days, was in doubt about its priorities. Although it had responsibility for streets and many other activities besides sewers, it moved swiftly to the problem of drainage. Having elected Thwaites as chairman on 22nd December 1855, and having asked Bazalgette to continue to act as Chief Engineer on 1st January 1856,[108] the Board passed the following resolution on 18th February 1856:

> "That this Board, impressed with the necessity of at once proceeding with the works necessary for the complete interception of the sewage of this Metropolis, request the Chief Engineer to report to the Board at the earliest possible period as to the plans necessary for the accomplishment of such

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105*Observer,* 6th January, 1856, p.5

106Ibid.,, 20th January 1856 p.5

107The controversy over the merits of bricks and pipes in the construction of sewers engaged the attention of numerous public figures during this period and many public enquiries. See for example P.P. 1844 vol. 17; 1847-8, vol. 32; 1852 vol. 19; however the size of the intercepting sewers was such as to ensure that bricks, and later concrete, were adopted by the Board without much argument despite the fact that Frederick Doulton, whose family were the leading pipe manufacturers, was the Board member for Lambeth from 1855 to 1868. Bazalgette did approve the use of pipes for many miles of street sewers, as recorded in the Board's Annual Reports. In discussion of his paper to the I.C.E. on London's intercepting system Bazalgette went so far as to criticise the brick sewers of Paris on the grounds that they were *too large* to carry away deposits; M.P.I.C.E. 1864-5 Vol. 34, p.315

108M.B.W.*Minutes of Proceedings,* 1856, pp. 5 & 7

object".[109]

Bazalgette, who was appointed as Engineer to the Board on 25th January 1856 (despite a late objection from the engineer F.O.Ward, who claimed that Bazalgette had misrepresented his previous experience, a claim that Bazalgette was able to explain to the satisfaction of the Board),[110] was as familiar as anyone with the numerous proposals that had been advanced for Metropolitan drainage since 1849, when he had been appointed Assistant Surveyor to the Second Commission of Sewers. He had been responsible for examining and evaluating the one hundred and thirty-seven plans submitted to the Third Commission in 1850 and had worked on the Commission's own scheme with Frank Forster, whom Bazalgette succeeded as Chief Engineer upon the death of Forster in 1852 (see Chapter One for a fuller account of these events). Bazalgette was therefore well acquainted with the multitude of solutions to London's drainage problems that had been propounded over the previous seven years. Following the instruction issued by the Board on 18th February 1856 Bazalgette was able to submit plans for the Southern drainage on 4th April and for the Northern drainage on 23rd May.[111] He presented the plans with a modesty that was to become a hallmark:

> "Almost every suggestion which can be made upon the subject has been so often repeated in some shape or other that it would be difficult to detect which were the first authors of the various schemes propounded. Having had the advantage of access to all, I cannot pretend to much originality; my endeavour has been practically to apply suggestions, originating in a large measure with others, to the peculiar wants and features of different districts, with which my position has made me familiar."[112]

Sir George Humphreys who, as Chief Engineer of the London County Council, assumed responsibility for Bazalgette's system in the twentieth century, took a more flattering view of his predecessor's work in his account of the development of London's drainage system. Commenting in 1930 on Bazalgette's modest claims he wrote that:

> "This fair and frank statement, disclaiming credit which he considered was not due to him, must not be allowed to deprive Sir Joseph Bazalgette...of the great credit to which he is entitled as the engineer who not only evolved a practical scheme out of these various proposals but also carried it out in so efficient a manner that to-day, with trifling exceptions, the whole work is still

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109Ibid., p.35
110Ibid., p.20
111Ibid., p.96 (Southern drainage) and p.200 (Northern drainage)
112M.B.W. *Printed Papers*, Vol. 1 No. 10, G.L.R.O.

carrying out the function for which it was created."[113]

The area North of the river was to be served by three sewers and that South of the river by two, with some sewers also having branches. The lengths and dimensions proposed are shown in Appendix 2:[114] At Abbey Mills in the North the Low Level Sewer's contents would be pumped to a level with the Middle and High Levels; thence the combined flow would proceed via the three Outfall Sewers to Barking where it would be discharged into the Thames. At Deptford the contents of the High level sewers would discharge to an outfall and the Low level sewer would be lifted to the outfall which would run to Plumstead marshes. The capacity of the system was calculated using the following information and estimates.

	Northern Area	**Southern Area**	**Total Area**
Acres drained	31,896	43,456	75,442
Future population allowed for	2,300,000	1,150,000	3,450,000
1856 population (Humphreys' est.)	1,889,300	696,760	2,586,060
Sewage per day @ 31.25 gallons 108m. gallons per person	72m. gallons	36m. gallons	
Rainfall per day	178m. gallons	108m. gallons	286m. gallons
Total sewage + rainfall	250m. gallons	144m. gallons	394m. gallons

On 3rd June 1856 Bazalgette's plan was sent to the First Commissioner, Sir Benjamin Hall, for his approval, as the Act required. There followed a protracted, frustrating

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113Humphreys, Sir George,: *The Main Drainage of London,* L.C.C., 1930, p.11

114M.B.W. *Printed Papers*, Vol. 1, No. 10, G.L.R.O., and M.P.I.C.E., Vol. 24, 1864-5, pp. 280-358

and sometimes acrimonious debate between Hall and the Board concerning the interpretation of the Act, particularly as it affected the positions of the outfalls into the Thames. From the beginning of the project Hall showed a keen awareness of his responsibilities in supervising the Board's affairs though this appears to have been prompted by diligence rather than by distrust of the Board. As early as 10th March 1856 Hall wrote to Thwaites reminding the chairman of the Board's duty to seek his approval for the Main Drainage plans as well as for any expenditure exceeding £50,000, as stipulated in clauses 135 and 144 of the Metropolis Local Management Act.[115] A month later, on 14th April, Hall's secretary Alfred Austin wrote to the Board concerning reports that Hall had read in newspapers about the Board's plans for drainage South of the Thames, asking that Hall be represented at float trials that the Board was evidently planning[116]. On 24th May Austin wrote again to inform the Board that Hall had appointed his own consultant engineer, Captain R.Burstall, R.N., to test the accuracy of experiments carried out by the Board with tidal floats.[117] On 13th June, ten days after the Board had sent its Plan to Hall, Bazalgette reported to the Board that he had met with Captain Burstall to discuss the results of the Board's experiments and that Burstall had informed him that "though he had no doubt of the accuracy of the observations he proposed to test them generally during two days in the present month at Spring and two days at Neap tides".[118] It should not have surprised the Board when its proposals were subjected to the most searching appraisal. Nevertheless other evidence suggests that Hall was not ill-disposed towards the Board or distrustful of its activities: rather that he was fully aware of the highly sensitive nature of their proposals and anxious to ensure that he was not held responsible for any shortcomings which might later emerge. During the heated controversy that dominated the first two and a half years of the Board's existence, until the summer of 1858, Hall approved numerous road improvement schemes without making difficulties and in November 1856, at a sensitive point in the debate, he agreed to accompany a deputation of the Board to wait upon the Chancellor of the Exchequer in an attempt to increase the Board's borrowing powers. He supported their aims while legitimately questioning whether their methods were in conformity with the Act which had created the Board and for whose application he was answerable to Parliament.

115M.B.W.*Minutes of Proceedings*, 1856, pp. 69-70
116Ibid., pp.138-9
117Ibid., p.208: for details of experiments see M.P.I.C.E., Vol. 13, 1853-4, p.93
118Ibid., p.256

Hall submitted the Board's plans to Captain Burstall who reported on them in little more than three weeks, on 30th June 1856.[119] On 2nd July Hall sent the plans back to the Board accompanied by a letter which made plain his own reservations about them:

> "By the Metropolis Act of 1855 it is provided that the Metropolitan Board of Works shall make sewers and works for preventing *all or any part of the sewage of the Metropolis from flowing or passing into the Thames in or near the Metropolis* [my italics]. But the scheme submitted for the approval of the First Commissioner actually provides that the sewage shall flow into the Thames at a point within the Metropolis... It consequently follows that, before any such scheme can be carried out, it will be necessary to call upon Parliament to repeal so much of the Act of last session as provides for the purification of the river Thames within the Metropolis. The First Commissioner feels that he cannot undertake to do this and, considering that the scheme is entirely at variance with the intentions of the legislature as set forth in the Act which passed last August he considers it to be his duty to return the plans which were submitted for his approval".[120]

It is hard to fault Hall's judgement despite the delay it now caused. Clause 135 of the Act, as quoted in the italicised section of Hall's letter above is unambiguous. Hall's letter went on to state that, according to Burstall's experiments, sewage discharged into the river at Plumstead two hours before high water would reach East India Dock two and a half hours later.

Three weeks later, on 22nd July Doulton proposed a motion "that the Engineer be directed to prepare a plan, section and estimate for extending the main outfall sewer on the Southern side to a point in Long Reach below Erith and so as to be discharged at and after high water only". After debate the vote was fourteen for and fourteen against, the motion being carried by Thwaites's casting vote.[121] In the weeks that followed other motions were debated, the most radical of which required Bazalgette to prepare a plan for carrying the Southern sewage across the river by a tunnel starting near Greenwich marshes and then proceeding by one channel to an outfall near Mucking Creek, Essex, twenty miles beyond the Metropolitan boundary. (See map 2 which illustrates the various discharge points proposed). The numerous resolutions and the heated debates which characterised these few weeks are no doubt a reflection of the pressure felt by the Board: on the one hand to conform with the Act; on the other to do so at a cost which would be acceptable to the Vestries and Districts whose

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119P.P. 1884, vol. 41; Minutes of Evidence 6491; also MBW Annual Report 1856, p.6
120P.P. 1884, vol. 41, pp. xvi - xvii
121M.B.W., *Minutes of Proceedings*, 1856, p.346

rates would have to pay for it. The dilemma was reflected in a motion of 22nd October which was carried by twenty-four votes to six:

> "That the engineer's plan marked B in his report dated 25th September 1856 be now adopted and presented to the Commissioners of Her Majesty's Public Buildings and Works and that it be intimated to them that this Board has also had under consideration other plans for discharging sewage into the river below Gravesend; but that, it appearing that such extension would add between one and two millions to the outlay and that this sum would be spent not to benefit the inhabitants of the Metropolis but to meet the wishes of the people of Kent and Essex who reside on the banks of the river, this Board has declined to entertain any such scheme. Nevertheless if it shall be the opinion of Her Majesty's Government that such an extension is desirable this Board will readily undertake the work; the government providing for such additional outlay out of the National Revenue".[122]

The plan referred to was a slight modification of Bazalgette's original plan, the outfalls being moved a little further downstream so that they fell just outside the Metropolitan boundary. On 5th November Thwaites and Bazalgette visited Hall to submit the modified plan, together with the offer, contained in the above motion, to site the outfalls further downstream at the government's expense. The plan did not really suit anyone and, in the words of *The Builder*, "it would appear that the deputation was considerably snubbed".[123] Burstall advised Hall that, although the outfalls were now beyond the Metropolitan boundary, the incoming tide would still carry the sewage to a point within the Metropolis (though the Act did not specifically forbid this). On 12th November Thwaites read Austin's reply on behalf of Hall which stated that the First Commissioner "considers that the plan presented to him as regards the outfall is at variance with the intention of the legislature and contrary to the spirit of the statute. It is, therefore, with much regret that he feels bound to return the plan, withholding his approval". However, in referring to the Board's offer to construct an additional length at public expense Thwaites reported that "The First Commissioner had intimated that if this Board could make out a case for contribution he would be prepared to submit the same for consideration by the government". Thwaites added that, in his opinion, the matter could be resolved without difficulty.[124]

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[122]Ibid., p.550
[123]*The Builder*; 8th November 1856, p.609
[124]Ibid.,pp. 605-6

On 21st November 1856 Thwaites and Bazalgette attended a meeting with Hall and reported to the Board on the same day. Hall showed the deputation Burstall's report, dated 18th November, in which he had written:

> "I should therefore submit that the nearest point to London at which the outfall be made (so as to be certain that the portion discharged at one and a half hours before high tide would not flow in or near the inhabited parts of the Metropolis) be in the upper part of Erith Reach, fifteen miles from London Bridge".[125]

This point was one mile beyond the Board's proposed outfall. Burstall recommended that the Northern outfall be almost immediately opposite the Southern, at Rainham Creek, five-eighths of a mile beyond the Board's proposed outfall at Barking. It was at this meeting with Thwaites and Bazalgette that Hall agreed to accompany a deputation of the Board to see the Chancellor of the Exchequer to seek an increase in the Board's borrowing powers.[126] At the Board's meeting on 28th November the members considered a proposal from Sir Samuel Morton Peto to construct an additional length of outfall from Abbey Mills to the North Sea ("German Ocean") at a cost of £1.6 millions. He proposed to charge the Board a rental for the use of this sewer amounting to 4% of the construction cost and also expected to be able to recover, for agricultural use, four thousand acres of South Essex between the Blackwater and the Crouch.[127] The degree of anxiety and urgency which attended the issue may be gauged from the fact that, between 21st and 28th November, the Board met four times in eight days. After further work the Metropolitan Board submitted a third plan in which Bazalgette, following Burstall's recommendations, proposed to place the Northern outfall at Rainham Creek on Hornchurch marshes and the Southern outfall at Erith Creek. This plan was forwarded to Hall on 22nd December 1856.[128]

By this time the delays in constructing the long-awaited system were beginning to attract critical comment. In December 1856, as Bazalgette was preparing the third plan, a leading article in the *Illustrated London News* referred to the disagreements between the Board and Hall, commenting that:

125M.B.W.,*Minutes of Proceedings*, 1856, pp.626-7
126Ibid., p.629
127Ibid., pp. 669-70
128M.B.W., *Annual Report*, 1856-7, p.6

> "In sullen, Pistol-like compliance with Sir Benjamin Hall's desire they have, a fraction at a time, amended their plan for Thames purification; though in this respect their latest effort is still a half-measure. It will, however, ensure the destruction of the riverborne fish trade, ruin the waterside towns and waste upon the unthankful flood the fertilising matter for which the farmers petitioned".[129]

The Referees' Plan

On 31st December 1856 Hall referred the Board's third plan to a committee of three referees: Captain Douglas Galton of the Royal Engineers; James Simpson, engineer to two London water companies; and Thomas Blackwood, engineer to the Kennet and Avon canal.[130] Their terms of reference were broader than those of Burstall since they were allowed to put forward their own proposals and were especially enjoined to consider the possibility of using the sewage for agricultural purposes: a matter to which the *Illustrated London News* had referred and which was to influence, and often confuse, the deliberations of the Board over the following years. Seven months passed before the referees submitted their five hundred page report to Hall on 31st July 1857[131] and its solution to the Metropolitan drainage problem differed in two important respects from those of Bazalgette and Burstall. First, the referees believed that Bazalgette had significantly underestimated the volume of liquid waste that would need to be removed. The referees estimated that the system would need to accommodate a daily volume of 211 million cubic feet against Bazalgette's provision for 69 million cubic feet, the difference being caused by discrepancies in three areas. First, Bazalgette had calculated that he would need to provide for a population of 3,143,000 while the referees proposed 3,578,000 (the population of London at the time being about two and three-quarter millions). The difference between the referees and Bazalgette was attributable to the fact that the referees proposed to extend the drainage to a substantially larger area than Bazalgette had included in his plans though the additional areas, which were extended in the West from Chiswick to Brentford, in the South from Tooting to Malden and in the North from Stamford Hill to Hoddesden, were thinly populated agricultural areas at the time.[132] Second, the referees estimated that each person would generate a daily average of seven cubic feet of waste against Bazalgette's allowance for five cubic feet. However the greatest difference lay in the estimate of the average amount of rainfall which would run off through the system. Bazalgette had allowed for a daily average rainfall of a quarter of

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[129] *Illustrated London News*, 13th December 1856, p.605
[130] M.B.W., *Annual Report*, 1856-7, p.7
[131] M.B.W., *Annual Report*, 1857-8, p.5
[132] P.P. 1857-8, vol. 48, ref. 419, map 2d.

an inch in the urban area and an eighth of an inch in the suburbs - the difference being accounted for by the fact that, in the suburbs, a larger proportion would fall on soft surfaces (earth, grass etc.) and would thence make its way to natural watercourses without running into the sewers as would the rain which fell on roads. The referees estimated that rainwater would amount to two fifths of an inch daily throughout the drainage area - twice the volume for which Bazalgette had allowed. The referees summed up their view of the capacity of the system:

> "We must express our decided opinion that this plan does not provide for the removal of a sufficient quantity of sewage from the population of the Metropolitan districts, including the prospective increase, and that the provision for the removal of storm water during rain is not carried to the extent necessary to prevent the frequent pollution of the river".[133]

Their second major reservation concerned the position of the outfalls. Rainham Creek, on the North side, they considered unsuitable because of the tendency of the river to shoal at that point. In considering the Southern outfall they reviewed the results of the float experiments carried out by Burstall and Bazalgette and concluded that :

> "the proposed outfall at Dee in Erith Creek is objectionable because it would not actually prevent the sewage from returning within the limits of the Metropolitan boundary; because it would have a deleterious effect on the health of the district; and because it would probably be prejudicial to navigation".[134]

They recommended that, on the North side, the outfall be situated near Mucking lighthouse in Sea Reach and on the South side at Higham Creek - twenty miles beyond the Metropolitan boundary on the North side and sixteen and a half miles on the South side since "These are the only places in the river, either above or below, which appear to us entirely to fulfil the conditions essential to the objective in view". The proposed outfalls would be open channels (in effect canals of liquid waste) and were designed to run to an outfall some fifteen miles beyond the lowest points at which the Board considered it necessary to discharge. Moreover the additional drop in the level of the outfalls at the point of discharge, caused by the additional fifteen mile incline, was such that the outflow could take place only at low tide, thereby ensuring that the initial movement of the sewage would be *upstream* towards the population centres. During dry weather the referees proposed that tidal water would be admitted to the outfall channels via reservoirs which would balance the flow and, in effect,

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[133]P.P.1884, vol. 41, p. xviii
[134]Ibid., p. xix

flush the channels. Finally, the referees added that the construction of the system should *not* be dependent upon the development of proposals for sewage utilisation though it was hoped that some of the sewage would be siphoned off from the channels in order to fertilise the barren Essex marshes through which it would pass on its long journey to the outfalls.[135]

In the meantime, during the summer of 1857, Hall was starting to come under pressure to bring about some improvements in the condition of the river, flowing past the Palace of Westminster itself. The Lord Chamberlain wrote to Hall stating that "the pestilential state of the atmosphere at times in and about the New Houses of Parliament has on several occasions compelled me to leave the terrace and I am frequently obliged to close the door of my office".[136] Similar pressure in the following summer, that of 1858, proved to be more decisive.

The referees' report was submitted to the Board in October 1857 and was greeted with a predictable lack of enthusiasm. The referees estimated that it would cost £5,437,265 compared with the estimates for Bazalgette's plans ranging from £2,135,196 to £2,413,376.[137] On 5th November a meeting was held attended by Hall, two of the referees (Galton and Simpson), Thwaites and Bazalgette. Hall supported the objections of the Board to the huge open outfalls but the referees re-affirmed their belief that Bazalgette's scheme, with its lower capacity, would require overflow discharges into the Thames at times of heavy rain.[138] In response to a question from Thwaites and Bazalgette concerning the additional cost of carrying the outfalls so much further downstream Hall "stated that in his opinion Parliament will refuse to make any contribution to the works in question".[139] This news prompted such an adverse reaction from Vestry and District Boards that, on 16th November, the Metropolitan Board passed a resolution to the effect that it would be contrary to the provisions of the Metropolis Local Management Act to charge Metropolitan

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135P.P. 1884, vol. 41 pp. xvii - xx; correspondence on the report is in P.P. 1857-8, Vol.48

136P.P. 1857, (Second Session) vol. 41, p.4 *Correspondence respecting the state of the Thames*

137M.B.W., *Annual Report,* 1857-8. pp 5-6

138This prediction was confirmed in the 1884 Report on the Effect of Metropolitan Sewage Discharge on the River.It remains so to this day. However during heavy rain the volume and disposition of the flow is such that the discharge does not represent a significant threat to the quality of the river.

139M.B.W.,*Annual Report,* 1857-8, p.7

ratepayers with the cost of the extension.[140] At this point, therefore, there was fundamental disagreement between three critical aspects of the scheme: the capacity of the system to carry off the waste; the location of the outfalls; and the question of who should pay. On 23rd November 1857, the motion was repeated and was followed by a debate on a proposal to convene a meeting at the Guildhall of Metropolitan M.Ps, with a view to bringing pressure to bear on the legislature. The proposal was not carried. Instead, in an attempt to break the deadlock, the Board referred the two schemes, its own and that of the referees, to a committee of three: Bazalgette; George Parker Bidder and Thomas Hawksley.[141] The eight months that followed were occupied by increasingly acrimonious exchanges between this committee and the referees in a debate that was eventually resolved not by the merits of either case but by the intervention of the weather in the form of the hot, dry summer of 1858. In their report to the Board on 6th April 1858 the committee commented that:

> "Without saying that these works are absolutely impracticable, i.e. that money, time and skill may not surmount the difficulties incident to them, yet their execution must be attended with the utmost uncertainty both of time and cost".[142]

In proposing the adoption of the Board's first plan, with a slight modification to the outfalls (now sited at Barking Creek and Crossness) the three engineers reminded the Board that, at the proposed Crossness / Barking outfalls the river was four times as wide as at London Bridge and that:

> "If the sewage matter was poured into a much larger volume of fresh or freshened water, in a flowing stream, it would become immediately oxygenised and cease to exist as a noisome or offensive agent...The average volume of tidal water [is] about four hundred times as much as the volume of the sewage water to be admitted into it.....Mr. Bazalgette, in one of his communications to your Board, has already shown that for many miles there are no points below the Metropolitan boundary so remote from habitation and population, and therefore so well fitted for points of outfall, as the points close to the boundaries of the Metropolis itself".[143]

Significantly, in the light of future events, the authors added that:

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[140]M.B.W., *Minutes of Proceedings*, 1857, p.826
[141]Ibid., p. 843
[142]P.P.1884, vol. 41, p.xxiii
[143]Ibid., p.xxiv

> "The reservoirs are proposed to be constructed so as to enable the precipitation of the sewage matter to be effected by the application of lime...we do not, however, believe this process to be needed for the prevention of injury to the Thames, or to the health of the population residing on its banks; and we certainly do not recommend it for adoption because, when produced in large quantities, the precipitated matter is unsaleable and must be removed at considerable expense".[144]

On 7th July Galton and Simpson (the third referee, Blackwood, taking no further part in the dispute) replied rather bitterly to the report of Bazalgette's committee, commenting that:

> "It is to be lamented that the Metropolitan Board of Works did not refer its consideration to an unbiassed tribunal; and we regret that Messrs Bidder, Hawksley and Bazalgette have, in their report, misrepresented our statements, and have founded upon these misrepresentations arguments adverse to our conclusions".[145]

Charge and counter-charge continued in this way from each party during the hot, dry summer of 1858 in a correspondence which the 1884 *Report of the Commissioners appointed for the Purpose of Enquiring into the Effect of the Discharge of the Sewage of the Metropolis into the River Thames* characterised as having "taken a somewhat acrimonious and personal tone" and which closed with a final letter from Bidder on 20th September 1858.[146] In the meantime events had occurred which had the effect of relegating the engineering disputes to the margin.

The Great Stink

In February 1858 the government of Palmerston fell and was replaced by a Conservative administration led by Lord Derby who appointed Lord John Manners as First Commissioner of Works in place of Hall. In the months that followed the hot, dry summer reduced the Thames to a condition which the press named the *Great Stink*. It raised to irresistible levels the pressure to resolve the disputes over London's drainage in circumstances which were described in a leading article in *The Times* on 18th June:

> "What a pity it is that the thermometer fell ten degrees yesterday. Parliament was all but compelled to legislate upon the great London nuisance by the

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[144]Ibid., p.xxvi
[145]Ibid., p.xxvii
[146]Ibid., p.xxxii

> force of sheer stench. The intense heat had driven our legislators from those portions of their buildings which overlook the river. A few members, indeed, bent upon investigating the matter to its very depth, ventured into the library, but they were instantaneously driven to retreat, each man with a handkerchief to his nose. We are heartily glad of it".

Eleven days earlier *Hansard* recorded a claim by one honourable member that " It was a notorious fact that Hon Gentlemen sitting in the Committee Rooms and in the Library were utterly unable to remain there in consequence of the stench which arose from the river"[147] and *The Times* writer went on to predict that the discomfort suffered by the Parliamentarians would finally lead to a remedy and on the same day the House of Commons debated the state of the river in response to a question by a member, R.D.Mangles,(M.P.. for Guildford) who "rose to ask the Chief Commissioner of Works what steps he has taken, or proposes to take, to preserve the health of the members of the two Houses of Parliament from being destroyed by the present pestilential condition of the River Thames". Mangles proceeded to make several unflattering references to the Metropolitan Board of Works who, he had heard, proposed to take a voyage in a steamboat for the purpose of inspecting the river:

> "If they were to go on that voyage of inspection, he hoped that they would take a good supply of brandy and other condiments with them for the purpose of obtaining relief from the sickening sensations they must experience.....he believed that the House has committed a great mistake in handing over a matter of that importance to any municipal body. The question was really one of an imperial character and ought to have been so treated by the legislature".[148]

The debate that followed attracted much press comment, led by the *City Press* which wrote that "Gentility of speech is at an end - it stinks; and whoso once inhales the stink can never forget it and can count himself lucky if he live to remember it".[149] *The Observer* commented in similar terms two days later while a later commentator has written that "The Thames, which had become more and more heavily used as a sewer, finally made its point by stinking out the Commons Committee".[150]

147*Hansard*, 11th June 1858,, vol. 150 col 1921

148*Hansard* 1857-8 Vol. 151 cols. 27-8

149*City Press* 19th June 1858

150Weightman, G., & Humphries, S.,: *The Making of Modern London, 1815-1914,* Sidgwick and Jackson, 1983, p.161

In his contribution to the debate Sir Benjamin Hall, now out of office, hinted that the Metropolitan Board was attempting to exert pressure upon the House's deliberations in order to resolve the engineering and financial arguments in its favour. Referring to the plan devised by Bazalgette and supported by Bidder and Hawksley, Hall reported that Board had "passed a resolution that they would defer all consideration of it until the middle of October next, leaving the whole summer to pass without any care for the state of the river".[151] Echoing the view of Mangles, Hall went on to ask whether:

> "the Government should consider whether it would not be better to take the whole of this great work into their own hands.....works of such magnitude that it was impossible that they could be paid for wholly out of local rates".[152]

Other speakers also questioned the wisdom of entrusting a project of such scale to the Metropolitan Board, with Members' estimates of its costs ranging as high as ten million pounds.

A week later, on 25th June, the House debated the matter again when Owen Stanley, M.P.. for a Welsh constituency, quoted a letter addressed to the Speaker by Mr. Goldsworthy Gurney, who was responsible for lighting and ventilation of the house. Gurney had written that "he can no longer be responsible for the health of the house" and Stanley went on the describe interruptions to the business of the Court of Queen's Bench where a surgeon, Dr. John Bredall, had testified that "it would be dangerous to the lives of the jurymen, counsel and witnesses to remain. It would produce malaria and perhaps typhus fever".[153] In his contribution to this second debate Hall referred to the fact that, in the original draft of the Metropolis Local Management Act, he had proposed that the Metropolitan Board be allowed to borrow money from the Treasury on the security of the rates but that this power had been removed during the debates over the Bill. He advocated its restoration, as had Sir John Shelley, M.P.. for Westminster.[154]

On 29th June the Metropolitan Board approved the scheme advocated by Bazalgette, Bidder and Hawksley and on 1st July a delegation from the Board went to meet the First Commissioner, Manners.[155] Even at this late stage a number of new schemes

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151 M.B.W., *Minutes of Proceedings,* 2nd June 1858, p.383; the motion was rescinded on 29th June, after the Parliamentary debate had concluded

152 *Hansard,* 1857-8, Vol. 151, col. 39

153 Ibid. col. 423.

154 Ibid. cols 349 and 39-40

155 M.B.W., *Minutes of Proceedings,* 1858, p.448

were still being considered. On 1st July *The Times* reported the proceedings of the Parliamentary Select Committee on the State of the Thames which had examined a plan submitted by Goldsworthy Gurney for the construction of open sewage channels on either side of the river, each channel being thirty yards wide and three yards deep, with a slope of one in twelve. Bazalgette and Bidder, in their evidence to the Committee, expressed the view that the channels would soon become blocked by gravel and this view was accepted.

Despite these distractions the movement for reform proceeded. On 15th July Disraeli introduced the Metropolis Local Management Amendment Act: "An Act to alter and amend the Metropolis Local Management Act (1855) and to extend the powers of the Metropolitan Board of Works for the purification of the Thames and the Main Drainage of the Metropolis" (22 & 23 Vict. cap. 104). The first clause amended the original Act in a subtle but significant way by instructing the Board as follows:

> "The Metropolitan Board shall cause to be commenced as soon as may be after the passing of the Act and to be carried on and completed with all convenient speed according to such plan as to them may seem proper the necessary Sewers and Works for the Improvement of the Main Drainage of the Metropolis, and for preventing *as far as may be practicable*, [author's italics] the sewage of the Metropolis from passing into the River Thames within the Metropolis".

The italicised passage effectively resolved, in the Board's favour, the arguments over the positioning of the outfalls which had involved Bazalgette, Burstall and Hall's three referees for the previous two years since it effectively repealed clause 135 of the original Act with its unambiguous prohibition on "all or any part of the sewage of the Metropolis...passing into the Thames in or near the Metropolis", to which Hall had referred in rejecting the Board's original plans in July 1856. Clauses four and six enabled the Board to raise three million pounds by bonds or debentures and allowed the Treasury to underwrite these instruments, thus enabling the Board to obtain the money at low rates of interest, often from Insurance companies.[156] Clauses ten and eleven authorised the Board to raise a "Metropolis Main Drainage Rate" of threepence in the pound on all properties, including those in the City, while clause twelve provided that "For the purposes of the Assessments under the Act, all the parts of the Metropolis shall be deemed to be equally benefited by the Expenditure under this Act". This had the effect of removing the obstacles that had arisen from the provisions

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156Cannadine, D. & Reeder,,D. (ed.): *Essays in Urban History by H.J.Dyos,* , C.U.P., 1982, p.169

of clauses 177 to 179 of the original Act which had enabled ratepayers to appeal to Quarter Sessions against their assessments on the grounds that they were deriving less benefit from the works than were other ratepayers. Clause twenty-five repealed Clauses 136 and 144 of the original Act - the two clauses which had, in effect, enabled Parliament in the form of the First Commissioner to veto plans for the Main Drainage and any expenditure on any project in excess of fifty thousand pounds.

The introduction of the Bill was preceded by debates on the state of the Thames and was itself debated on 22nd, 23rd and 24th July 1858. On the day before the debate started, *The Times,* in a long article, expressed its frustrations in the most trenchant terms:

> "The truth is, that this is a case where the fool's argument that 'something must be done' is applicable...the sewage of a mighty city lies in a broad stream under our very noses". The Board had been "appointed with the clear, precise and definite mission of ridding the Thames of its polluting matter and carrying the sewage outside the Metropolitan limits. This was a step gained, but the action of the new Board was crippled in two most important respects. It had no money and it had no power; it had no authority to raise the means required, and its engineers were liable to be confronted with engineers appointed by government and armed with a veto...if we wait for a concurrence of opinions on this subject, we shall never stick a spade in the ground or construct either a drain or a tunnel, or get, in fact, a single inch beyond the recent expedient of correcting Thames water with tons of lime.....The stench of June was only the last ounce of our burden. That hot fortnight did for the sanitary administration of the Metropolis what the Bengal mutinies did for the administration of India".[157]

At the same time the *Journal of Public Health and Sanitary Review* in an article called *Is the Thames Pernicious?* reported "stories flying of men struck down with the stench, and of all kinds of fatal diseases, upspringing on the river's banks".[158]

At this time the Board's engineers and the referees were still debating, and failing to agree, on the capacity of the system or the position of the outfalls and there was no prospect of resolving their differences under the original Act. In the circumstances it is perhaps not surprising that the tone of the debates on the Bill was such as to convey the impression that Parliament was prepared to overlook some matters of detail previously regarded as important in order to get the work started. Robert Stephenson, who had been a member of the Metropolitan Sewers Commission, spoke in the debate

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157*The Times*, 21st July 1858, p. 9 col. 2

158*Journal of Public Health and Sanitary Review*, iv, 1858, p.142

as M.P.. for Whitby and, commenting on the previously controversial issue of the outfalls, gave his opinion that "Whether or not it might be necessary hereafter to go down to Sea Reach, was not a question for the House now to decide. Meanwhile, let them be contented to get down to Barking Creek". He estimated that, whereas the Board's plans, with outfalls at Barking, would cost three million pounds, the plans of the referees would cost six millions.[159] Disagreeing with Stephenson, Mr. Puller, Member for Hertfordshire, moved an amendment that would specify that the position of the outfalls should prevent the waste "from being brought within the bounds of the Metropolis by the action of the tide" but he was opposed by the Chief Commissioner, Manners, who observed that "the House would see that this was only a roundabout way of coming back to the point they had agreed to abandon, that of fixing the points of outfall".[160] Manners was no doubt anxious to avoid finding himself in the same position as his predecessor, Hall, whose responsibilities for enforcing the provisions of the earlier Act had obliged him to become embroiled in controversies about tides, shoals and outfalls. Bazalgette himself, who was as close as anyone to the controversies, believed that the influence of Manners was decisive. In an address to the Institution of Civil Engineers on the Main Drainage Works as they neared completion in 1865 Bazalgette stated that "It was through the influence of Lord John Manners, who afterwards became the First Commissioner of Works, that the Board was left free to carry out their (sic) system of Main Drainage.[161] Puller's amendment was rejected and there could have been no clearer indication of the House's readiness to give the Board the authority it needed to start work.

A fiercer debate was joined on the question of who should pay for the work, with members for Metropolitan constituencies emphasising the responsibility of the imperial Parliament and provincial members taking a contrary view. P.Blackburn, M.P. for Stirlingshire, observed that "the inhabitants of a very large town put an enormous quantity of dirt into their very fine river, and then they wanted the inhabitants of smaller and poorer towns to come and take it out for them".[162] Gladstone, member for Oxford University, added his voice to this argument:

> "If it should be the opinion of the House that London, the richest city in the world, should not bear the cost of draining its own river, as was done by less wealthy and less important places, what would be the future position of local government in London if that House interfered to do that which ordinarily

159*Hansard*, 1857-8; Vol. 151; col. 1937
160Ibid. cols. 2050-1
161M.P.I.C.E.: vol. 24, 1864-5, p.286
162*Hansard*, Vol. 151, Col. 577, 28th June 1858,

ought to be done locally"[163]

London Members, unsurprisingly, took the contrary view. T.S.Duncombe, Member for Finsbury, offered the rather unconvincing argument that "Parliament and the state contributes to the stench of the Thames; surely they ought to contribute to its purification",[164] while Sir John Shelley, representing the constituency of Westminster, addressed the specific question of the position of the outfalls by telling the House that "the inhabitants of the Metropolis did not object to pay for the drainage of their own district but they objected to pay for carrying the sewage five or six miles below that district ".[165] Luckin has characterised the 1858 debate as having an "ideological and philosophical focus" on the concept of self-government: "the notion, deeply embedded in the consciousness of a majority of members that it was the locality, rather than the state, which must order and, crucially, pay for its own affairs"[166].This summary which would no doubt have been warmly endorsed by Toulmin Smith and his supporters who remained active long after the establishment of the Board. As late as 1872 the *Pall Mall Gazette* defended the right of representative bodies within "the province of houses we call London" to petition against a Bill promoted by the Metropolitan Board, on the grounds that the works it proposed would not directly benefit their locality.[167]

Several members including Stephenson, Manners and Disraeli referred to the need to de-odorise the waste before it was discharged and Derby himself, during the debate in the Lords on 27th July made a more specific reference to this question, while summarising the difficulties faced by the Board. He argued that, contrary to the opinions of some members, the Board should execute the works and pay for them out of the rates. If Parliament were to become involved in supervising or financing the project, this would be regarded as a precedent by any other city that ran into difficulties with major works. He conceded that the Board did not have an impressive record:

> "That Board, since its establishment, has certainly not been very effective or very operative; but it must be remembered that it never had either any absolute discretion as to the carrying out of works, or any funds for the

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163Ibid. Cols 876-7
164Ibid., Col. 1168
165Ibid. Col 577
166Luckin, W.,: *Pollution and Control: a Social History of the Thames in the Nineteenth Century*; Adam Hilger, 1986, p.17
167*Pall Mall Gazette*; 1st May 1872, p.11

> execution of them...its powers were so limited as to be absolutely and entirely worthless". He added that "It is generally understood, although there is no express provision in the Bill to that effect, that the modus operandi is to be by intercepting sewers, whereby the sewage of the Metropolis will not be allowed to be poured into the river until it shall have undergone, at such place or places as shall be determined on, the process of de-odorisation" [168]

The implication of Derby's "general understanding" and of the thrust of the debate on the matter, was that, if sewage were to be allowed to drift with the tide to within the boundaries of the Metropolis, then de-odorisation would have removed its most offensive properties. Such de-odorisation was normally accomplished by the addition of lime but Bazalgette, Hawksley and Bidder had specifically rejected this process when putting forward their own revised plan for the system (see pages 102-3 above).The only reference to the subject in the Amendment Act itself was Clause twenty-three which prescribed that the sewage would be de-odorised "in the meantime and until the works required by the Act for the purification of the River Thames are completed". This ambiguity became significant in a later dispute about the outfalls.

On 2nd August 1858 the Metropolis Local Management Amendment Act became law, two weeks and four days after Disraeli introduced it. It gave the Board all it needed to carry out the Main Drainage. The Parliamentary veto was removed, thus overriding the anxieties that members had expressed, when the original Bill was debated, about giving so much power to an assembly which might rival Parliament itself. It empowered the Board to borrow three million pounds, guaranteed by H.M.Treasury, to be repaid by the proceeds of a threepenny rate levied over forty years. In 1863 the Board was authorised to raise a further one million two hundred thousand pounds on the same terms. These additions to the Board's powers may be interpreted as a move towards Toulmin Smith's feared "centralisation" at the expense of vestry power - further confirmed by the clause which abolished the right of ratepayers to appeal against their assessment on the grounds that some localities benefited more than others from the scheme. It gave the Board discretion over the siting of the outfalls. It did not mark the end of criticism of the Board. In 1861, with the drainage works well advanced, *The Times* compared the municipal government of London with that of Paris, to the detriment of London and it advocated a directly elected body to govern the whole Metropolis, including the City, arguing that such a

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168*Hansard,* Vol. 151, cols 2156-7

body "would have strength enough to double the work of Hercules and to cleanse not only the filthy stables but the river which runs through them".

Dyos, in commenting on the extent to which, later in the century, other cities were prepared to accept guidance from the central government write that: "The great leveller, of course, was sewage. How to get rid of it, where and how to sweeten it, or simply how to forget about it, this was the problem that made so many proud places turn like tired children to Whitehall"[169]. In a late contribution to the debates on the Amendment Act Viscount Ebrington, who had experienced some of the problems of the earlier Sewers Commissions was close to the truth when he "Remarked that this Bill had been forced upon the government by a panic rather than with dignity".[170] A later commentator observed, more succinctly, "The 'Great Stink' concentrated minds wonderfully"[171]. Whatever the reasons, the "centralisers" had won. Parliament had given the Board more authority than any of its predecessors to construct a new system of drainage for London according to its own judgement, with little danger of interference either from Parliament or from the vestries. Thwaites and his colleagues had gained a degree of autonomy which Chadwick had sought in vain and they could now set about ridding the capital of its foul smells, fouler water and the diseases which were carried by the water, though blamed on the air.

169Cannadine & Reeder,(ed.),:*Essays in Urban History by H.J.Dyos,*C.U.P.,1982,p.45

170*Hansard,* 1857-8, Vol. 151, col. 2075

171Clifton,G.,:*Professionalism,Patronage and Public Service in Victorian London: the Staff of the Metropolitan Board of Works,1856-86*:Athlone Press, 1992 p.24.See also Port, M.H.: *Imperial London: Civil Government Building in London, 1851-1915*, Yale U.P. 1995 p.10; argues that the MBW owed its powers to the Great Stink..

Chapter Three: The Health of the Metropolis

> "although great differences of opinion existed, and continue to exist, as to the causes of the disease, yet an inspection of the houses in which deaths occurred was sufficient to show that, however occult might be the connection between death and defective drainage, the places formerly most favourable to the spread of disease became quite free from it, when afterwards properly drained". (Joseph Bazalgette: I.C.E. *Minutes of Proceedings*, vol. 24, 1864-5, page 285)

> "The environmentalists had done the right thing for the wrong reason" (E.C.Midwinter: Seminar Studies in History; Victorian Social Reform, Longman, 1968, page 55)

In the mid-nineteenth century London suffered four major outbreaks of cholera, the deaths in the capital being recorded as follows:[1]

1832: 6,536 } in these three outbreaks death rates exceeding fifty per ten
1849: 14,137 } thousand were found in the East and West ends of London
1854: 10,738 } and both North and South of the River

1866: 5,596 high death rates confined to East End between Aldgate and Bow

Each epidemic was the cause of much public debate concerning the nature of the disease and the means by which it was propagated. It is argued, in Chapters One and Two of this work, that concern over the nation's health, particularly during cholera epidemics, contributed to the sequence of events that led to the establishment of the Metropolitan Board of Works. The Board's first duty was the construction of the main drainage but this chapter proposes that the connection between sanitation and water-borne diseases, especially cholera, was misconstrued to the point where the contribution of the main drainage works was not fully understood until many years later and was still a matter for debate when Bazalgette died in 1891. The chapter begins by examining contemporary views of the role of government in providing a healthy environment for its population and proceeds to examine the theories of the causation of disease which were held at this time. It analyses the influence of these theories upon policy as reflected in the ideas and practices of four campaigners who influenced sanitary ideas in the mid-nineteenth century: Edwin Chadwick, John Snow, John Simon and William Farr. First, it will consider the work of the General Board of Health which from 1848, under the influence of Chadwick, was the centre of

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[1]Creighton, C.,: *A History of Epidemics in Britain;* C.U.P., 1894, p.858

the miasmic doctrine of disease propagation which Lambert has called "during the forties and fifties the orthodoxy of the Public Health movement"[2]. It proceeds to consider the ways in which the work of Snow, Simon and Farr moved theories of disease propagation substantially, but not conclusively, away from miasmatic doctrine towards the idea that epidemics could be waterborne and therefore susceptible to control by the adoption of effective sanitary measures.

The Role of Government

The struggle between those who believed that central direction had an important role in the creation of a free and healthy society and those opponents who believed that it represented an infringement upon personal liberty has already been observed in the debates which accompanied and followed the establishment of the Metropolitan Board of Works (Chapter Two pages 66 et seq.). The Board won its battle but this did not mean that enthusiasm for the enforcement of sanitary regulations, or the taxation to pay for them, was universally shared. In 1873, fifteen years after the passing of the Amendment Act, the Association of Municipal and Sanitary Engineers and Surveyors, which had been founded in that year by Lewis Angell, engineer to West Ham Local Board, to protect the autonomy of local engineers, recorded that:

> "Great is the *vis inertiae* to be overcome, the repugnance to self-taxation, the practical distrust of science, and the number of persons interested in offending against sanitary law, even amongst those who must constitute chiefly the local authorities to enforce them".[3]

Sanitary reformers had to fight a battle as fierce as that of the Board before they gained acceptance of the fact that the state had responsibility for the health of its citizens. There were precedents. R.Porter has written of the introduction of compulsory vaccination in 1853 that "legislation in 1853 eroded the liberty of the person and invaded the sanctuary of the family by making smallpox vaccination compulsory - a drastic act, given opposition on grounds of religion, science and liberty".[4] R.J.Lambert has described the vaccination programme after 1853 as one of a number of government functions which "grew in principle and realisation in the

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[2]Lambert, R.,: *Sir John Simon*, McGibbon and Kee, 1963, Ch.2, p. 49; pages 48-55 give a lucid account of the other doctrines which were accepted at the time

[3]*Proceedings of the Assoc'n of Municipal and Sanitary Engineers and Surveyors*, I, (1873-4), p.221

[4]Porter,R.:*Disease, Medicine and Society in England, 1550-1860*;C.U.P.,1995,p.55

heyday of *laissez-faire* and vaunted de-centralisation"[5] despite the fact that the period is associated with the overthrow of the "centralising" Chadwick at the General Board of Health.

Moreover a struggle had to be undertaken on a second front in order to reach agreement on the causes of epidemic diseases and the means of preventing them. G. Rosen has argued that "The protection and promotion of the health and welfare of its citizens is considered to be one of the most important functions of the modern state"[6] and suggested that there were two components in the discharge of this responsibility:

> "One is the development of medical science and technology. Understanding the nature and cause of disease provides a basis for preventive action and control. However, the effective application of such knowledge depends on a variety of non-scientific elements, basically on political, economic and social factors. This is the other major strand in the fabric of public health."[7]

The development of medical science, in particular the identification of specific organisms for diseases like cholera and typhoid, did not occur until much later in the century, leaving the field clear for misconceived theories about the true causes of epidemics. In the meantime Rosen's second major strand, the establishment of a suitable basis for the implementation of appropriate social policies was proceeding through such measures as the appointment of local medical officers like W.H.Duncan (Liverpool, 1847) and John Simon (London, 1848). Simon himself recognised that such social policies were innovatory, writing, in *English Sanitary Institutions*, towards the end of his life:

> "In 1830, when William IV began his reign, and equally in 1837, when the reign ended...the statute book contained no general laws of sanitary intention...the central government had nothing to say in regard to the public health, and local authorities had but the most indefinite relation to it".[8]

R. Porter, while arguing that sanitary conditions and policy in the years before Chadwick were not as bad as has sometimes been assumed, recognises the magnitude of the task that confronted later reformers and the *laissez-faire* doctrines they had to

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[5]Lambert, R.J.,: *A Victorian National Health Service: State Vaccination 1855-71*: Historical Journal, Vol V, 1962, No. 1, p. 14

[6]Rosen, G.,: *The History of Public Health*; M.D.Publications, 1958, p.17

[7]Ibid., p.109

[8]Simon, J.,: *English Sanitary Institutions*, p.166, Cassell, 2nd ed., 1897

surmount[9] and W.F. Bynum has argued that the sanitary reformers had a more difficult task in England than in some continental countries because "the philosophy of *laissez-faire* was strongest in English-speaking countries, where relatively weak central governments, minimal bureaucracy, and individualism went hand in hand".[10] Toulmin Smith and his supporters in Britain were arguing in the spirit of the times when they advocated local autonomy and low taxes. Their views were reflected by the French writer, Rene Villerme, (1782-1863) in Restoration Paris, who studied the relative mortality rates in affluent and impoverished arrondisements of Paris and argued in his work *Etat Physique et Moral des Ouvriers* (1840) that disease was caused by malnutrition, which was caused by poverty, which was in turn produced by the iron laws of political economy against which there was no remedy. It is against this doctrinal background that Porter judges that:

> "Because it had to cope with problems of a new order of magnitude, the public health transformation from Chadwick to Simon and Bazalgette deserves to be regarded as qualitatively different - a commitment to centralised responsibility for the prevention of disease".[11]

Dorothy Porter has suggested that Rosen's arguments amounted to a belief that the mercantilist state made a healthy population co-terminous with the interests of the state and presented a heroic vision of "the power of scientific logic to bring about the rational organisation of society through comprehensive planning of economic, social and medical relations"[12].P.Weindling, in the same volume, has proposed that in nineteenth century Germany the state took a similarly "mercantilist" view of a healthy population as an asset to the state. The physician Johann Peter Frank (1745-1821) who at various times served the governments of Austria, Russia, Lithuania, Germany and Italy drew a link in his nine-volume *Medicinischen Polizei* (1779-1829) between communal health, a large population and material prosperity. Max von Pettenkofer (1818-1901), the German scientist and pioneer in public hygiene, reflected a similar view when he attempted to calculate the financial returns which arose from investment in educational and other programmes to promote public health

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[9]Porter, R.:*Cleaning up the Great Wen*, in Bynum, W.F. & Porter, R.,(Eds) *Living & Dying in London*, Medical History Supplement No. 11, Wellcome, 1991

[10]Bynum, W.F.,: *Science and the Practice of Medicine in the Nineteenth Century;* C.U.P., 1994, p. 56

[11]Porter, R.,: *Cleaning up the Great Wen: Public Health in Eighteenth Century London*, p. 72, in *Medical History Supplement 11,* Wellcome, 1991

[12]Porter, D., (ed.): *The History of Public Health and the Modern State*; editions Rodopi, Amsterdam, 1994, p.2

and reduce social deprivation.[13] Such connections were not always welcomed by the authorities. In 1848 the German pathologist Rudolf Virchow (1821-1902) was sent by the government of Prussia to investigate an outbreak of typhus in Upper Silesia. He concluded that a high incidence of disease, particularly among the repressed Polish minority, was associated not only with poor living conditions and shortage of food but also with political, social and religious repression. He suggested that any reforms should include democratic self-government and a greater degree of self-determination. Epidemics could arise in response to social upheavals.[14] He was encouraged by the Prussian authorities to retire to Wurzburg though in the 1860s he was recalled to Berlin to oversee the re-construction of the city's sewers.

H. Perkin has suggested that public concern with the health of the population was a consequence of the professionalisation of society and the rise of a corpus of professional managers and officials characteristic of the later nineteenth century[15] while others have argued that it was due to the earlier influence of a handful of powerful individuals like Simon in London and Duncan in Liverpool, creating what Dorothy Porter has described as "health bureaucracy becoming despotic technocracy".[16] C. Hamlin has cited the influence upon the public health movement of "new humanitarianism" deriving from the influence of John Locke and religious movements such as the Quakers and Methodists.[17] Such debates over the responsibility of the state for promoting the health of its population may be compared with those over the merits of local and central administration which preceded the establishment of the Metropolitan Board of Works. However the debate over public health was further complicated by basic misunderstanding, caused by ignorance, of the causes of disease propagation.

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[13]Weindling, P., and Fee, E.,: writing in Porter,D.,(ed.). *The History of Public Health and the Modern State,* Editions Rodopi, Amsaterdam, 1994,.Ch. 2 p.123,and Ch. 6 p. 235

[14]*Dictionary of Scientific Biography*, American Council of Learned Societies; New York, 1975 vol. XIV, p.139 gives an account of Virchow's views

[15]Perkin, H.,: *The Rise of Professional Society; England since 1880;* Routledge, 1989

[16]Porter D.,(ed.): *The History of Public Health and the Modern State*; editions Rodopi, Amsterdam, 1994, p.4. See also R.Lambert: *Sir John Simon 1816-1904 and English Sanitary Administration,* McGibbon & Kee, 1963; and Fraser, W.M.,: *Duncan of Liverpool. Being an Account of the Work of Dr W.H.Duncan, M.O.H. of Liverpool, 1847-63,* Hamish Hamilton, 1947

[17]Hamlin, C., in Porter, D., (ed.) op.cit.,Chapter 3, *State Medicine in Great Britain,* pp.134-5

The Miasmic Orthodoxy

In the late 1820s the spread of cholera from India across Asia, via the Caspian sea and continental Europe was the cause of much anxious comment and speculation as to its causes, both in medical journals like *The Lancet* and in newspapers like *The Times*. A.S.Wohl has suggested that its arrival in Britain in 1831 was attended by a degree of anxiety unprecedented since the plague in the seventeenth century and has recorded that thirty riots were caused by concern about the disease in 1832.[18] Each subsequent outbreak prompted further theorising, over seven hundred works on the subject being published in London alone between 1845 and 1856.[19] It is now known that cholera is usually spread by water which has been contaminated by the faeces of someone infected with the disease though it can also be spread by flies which have either been hatched in diseased faeces or have fed on it. In the absence of this knowledge the epidemics which afflicted Britain between 1831 and 1866, and their possible remedies, were the subject of conjecture which was sometimes informed by despair.

In November 1831, early in the first outbreak that struck Great Britain, *The Lancet* reported from Vienna that a community of Jews in Wiesniz had escaped its effects by rubbing their bodies with a linament containing wine, vinegar, camphor powder, mustard, pepper, garlic and ground beetles.[20] In 1853, as the third great cholera outbreak was observed making its way across Europe towards Great Britain, *The Lancet* speculated on the nature of the disease:

> "What is cholera? Is it a fungus, an insect, a miasma, an electrical disturbance, a deficiency of ozone, a morbid off-scouring of the intestinal canal? We know nothing; we are at sea in a whirlpool of conjecture...Every analogy leads to the conclusion that the essential cause of cholera consists in a morbid poison, which under certain congenial conditions becomes developed into activity, and ferments in the blood".[21]

In 1853 *The Lancet* was no better informed than *The Times* had been four years earlier when, at the height of the second cholera epidemic, the newspaper had published a series of articles, stretching over three days, in which the possible causes of the disease, and its remedies, were debated.[22] On 13th September the writer listed

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[18]Wohl, A.S.,:*Endangered Lives:Public Health in Victorian Britain*,Methuen, 1984, p.119

[19]Pelling, M.,: *Cholera, Fever and English Medicine, 1825-65*, O.U.P., 1978, p.60

[20]*The Lancet*: 12th November 1831, p.216

[21]Ibid., 22nd October 1853, pp.393-4

[22]*The Times*: 12th September 1849, p.3 cols 3-4; 13th September, p. 4, cols 2-3.

the current theories, starting with "The Telluric theory [which] supposes the poison of cholera to be an emanation from the earth". He then considered the "Electric theory" which attributed disease to atmospheric electricity and the "Ozonic theory" which laid the blame on a shortage of ozone. He briefly considered the idea that the epidemic was caused by "Emanations from sewers and graveyards...for such an hypothesis we can find no solid foundation". More space was devoted to the "Zymotic theory" which was particularly associated with the German professor of organic chemistry at the university of Giessen, Justus von Liebig, a friend of Michael Faraday. Liebig believed that some compounds were inherently unstable and that, under the influence of temperature, electricity or friction, they could be prompted into a condition of fermentation, similar to that associated with yeast. He suggested that the putrefaction of bodies which had suffered from the disease could produce ammonia which could be "the means through which the contagious matter received a gaseous form",[23] thereby creating a "miasma" in the atmosphere which would spread the infection. An early writer on the subject, John Mason Good, defined "miasm" as a process of corruption and "contagion" as "the application of such miasm or corruption to the body by the medium of touch" and went on to add that both terms applied "to any source whatever of defilement and touch; and either may be predicated of the other; for we speak correctly of the miasm of contagion, or of contagion produced by miasm".[24] A medical dictionary available at the time listed 'Miasma' as "see contagion".[25] Christopher Hamlin has characterised the contemporary view of this widely held theory of disease causation in the following words:

> "Properly so-called, miasmas were unisolatable (and according to some, inodorous) materials in the air emanating from vegetable decomposition. They touched one at a particular time and place much as a contagion did".

Hamlin adds that the view of fever in the fifty years preceding Chadwick's *Report* was:

> "that it could be induced either by an 'epidemic constitution' (a peculiar and unanalysable state of atmosphere presumed responsible for the occasion of the epidemic) or *de novo* from any number of predisposing factors including mental depression, constipation, insufficient or inappropriate food, cold, or prolonged re-breathing of the same air".[26]

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[23]Pelling, M.,: *Cholera, Fever and English Medicine, 1825-65*, O.U.P., 1978, p.141

[24]Good, J.M.,: *The Study of Medicine*, 2nd edition vol. 2, pp. 64 and 65

[25]Hooper, R.,: *Compendious Medical Dictionary*, 1799

[26]Hamlin, C.,:"Predisposing Causes and Public Health in Early Nineteenth Century Medical Thought"; *Social History of Medicine*, 5, (1992) pp.55 & 48, based on J.M.Good: *A Dissertation on the Diseases of Prisons and Poor Houses,*

Rosen has distinguished between three schools of disease propagation at this time. The first he describes as the *contagionists* who associated disease with specific organisms passed from one person to another, giving John Snow and William Budd as the leading protagonists of this theory. Amongst the *anti-contagionists* or *miasmatists* he includes Chadwick and Florence Nightingale who laid the cause of disease at the door of filth, while to a third group, described as *contingent contagionists*, including John Simon, he attributes the view that a filthy environment could create a *pre-disposition* to disease which was nevertheless triggered by a discernible cause.[27]

Thomas Watson, Professor of medicine at Kings College London and later President of the Royal College of Physicians drew a distinction between *exciting causes* and the *condition of the body* at the time the exciting cause was applied, enabling the influence of *pre-disposing* factors to be accommodated within theories of disease causation without excluding other explanation for the immediate cause of infection.[28] The author of a mid-century text, *A Dictionary of Practical Medicine*, held that *predisposing* causes could themselves be the source of disease, without the need for any immediate, or *exciting* cause. He wrote:

> "predisposing causes may, either by their activity, or by their acting in combination or in close succession, of themselves produce disease, without the aid of any of those usually termed exciting...the indulgence of the appetites, fatigue, the depressing passions, moist states of the air etc. are often the only causes to which disease can be traced".[29]

The idea of a spontaneous generation of poisons creating an "epidemic atmosphere" has been rendered obsolete by the work of Pasteur, Koch, Eberth and others in identifying bacteria and their effects. However in the mid-nineteenth century the hypothesis must have appeared highly plausible to citizens who were daily aware of the foul air they were compelled to breathe but who could not see bacteria in the water they drank. Even the high mortality rates among infants to whom opiates had been administered were attributed indirectly to foul emanations from sewers. Lyon

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1795, pp. 67 et seq.; on Watson's *Principles*, Good's *Study of Medicine* and Copland's *Dictionary of Practical Medicine*

[27]Rosen, G.,: *Disease, Debility and Death* in *The Victorian City, Images and Realities*, ed. H.J.Dyos and M.Wolff, Routledge & Kegan Paul, 1973, pp. 625 et seq.

[28]Watson, T.,: *Lectures on the Principles and Practice of Physic*, 1844, p.50.

[29]J Copland, (ed.),: *A Dictionary of Practical Medicine*, 1858, p. 564

Playfair, an associate of Chadwick, in evidence to the Health of Towns Commission, gave his view that opiates were administered to infants by mothers in order to calm them and that such tranquillising measures were needed because the children were made irritable by foul air from the sewers:

> "On the removal of these causes the general inducement to the continuance of the system would cease, for the irritability and difficulty of management of children would diminish with their increased health".[30]

Such views appeared to be supported by Max von Pettenkofer who had studied cholera epidemics in Munich. He formed the view that the bodies of victims of cholera produced a ferment, as Liebig believed, but that this was not transmitted to others until the earth was contaminated by the faeces of victims and itself fermented, creating a miasma which was inhaled by others. Pettenkofer postulated that "the Cholera germ-bearing excrements...modify the existing process of decay and decomposition" so that "a specific Cholera-Miasma is developed, which is then spread along with other exhalations into the houses".[31] Pettenkofer did not so much disagree with Liebig's fermentation theory as extend it by suggesting the mechanism by which the fermentation could be prompted. So confident was von Pettenkofer in his rejection of germ theories of disease that he swallowed cholera bacteria to demonstrate its harmlessness. He suffered no ill effects, probably because he had developed an immunity from an earlier, mild infection.[32] Christopher Hamlin has drawn attention to the fact that some prison reformers held that moral, as well as physical contagion could spread through air.[33] A narrower view of "putrefaction" as a source of disease was associated with a group centred on the President of the Royal Society, Sir John Pringle, (1707-82), Physician-General to the Army (and to George III) and author of the influential text *Observations on the Diseases of the Army* (1752) who held that fever was caused by a process of internal putrefaction.[34]
Moreover the idea of an infected atmosphere as the source of disease had a long history. Hippocrates had noted that certain fevers were associated with warm weather

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[30]P.P. 1845: vol. 18; Health of Towns Commission, Second Report; part 2, p.67

[31]Translation taken from *Dictionary of Scientific Biography*: American Council of Learned Societies; New York, 1975; p.558

[32]Ackernecht, E.H.,: *A Short History of Medicine*; Johns Hopkins U.P., 1982, p. 213; also *Dictionary of Scientific Biography*(see previous note).

[33]Hamlin, C., writing in Porter, D., (ed.), note 12 (above), Ch. 3 *State Medicine in Great Britain*, p.137; see also R.Evans: *The fabrication of Virtue; English Prison Architecture, 1750-1840*; C.U.P., 1982

[34] Singer, D.,: *Sir John Pringle and his Circle*; Annals of Science, vi, 1948, pp. 127-80 and 227-61

and with wet, poorly drained places where the air was dank and foul. Nevertheless, other observers had tentatively advanced the hypothesis that invisible elements could enter the body through the mouth and nose to cause disease. In the first century B.C. Varro had suggested that these agents might be minute animals and in 1546 the Italian physician Girolamo Fracastoro had suggested in his work *De Contagione* that infection might be caused by living organisms which he called "seminaria", passed from one person to another by direct contact or through the air. In the seventeenth century the Dutch microscopist Antony Leeuwenhoek saw and described organisms which we would identify as bacteria and he reported his findings to the Royal Society but their significance was not appreciated. So strong was the miasmic orthodoxy that reputations could be lost by opposing it. John Crawford, a reputable Baltimore surgeon, lost his reputation and his practice for maintaining, in 1806, that disease was spread by microscopic insects that he called "animalculae".

The miasmic theory was particularly well established amongst active and influential figures in the sanitary movement. Florence Nightingale believed that common diseases such as scarlet fever, measles and smallpox were caused by the practice of laying drains beneath houses, so that odours from them could penetrate the dwellings and infect the inhabitants.[35] Professor Booth, a professor of chemistry, wrote to *The Builder* in 1844 to advocate watering the streets so that the consequent evaporation "will carry up with it into the atmosphere, and above the reach of mischief, the various decomposing and decomposed organic matters floating about, and which otherwise allowed to remain would be productive of contagious miasms".[36] Charles Murchison (1830-79) physician to the London Fever Hospital and to St Thomas's Hospital in his book *Continued Fevers of Great Britain* (1862) argued that typhoid could arise spontaneously from filth and he coined the term "pythogenic" to describe fever generated by rottenness. The beliefs took more eccentric forms in other influential quarters. In 1842 Sir Francis Head, a former colonial governor, reviewed Chadwick's *Report* in the pages of the Quarterly Review.[37] He applauded Chadwick's criticism of bad drainage and ventilation and, in supporting the miasmic theory of disease propagation, added that some of the new settlements in the Americas had been rendered dangerous by ploughing virgin soil, thereby exposing decaying vegetable matter and the miasms which arose from it. As previously noted (Chapter Two, page 71) Chadwick believed that engineers held the key to sanitary reform and Hamlin characterises Chadwick's position in the following words:

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[35]Florence Nightingale: *Notes on Nursing*, Harrison, 1859, facsimile reprint, p.16
[36]*The Builder*, 13th July 1844, pp.350-1, see also Ch.1 footnote 1
[37]*Quarterly Review*: vol. 71, 1842, p.422

> "The view that disease was a function of environmental filth brought with it the expectation that prevention was a simple matter of installing high pressure water supplies, velocity-enhancing sewers and sewage farms - a hydraulic system that would spirit away all evil".[38]

Chadwick's belief that "filth" was the cause of epidemic disease was not confined to Britain. One of his disciples was a citizen of Massachusetts, Lemuel Shattuck (1793-1859). In 1839 Shattuck was one of the founding members of the American Statistical Society and in 1849 was a member of a three-man commission for a sanitary survey of Massachusetts. The subsequent *Report of the Sanitary Commission of Massachusetts*, published in 1850, was influenced by Chadwick and, like his *Report* of 1842, recommended the establishment of a Board of Health for the State. It also concurred with Chadwick's analysis of the sources of disease, dividing them into three:[39]

> **atmospheric**: including climate, season and atmospheric "contagion"
> **local**: filth, damp and animal effluvia
> **personal**: bad habits, irregular living and vice

Hamlin draws attention to the tension between the advocates of a "moral, humanitarian crusade" like Edwin Chadwick and Florence Nightingale who believed that higher standards of public health would be achieved by clean water, good habits and good drains and the "materialists" like Edward Frankland and Thomas Huxley who believed that more would be achieved by identifying and understanding disease organisms.[40]

Edwin Chadwick and the General Board of Health

While some sanitary authorities slowly accustomed themselves to the view that the condition of the capital's water, rather than its air, might be the principal cause of its cholera and typhoid epidemics, a further adjustment was required before there was a complete acceptance of the idea that disease was a matter of public, rather than private, concern. Chapter Two identified the steps which led first to the creation of the

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[38]Hamlin, C.,in Porter, D., (ed.)note 12 (above)., Ch.3, *State Medicine in Great Britain*, p.143

[39]For an account of Shattuck's work see W.F.Bynum, *Science and the Practice of Medicine in the Nineteenth Century*, C.U.P., 1994, pp. 87-9

[40]Hamlin, C., in Porter, D.,(ed.) note 12 (above), Ch.3, *State Medicine in Great Britain,* p.150

Metropolitan Board of Works and then, after an interval, to further measures which conferred upon the Board the authority to carry out the works for which it had been established. These events took place amidst a debate between the advocates of strong, central authority, like Chadwick and those who argued for local autonomy and low taxes, like Toulmin Smith. The centralisers had won the argument on behalf of the Metropolitan Board of Works with the assistance of the "Great Stink" of 1858. A similar process may be observed in the development of public attitudes towards the causes of disease and their possible remedies. Anne Hardy has described the eighteenth century response to illness in terms which echo those of the "anti-centralisers" whose views were considered in Chapter Two:

> "Individualism seems to be the key to the eighteenth century response to epidemic diseases....Medical treatment, and the medical response to illness, centred on the individual patient and did not extend from the individual to the implications for Society at large".[41]

In 1840 was published the *Report from the Select Committee on the Health of Towns*, a document which reflected and enshrined the "miasmic" theory of disease causation and which recommended the establishment of the General Board of Health, an event which followed eight years later. Dr Neil Arnott[42] (1788-1874), in his evidence, told the committee that one of the requirements of good sanitation was "Free ventilation, by wide streets, open alleys and well-constructed houses, to dilute and carry away all the hurtful, *aeriform* [my italics] products of the processes of society"[43], a clear statement of the miasmic theory. He re-affirmed his view four years later in his evidence to the Royal Commission for Enquiring into the State of Large Towns and Populous Districts:

> "The immediate and chief cause of many of the diseases which impair the bodily and mental health of the people, and bring a considerable proportion

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[41]Hardy, A.,: *The Medical Response to Epidemic Disease During the Long Eighteenth Century*, in *Epidemic Disease in London,* Centre for Metropolitan History Working papers No.1, 1993, p.66

[42]Arnott, with Drs Kay and Southwood Smith, had written the appendix to the Fourth Annual Report of the Poor Law Commissioners which had led to the publication of Chadwick's *Report* as described in Chapter One. Margaret Pelling has argued, with reference to this earlier report that "The centralisation of doctrine in epidemic disease may be said to have begun with Neil Arnott, James Kay and Southwood Smith's reports for the Poor Law Commissioners on fever in the Metropolis". Pelling, M., *Cholera, Fever and English Medicine, 1825-65*, O.U.P., 1978, p.6

[43]P.P.1840, vol. 11, p.33

> prematurely to the grave is the *poison of atmospheric impurity* [his italics] arising from the accumulation in and around their dwellings of the decomposing remnants of the substances used for food and in their arts, and from the impurities given out from their own bodies".[44]

Another witness to the Commissioners, a surgeon called Nathaniel Ward, emphasised the importance of light to a healthy environment while Dr Duncan, physician to Liverpool Infirmary and, from 1847, the city's first Medical Officer, calculated the extent of the problem in that city in precise terms:

> "By the mere action of the lungs of the inhabitants of Liverpool, for instance a stratum of air sufficient to cover the entire surface of the town, to a depth of three feet, is daily rendered unfit for the purposes of respiration".[45]

In 1846 Southwood Smith described in detail the biological processes by which infection from foul air was supposed to occur:

> "If provision is not made for the immediate removal of these poisons, they are carried by the air inspired to the air-cells of the lungs, the thin delicate membranes of which they pierce, and thus pass directly into the current of the circulation. It has been shown that by the natural and ordinary flow of this current, three distinct and fresh portions of these poisons must necessarily be transmitted to every nook and corner of the system in every eight minutes of time. The consequences are sometimes death within a few hours, or even minutes."[46]

Chadwick himself, one of the most influential of all sanitary campaigners at this time, was equally emphatic if less precise in his evidence to the Metropolitan Sewage Committee the same year:

> "All smell is, if it be intense, immediate acute disease; and eventually we may say that, by depressing the system and rendering it susceptible to the action of other causes, all smell is disease".[47]

From this shaky premise Chadwick drew the conclusion that it was more important to install house drains than to build main sewers since the removal of smells from the

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[44]P.P.1844, vol. 17, p.50

[45]Ibid., p.122

[46]Southwood Smith: *Health of Towns Association's Report on Lord Lincoln's Bill 1846,* pp. 72-3, referred to in S.E.Finer: *The Life and Times of Sir Edwin* Chadwick, Methuen, 1952, Book 7, Ch.2.

[47]P.P. 1846, vol. 10, p.651

houses would remove the causes of disease. He further argued that small pipe drains were preferable to large brick sewers since pipes had smaller surface areas from which noxious fluids could evaporate and poison the atmosphere and claimed that the first glazed earthenware pipes had been baked at his request.[48] Porter has characterised Chadwick's hypothesis as that of "anti-contagionism, which laid the problem [of disease] at the door of filth" as distinct from the "contagionist" doctrine held by doctors like Snow and Budd which held that disease was passed from person to person.[49] Chadwick never altered his belief in the miasmic theory despite the discoveries, during his lifetime, of Snow, Pasteur, Koch and others. In the year of his death, 1890, *The Builder* reported his contribution to a discussion which had taken place at the Society of Arts on a paper by Sir Robert Rawlinson on the disposal of sewage. In the words of *The Builder:*

> "Sir Edwin concluded his somewhat prolix communication by advocating the bringing down of fresh air from a height, by means of such structures as the Eiffel Tower, and distributing it, warmed and fresh, in our buildings ".[50]

McDonagh attributes the almost universal acceptance of the miasmic theory at this time to the influence of Chadwick and his followers. Referring to the profound influence upon the authorities of Chadwick's 1842 *Report* he argues that:

> "they got stuck, so to speak, in 1842. They were incapable of taking advantage of the very considerable advances in chemistry, medicine and engineering during the next fifteen years because the prevailing atmosphere of combat and assertion had committed them beforehand to a particular dogma"[51].

Margaret Pelling has also commented on the effectiveness with which the doctrine was turned into the received wisdom at a time when decisions were being taken which were critical for the health of the Metropolis, writing "that the correlation between smell and disease became an article of faith was a triumph of sanitary propaganda".[52]

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[48]P.P. 1847-8, vol. 32, p.156, Chadwick's evidence for the First Report of the Sanitary Commission

[49]Porter, R.,:"Cleaning up the Great Wen", p. 70, in *Medical History Supplement 11,* Wellcome Institute for the History of Medicine, 1991

[50]*The Builder*: 1st February 1890, pp. 78-9

[51]MacDonagh,O.,: *Early Victorian Government*, Weidenfeld & Nicolson, 1977, p.141

[52]Pelling, M.,: *Cholera, Fever and English Medicine, 1825-65;* O.U.P., 1978, p.60

John Simon and the City of London

While the Metropolitan Commissions of Sewers struggled to improve the sewerage of the remainder of the Metropolis, the City defended its own territory against possible intruders. On 12th April 1847 the City Sewers Commission declared: "the City of London, for health, cleanliness, effective drainage and supply of water to its inhabitants, cannot be surpassed"[53] To this comment the Lord Mayor added: "there could be no improvement in the sanitary condition of the City - it was perfect". [54] Others were even more flattering. J.Toulmin Smith who was one of the strongest advocates for freedom of local vestries from interference by central government described London as "The cleanest and healthiest City in the World" in one of a series of pamphlets called "Centralisation or Representation?" published in 1848. There were, however, those who took a different view. In the same report as that in which the Lord Mayor had declared the City's condition to be perfect Dr Hector Gavin had denounced the condition of the City and characterised its government as being:"of all the various trusts, the most [in] need of supervision and control".[55]

In 1848 the Health of Towns Association also published an insulting pamphlet on "The Sanitary Condition of the City of London" and the Prime Minister, Russell, who was representative of the City in Parliament announced[56] that the City would be included in the provisions of the legislation setting up the Metropolitan Commission of Sewers. Eventually Morpeth, the Home Secretary, agreed a compromise. The City would be excluded from the Metropolitan Commissions but would have four representatives on them and would agree to abide by their decisions in matters which affected the City.

The complacent view of the City's sanitation was not confirmed by the cholera outbreak of 1848-9. John Simon, an early practitioner of the use of disinfection processes in surgery and later lecturer in pathology at St. Thomas's Hospital Medical School, was appointed as Medical Officer to the City as a result of the City Sewers Act 1848, an Act which the City had promoted in order to shelter itself from the full effects of the Public Health Act. Simon made some early proposals to secure regular

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[53]Report of the City Commissioners 12th April 1847

[54]Report of the Health of London Association on the Sanitary Condition of the Metropolis, 1847, p.viii

[55]Gavin, H., *Sanitary Ramblings*, 1848, G.L.R.O., p.32

[56]*Hansard*, 5th May 1848, cols 720-22

returns of disease and mortality in his "General Suggestions on Preliminary Arrangements in the Sanitary Affairs of the City"[57].He proposed that returns be submitted by City workhouses, prisons and the eleven Poor Law medical officers. The last group refused to comply without payment and the City Commission refused to pay. A compromise was reached by which all but the East London Poor Law Union agreed and the latter conformed to the requirements when Simon began to make enterprising use of the Nuisances Removal and Diseases Prevention Act, 1846 (the "Cholera Bill", see Ch. 1 above) after the onset of cholera in 1849. Using the same methods he also encouraged Harvey, the City Police Commissioner, to inspect and suppress insanitary practices in the dwellings of the City. Harvey reported the results of his inspections in October 1849 and *The Times* carried a full account of them:[58]

15,010	houses were inspected
2,524	had "offensive smells from bad drainage or other causes"
720	had "filth or rubbish in the cellar"
446	were"in an offensive or unhealthy state from bad or deficient drainage"
1120	had "privities (sic) and water closets in a very offensive state"
223	had "cesspools full of soil"
30	"cesspools had burst or overflowed"
21	had "cellars used as cesspools"

5,084 houses, over one third of the total, were thus revealed as suffering from serious drainage problems and Simon used the experience of the 1849 epidemic to press for reforms. On 6th November 1849 Simon presented his first annual report in which he observed that "animals will scarcely thrive in an atmosphere of their own decomposing excrement; yet such, strictly and literally speaking, is the air which a very large proportion of the inhabitants of the City are condemned to breathe".[59]
The report advocated six measures:

Better house drainage
Improved water supply
Control of "Offensive Trades"
Cessation of intramural burials
Slum clearance

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[57]Guildhall Papers, MS Minutes Sewers Commission lxxxiii 529-36
[58]*The Times* 10th October 1849 page 5 col.4
[59]Simon, J.,: First Annual Report, p.9, published in *Reports Relating to the Sanitary Condition of the City of London,* 1854, G.L.R.O.

Regular house inspections

The degree of public interest in the issue is reflected in the fact that Simon's report was carried in full in *The Times, The Morning Chronicle* and *The Morning Post* on 7th November and in *The Morning Herald* between 7th and 10th November. *The Times* was unequivocal in its view, declaring in the leading article the following day, 8th November, that "If any number of this journal ever deserved to be rescued from the usual fate of ephemeral publications and regarded as 'a possession for all time' it is that of yesterday".

Simon used the publicity brought by the epidemic to advocate reform, despite a prevaricating response from the City Commissioners and he was supported by *The Times* and other newspapers. Shortly after the epidemic ended, in March 1850, Haywood reported to the City Commissioners of Sewers that, within the City, 10,386 dwellings were connected to the public sewers while 5,914 had cesspools. With the support of Haywood, Simon pressed for, and obtained, a new City Sewers Act (14 & 15 Vict. Cap. xci) which conferred greater power over the drainage of private houses, including poorer dwellings let for less than three shillings and sixpence a week which had been excluded from the earlier Acts[60]. Improvements followed. The City Commissioners enforced slum improvement measures against landlords (including some aldermen) and by 1854 Simon could claim that only one thousand dwellings were not connected to the sewers.[61] In the same year Haywood was able to tell the Royal Commission on the City that: "the owners of half the houses within the City have been compelled to do something about their premises".[62] Simon also pressed for the filtration of drinking water supplies in his evidence to the Select Committee on the Metropolis Water Bill and the measure was incorporated into the 1852 Metropolis Water Act.[63]

Simon believed that his measures accounted for the fact that, in the 1854 cholera epidemic, there was a 71% fall in mortality within the City compared with the 1848-9 outbreak: "less suffering in the City of 1854 than in the City of 1849, less in the City clean than in the City dirty, less in the City cared for than in the Metropolis

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[60]Lambert, R., Ch.8, *Sir John Simon,* McGibbon & Kee, 1963, Chapter 8, discusses this at some length.

[61]Ms Mins, Sewers Commission lxxxix, f.1010, G.L.R.O.

[62]P.P. 1854, vol. 26, Q.5981, Report of the Royal Commission on the City

[63]P.P. 1851, vol. 15, Q.3746

neglected".[64] Simon was still at this stage an adherent of the "miasmic" theory of cholera - the belief that the disease was inhaled from foul air rather than swallowed in polluted water.

During the 1854 cholera epidemic in London a number of observers drew attention to the relationship between the incidence of deaths from cholera and proximity to the river Thames. In September *The Times* reported a discussion in the Metropolitan Commission of Sewers in which one of the commissioners, Colonel Dawson, demonstrated that the relationship was as follows, using the figures available for the epidemic to that date: figures that were later confirmed and elaborated by Farr:[65]

Districts less than ten feet above the Thames: deaths 287 / 100,000
Districts ten to forty feet above the Thames: deaths 109 / 100,000
Districts more than forty feet above the Thames:deaths 32 / 100,000

In 1854 Simon served with Neil Arnott and William Farr on the Committee for Scientific Enquiry into the recent cholera epidemic. In 1838 Farr had been appointed as compiler of abstracts (chief statistician) to the Registrar-General and he used the data gathered by his office to draw a diagram which illustrated the relationship between the incidence of mortality from cholera and the elevation of the affected districts, using the figures compiled for the whole epidemic.

Farr's diagram revealed the incidence of mortality from cholera to be as follows:[66]

Elevation in feet	Cholera deaths per 10,000 population
0	137
15	50
25	40
35	25
45	20
55	13
65	**36** this level included **Golden Square**
75	19

This clearly demonstrated that, the further removed a district was from the lowest point (the Thames) the lower the mortality.[67] The most striking exception to this

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[64]Ms Mins Sewers Commission lxxxix, G.L.R.O.
[65]*The Times*: 6th September 1854, p. 4 cols 4-6
[66]P.P. 1854-5, vol. 21, p.16; see also pp. 26-31 for the Committee's explanations

inverse relationship between mortality and elevation was shown by Farr's diagram to lie in the vicinity of Golden Square, close to the site of the pump which, according to John Snow, was supplying the locality with infected water. Despite the evident connection between the water of the Thames, the water of the pump, and the incidence of cholera the "miasmic" orthodoxy was at this stage so strong that the authors of the report sought an atmospheric explanation, concluding rather that :

> "If the Broad Street[68] pump did actually become a source of disease to persons dwelling at a distance, we believe that this may have depended on other organic impurities than those exclusively referred to, and may have arisen, not in its containing choleraic excrements, but simply in the fact of its impure waters having participated in the atmospheric infection of the district". They added that "on the whole evidence, it seems impossible to doubt that the influences, which determine in mass the geographical distribution of cholera in London, belong less to the water than to the air".[69]

The committee reached this view despite their own observations that "in the Southwark and Vauxhall Water...evidence of unfiltered contamination reaches its highest degree, revealing to the microscope, not only swarms of infusorial life, but particles of undigested food referable to the discharge of human bowels".[70] The deliberations of this Committee are a good illustration of the strength of the miasmatic doctrine at the time and. for this reason, merit further examination. The Committee undertook a detailed study of the Broad Street outbreak and observed that, on the South side of Broad Street, forty-eight houses out of a total of forty-nine were affected by cholera while, from a total of 860 persons living in the street, 90 had died, together with 25 others who worked in the street but lived elsewhere. Nothing could better illustrate the strength of the miasmic doctrine than the Committee's explanation of this:

> "We cannot help thinking that the outbreak arose from the multitude of untrapped and imperfectly trapped gullies and ventilating shafts constantly emitting an immense amount of noxious, health-destroying, life-destroying exhalations".

They further observed that the enclosed character of the area meant that there was no wind to disperse the noxious vapours except at corners of streets and they took

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[67]Ibid., p.48
[68]Now renamed Broadwick Street and the site of a memorial to John Snow
[69]P.P. 1854-5: vol. 21, p.48
[70]Ibid., p.47

comfort from the fact that the incidence of deaths from cholera had been rather lower in corner houses than in others.[71]

In the words of the Report: "It may now be stated as the experience of two epidemics in London, that such local varieties of effect, grouped into masses for comparison, have been more nearly inversed to the elevation of soil in the affected districts than proportionate to any other general influence that we could measure".[72]There followed a lengthy discussion of the possible explanations for this relationship between elevation and mortality, a discussion which included atmospheric conditions, high barometric readings, temperature and the evaporating surface of the river. They also adduced the familiar doctrine of *pre-disposing* causes to support them:

> "With respect to the causes of this particular outbreak, we find no apparent exception to the conclusions arrived at in the preceding section of our Report...there must have pre-existed a certain local state of uncleanliness with putrefiable matters".[73]

Commenting upon Snow's conclusion that this phenomenon was due to the use of infected water from the Broad Street Pump, Simon, Farr and the rest of the Committee concluded:

> "In explanation of the remarkable intensity of this outbreak within very definite limits, it has been suggested by Dr Snow that the real cause of whatever was peculiar in the case lay in the general use of one particular well, situate (sic) at Broad Street in the middle of the district and having (it was imagined) its waters contaminated by the rice-water evacuations of cholera patients. After careful enquiry we see no reason to adopt this belief.". [74]

Indeed the Committee had its own ingenious explanation for the lower incidence of cholera farther from the river, an explanation which both depended upon and re-inforced the miasmatic doctrine:

> "For on the supposition that the choleraic infection multiplies rather in air than in water, meteorology explains how the balance of healthfulness is weighted in favour of the higher levels, by their less participation in the high night temperature of the Metropolis, by their comparative clearness

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[71]Ibid. Appendix 4; Report on Golden Square; pp. 155-61
[72]Ibid. p.15
[73]Ibid. p.51
[74]Ibid. p.52

from mist, and above all by the curative resources of more free ventilation".[75]

The Condition of London's Water Supply: Official Attitudes

For many centuries the condition of London's water supply had been a cause of some pride to its inhabitants. In 1237, during the reign of Henry III, Gilbert de Sandford granted to the city all the springs in his fief of Tyburn at Mary le Bourne, carried to a conduit in Cheapside by lead pipes. In 1582 a Dutchman called Peter Morice constructed a waterwheel at London Bridge which drew water from the Thames and piped it to premises in the city. This continued in use for 240 years until 1822 - seven years after house waste was permitted to be carried to the sewers. The most remarkable enterprise was that of Hugh Myddleton (1560?-1631) a successful goldsmith, banker and cloth maker and Member of Parliament for Denbigh. In 1613, with the assistance of an investment by James I, he constructed the New River which brought fresh water from a spring at Amwell in Hertfordshire to a point near Sadlers Wells, a distance of some 38 miles. For this he was made a Baronet in 1622. In 1723 the Chelsea water company started to draw water from the North Bank of the Thames and over the following one hundred and twenty-two years six other companies followed them in drawing water from the river: the West Middlesex, Grand Junction, East London, South London, Lambeth and Southwark companies. By the time the last of these started, in 1845, thirty years had passed since house drains had been emptying into the sewers, and by 1848 the Metropolitan Commission of Sewers was actively promoting the practice, with consequences for the purity of the water to which Snow drew attention in his papers of 1849 and 1857.[76] The "alarm" prompted by John Wright's pamphlet in 1828 (see Chapter One, page 18) had led to the appointment of Thomas Telford to investigate methods of improving the capital's drinking water but no practical steps were taken prior to the passing of the Metropolis Water Acts of 1851 and 1852 which required water companies to draw their supplies from above the tidal limit at Teddington lock and to keep their reservoirs covered. Yet as late as 1847 W.A.Guy, writing in *Fraser's Magazine* on "The Sanitary Commission and the Health of the Metropolis" wrote: "The river...constitutes a large open sewer in which the refuse of the town is diluted by so large a body of water as to lose all its injurious properties".[77]

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[75]Ibid. p.49

[76]See below, pages 141 et seq..

[77]*Fraser's Magazine,* vol. 36, November 1847 p.507

By 1850 a different note was being sounded in the *Edinburgh Review.* An article by a Civil Engineer, William O'Brien, on "The Supply of Water to the Metropolis" reminded the reader:

> "There are 141 public sewers between London and Battersea Bridges; Richmond, Isleworth, Brentford, Mortlake, Chiswick and Hammersmith furnish 68 more - and the whole of their contents are received into the Thames, and returned by the reflux of the tide - we perceive a state of things which renders exaggeration truly superfluous.[78]

In the same month, in his Journal *Household Words* Charles Dickens gave an account of his visit to the works of the Grand Junction Water Company at Kew.[79] Dickens asked the Engineer: "How many companies take their supplies from the Thames, near to, and after it has received the contents of, the common sewers? "The engineer replied: "No water is taken from the Thames below Chelsea, except that of the Lambeth Company, which is supplied from between Waterloo and Hungerford Bridges". Dickens observed that, the Thames being a tidal river, any sewage entering the river was liable to be conveyed by the flow above Chelsea but the engineer replied that many problems of water pollution were caused by dirt entering cisterns within houses. The engineer's complacency echoed that of a spokesman for the company, Dr Pearson, who, in evidence to the Royal Commission on Water Supply of the Metropolis twenty-two years earlier, had informed the Commissioners that:

> "The impregnating ingredients of the Thames are as perfectly harmless as any spring water of the purest kind in common life: indeed, there is probably not a spring, with the exception of Malvern, and one or two more, which are so pure as Thames water".[80]

This view was not universal. In 1850, the General Board of Health's had instituted an Enquiry into the Supply of Water to the Metropolis. Dr Hector Gavin, lecturer in forensic medicine at Charing Cross Hospital and Medical Inspector to the General Board of Health had claimed in evidence to the Enquiry that the condition of the capital's water was so repellent that the poor drank more beer than was good for them, thus promoting intemperance.[81] This view was reflected in one of the sixty-three conclusions of the resulting Report, which claimed that poor water led to "use of

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[78]*Edinburgh Review*, April 1850 vol. 91 pp. 381-2
[79]*Household Words,* 13th April, 1850
[80]P.P. 1828, vol.ix, p.149
[81]P.P. 1850, vol. 22, *General Board of Health's Report on the Supply of Water to the Metropolis*, Appendix III, p.62

fermented liquors and ardent spirits".[82] Another witness, Robert Bowie, who practised as a surgeon in the East End, observed that seamen whose ships were moored in London had discontinued the long-established practice of replenishing their water supplies from Thames water before setting out on a voyage, "believing that the water of the Ganges is quite as good as that of the Thames".[83]

The Enquiry, the Report which resulted from it and the further investigations which followed were exhaustive, yet the proceedings were couched in utilitarian tones which paid little heed to the specific health problems which would result from polluted water. Conclusion number 46 estimated that five million pounds a year would be saved on soap if softer water were piped into the capital and number 47 claimed that consumption of tea leaves would be reduced by one third by the same means. For these reasons the Report, in its 50th conclusion, recorded that the proposal to transfer the intake of the water companies to a point above the tidal limit, at Teddington, was satisfactory only as a temporary measure, since the water would be just as hard as that taken from the polluted tideway.[84]

Following the publication of the Board's Report a number of possible sources of water for the capital were considered, notably the Surrey springs from the Farnham and Hindhead area. This source was proposed in a document which bore the prolix title *Report and Papers of Suggestions to the General Board oif Health on the Proposed Gathering Grounds for the Supply of the Metropolis from the Soft-Water Springs of the Surrey Sands addressed to the General Board of Health by the Rt. Hon. William Napier.*[85] This scheme and another, which proposed to pipe water from Watford, were evaluated by three chemists, Thomas Graham, W.A.Miller and A.W.Hoffman, all F.R.S., who, like the authors of the General Board of Health *Report*, paid more attention to the problems of hardness than pollution in the water. They concluded:

> "The river [Thames] may reasonably be supposed to possess, in its self-purifying power, the means of recovery from an amount of contaminating injury equal to what it is at present exposed to in its higher section" [i.e. above Teddington]

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[82]Ibid. p. 311 conclusion number 10.
[83]Ibid. p.69
[84]P.P. 1850, vol. 22, p. 321, Conclusions 46, 47, 50
[85]This is the William Napier who proposed the Hope-Napier scheme described in Chapter 4

and, having thus briefly dismissed the problems of pollution they proceeded to devote much more space to discussing the problems posed by hard water.[86] There could scarcely be a clearer indication of official insouciance concerning the dangers of polluted water supplies.

However there was less complacency in other quarters whose views were uninhibited by flawed theories of the causes of disease propagation. In 1851 *Punch,* commenting on the preparations for the Great Exhibition, wrote that:

> "The contractor is bound to supply, gratis, pure water in glasses to all visitors demanding it. But the committee must have forgotten that whoever can produce in London a glass of water fit to drink will contribute the rarest and most universally useful article in the whole exhibition".

By July 1855 (in the same month that Faraday wrote his letter to *The Times* protesting about the condition of the river, (see Chapter One, page 20) *The Lancet* was writing:[87]

> "No-one having eyes, nose or taste can look upon the Thames and not be convinced that its waters are, year by year and day by day, getting fouler and more pestilential...The abominations, the corruptions we pour into the Thames, are not, as some falsely say, carried away into the sea. The sea rejects the loathsome tribute, and heaves it back with every flow. Here, in the heart of the doomed city, it accumulates and destroys".

Despite such comments Anne Hardy has observed that, at the official level, the early nineteenth century witnessed a reduction in concern about the water question, a view reflected in the public statements, quoted above, of the engineer to the Grand Junction company and of the three eminent chemists.[88] Luckin, in commenting on the reduction in the incidence of the rat-born disease typhus, writes:

> "The systematic drainage of the inner-city districts, which was undertaken during the sanitary revolution may indeed have reduced mortality from typhus but only at the short-term cost of a deterioration in water supplies drawn from river sources which were still too close to sewer outlets." [89]

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[86]P.P. 1851, vol. 23, *Report of the Commissioners on the Chemical Quality of the Supply* of *Water to the Metropolis*, p.9

[87]Jephson, H.,: *The Sanitary Evolution of London,* Fisher Unwin, 1907, p.77

[88]Hardy,A.,: "Water and the Search for Public Health in London in the Eighteenth and Nineteenth Centuries," *Medical History,* 28 (1984), p.263

[89]Luckin, W., *Urban Disease and Mortality in Nineteenth Century England,* Batsford Academic, 1984, Ch.5

The same author has argued that the extension of the piped water supply between 1850 and 1870 led directly to an increase in deaths from cholera[90] and, in commenting on the *Report of the Select Committee on East London Water Bills* he has observed that, as the number of dwellings supplied by companies had grown, "large numbers of consumers had merely exchanged safe or unsafe well water for unsafe company supplies".[91] In the 1860s and 1870s the chemist Edward Frankland, in reports to the Registrar General, delivered a series of highly critical judgements on the quality of public water supplies[92] though by 1877 he was reporting a significant improvement in water quality, an advance which he attributed to the widespread adoption of filtration systems.

In the meantime, some of the local authorities showed an understandable reluctance to add further to the pollution. Jephson, in *The Sanitary Evolution of London*, published in 1907 when the author was a member of the LCC, refers to the situation in Shoreditch as late as 1859: "In several vestries resolutions were actually moved with the view of averting the construction of sewers. It was thought by many persons of influence to be better to live in the midst of overflowing cesspools than to add to the defilement of the Thames". Simon himself, in his first report of 1849, commented upon the condition of the Thames, though he regarded it as a source of foul air rather than infected water.

> "I can have no hesitation in stating it as a matter greatly to be desired in the City of London that the noble river which ebbs and flows beneath its dwellings should cease to be the drainpool of our vast Metropolis, and that the immeasurable filth which now pollutes the stream should be intercepted in its course, and be conveyed to some distant destination, where, instead of breeding sickness and mortality, it might become a source of agricultural increase and national wealth.[93]

Yet by this time Simon was becoming more sympathetic to the view that water was at least relevant to the transmission of disease. In 1853 he had informed the Croydon Board of Health that its 1852 typhoid outbreak had been caused by a "Fog of faecal evaporation"[94] but by 1856, in his *Report on the Last Two Cholera Epidemics of*

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[90]Luckin, W.,: at a seminar at the Centre for Metropolitan History, London, 18/3/96

[91]Luckin, W., *Pollution and Control: a Social History of the Thames in the 19th Century*, Adam Hilger, 1986, p.79

[92]Ibid., pp. 24-7, discusses Frankland's work

[93]Simon, J.,: page 15 in *Reports Relating to the Sanitary Condition of the City of London*, 1849, G.L.R.O.

[94]Simon, J.,: *Report to Local Board of Health of Croydon with Regard to the Causes of Illness Recently Prevailing in That Town"*, 1853, p.12

London as Affected by the Consumption of Impure Water he was moving towards Snow's view on the causes of the epidemic. Like Snow, (see below page 142) he compared the incidence of mortality among the customers of the Lambeth water company with that of the Southwark and Vauxhall company and observed:

> "The population drinking dirty water [those supplied by the Southwark company] appears to have suffered three and a half times as much mortality as the population drinking other water"[95].

His arithmetic was slightly different from Snow's but the discrepancy between the mortality rates amongst the customers of the two companies was pushing him, like Snow, towards the water-borne theory. However at this stage he was not yet ready to accept Snow's conclusions in full. He dismissed Snow's conclusions about the dangers of the Broad Street pump by suggesting that its water was probably no more polluted than that of other London sources and concluded that:

> "It entirely consists with the facts here set forth to maintain that, under the specific influence which determines an epidemic period, fecalised drinking water and fecalised air equally breed to convey the poison".[96]

In his *Sanitary Papers* of 1857, he re-affirmed his belief in the role of clean water in preventing cholera epidemics while commenting on the practice of placing in quarantine ships that were thought to be carrying the disease. This phenomenon was believed to arise from the fact that, while at sea, the vessels had passed through a poison-charged layer of air:

> "as regards cholera it seems highly probable that the immigration of infected persons might occur to any extent without exciting epidemic outbreaks, if it occurred only in places of irreproachable sanitary conditions, especially as regards the supply of water and continuous removal of house refuse".[97]

In his capacity as Medical Officer to the Privy Council Simon re-affirmed this view in his 1859 Report when he referred to a survey into the incidence of diarrhoea in ten provincial towns. Citing the survey as evidence Simon reported that excess mortality was due to "The tainting of the atmosphere with the products of organic decomposition, especially of human excrement" though he added that an alternative

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[95]P.P.1856, vol. 53, p.6
[96]P.P. 1856, vol. 52, pages 11 and 15
[97]P.P.1857-8, vol. 23, p.281

cause was "the habitual drinking of impure water".[98] He maintained this ambiguous position for another ten years, even holding to it after the 1866 cholera outbreak in which a link between polluted water and epidemic cholera was clearly established. In his ninth Report to the Privy Council, written in 1867, Simon gave an account of a conference on cholera which he had attended in Weimar, citing with approval evidence from Lubeck and St Petersburg which appeared to support Pettenkofer's "fermentation" theories:"The different behaviour of cholera at different times in the same place is determined by temporary differences of soil". He added :

> "It cannot be too distinctly understood that the person who contracts cholera in this country is *ipso facto* demonstrated with almost absolute certainty to have been exposed to excremental pollution."[99]

Simon had thus, by 1867, recognised the link between excremental pollution, water and cholera epidemics but still had reservations about the full implications of Snow's theory.

Alternative Theories

There were other theories which would eventually lead to a sounder understanding of the true causes of disease. In his *Report* Chadwick referred to the work of the French sanitary campaigner Alexandre-Jean-Baptiste Parent-Duchatelet (1790-1836) who, in his work *Hygiene Publique* (1836) had observed that animals could drink dirty water without suffering harmful effects and had drawn a distinction between water that was dirty and water that was diseased. A greater understanding of the causes of disease might have been achieved earlier in France, but for the Revolution. From 1770 to 1790 the the Societe Royale de Medicine conducted a study of the relationship between weather, food, hygiene and illness, using thousands of questionnaires completed by local doctors throughout France. The information was not analysed because of the turmoil that followed the events of 1789.[100] In April,1850, an article in the *Edinburgh Review* by a Civil Engineer called William O'Brien drew attention to the potential hazards caused by the pollution of the Thames at a time when all of London's water companies drew drinking water from the tidal stretches of the river:

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[98]P.P. 1860, vol. 29, p.64

[99]P.P.1867,vol. 37,*9th Report of the Medical Officer to the Privy Council,*p.30 & 33

[100]For an account of this survey see W.F.Bynum, *Science and the Practice of Medicine in the Nineteenth Century,* C.U.P., 1994, p.60

> "The refuse and dirt of two millions of individuals - the enormous accumulation of waste and dead animal and vegetable matter - the blood and offal of slaughter-houses....and a thousand nameless pollutions - all find their way into the Thames. The mixture is next washed backwards and forwards by the tide; and, having been thoroughly stirred up and freely comminuted by the splash of two hundred and ninety-eight steamers, is then pumped up for the use of the wealthiest city in the world".[101]

In England, in July 1849, the Microscopical Sub-Committee of the Bristol Medical-Chirchurgical Society met at the house of Dr William Budd (1811-80) a local physician who later became a Fellow of the Royal Society. The Committee reported that it had found "singular bodies" in the evacuations of cholera sufferers and the findings were passed on to the Royal College of Physicians, though later experiments by that body failed to find similar organisms in samples of drinking water drawn from areas in which cholera was prevalent.[102] In a later study of the 1854 epidemic Budd observed that patients using a particular hospital privy were catching cholera but he held to the belief that air, rather than water, was the principal vehicle by which infection spread. He wrote that:.[103]

> "the poison accumulates on so vast a scale that, exhaling into the air, it broods like a great miasm over large districts, and in a manner to admit of its being carried by currents of air to indefinite distances with its deadly powers intact".

Budd also reported the organisms found by the Bristol Society to *The Times* in which he argued that cholera was caused by a "living organism of distinct species" with funghoid characteristics which could be conveyed in water[104] and he later concluded that a sewer should be regarded as "a direct continuation of the diseased intestine" and argued that the evacuations of typhoid patients should be disinfected.[105] The newspaper doubted his claim, observing that, in India, cholera had sometimes been transmitted *upstream* along rivers. Twenty years later Budd would only commit himself to the claim that "Fever, smallpox, measles, cholera, whooping cough and other diseases are communicated by the dissemination of material poisons, which dissemination can be stopped"[106] but by 1874 he felt confident in questioning the

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101*Edinburgh Review*: vol. 91, April, 1850, p.381

102Pelling, M.,: *Cholera, Fever and English Medicine, 1825-65*, O.U.P., 1978. p.163

103Budd, W.,: *Malignant Cholera, its Cause, Mode of Propagation and Prevention,* 1849, pp.21-2

104*The Times* 26th September 1849

105Budd, W.,: *Typhoid Fever, Its Nature, Mode of Spreading and Prevention,* 1874, pp. 176 and 181

106*The Times*:5th October 1869,p.7,col.4,Budd to Social Science Congress,Bristol

whole basis of the miasmatic theory. In a study of the effects of the "Great Stink" of 1858 he drew attention to the fact that, despite the appalling smell which hung over London, the mortality rate was low:

> "The hot weather passed away; the returns of sickness and mortality were made up, and, strange to relate, the result showed not only a death rate of below the average, but, *as the leading peculiarity of the season,* [his italics] a remarkable diminution in the prevalence of fever, diarrhoea, and the other forms of disease commonly ascribed to putrid emanations" adding that the miasmatic theory "will take its place in that limbo of discarded fallacies to which other superstitions have long been consigned".[107]

The Registrar-General's 22nd Annual Report confirmed Budd's claims. The deaths per one hundred persons living were recorded as follows:[108]

	Average 1849-58	1858
England	2.246	2.303
London	2.425	2.356

These statistics, compiled by Farr, showed that London had been slightly healthier in 1858, the year of the "Great Stink" than it had been in the previous decade as a whole.

The official report of the Board of Health on the cholera epidemic of 1848-49 managed to accommodate the phenomenon of polluted water within the miasmic theory by allowing the water to act as the *predisposing cause*[109] while continuing to place the immediate cause of the spread of the epidemic firmly in the air:

> "It is difficult to arrive at any other conclusion than that streams polluted by the refuse of large masses of people so deteriorate the air as to operate in the time of a destructive epidemic, when all depressing agents have increased force, injuriously on the human frame, and thereby predispose it to the attacks of disease".[110]

107Budd, W.,: *Typhoid Fever, Its Nature, Mode of Spreading and Prevention*, 1874, pp. 141-3 and 153

108P.P. 1861, vol. 18, *22nd Annual Report of the Registrar-General,* p.xiii, table XIV

109The concept of "predisposing causes" is discussed in: C.Hamlin: "Predisposing Causes and Public Health in Early Nineteenth Century Medical Thought;" *Social History of Medicine*, 5 (1992) pp. 43-70

110P.P. 1850, vol. 21, p. 543: *Report of the General Board of Health on the Epidemic Cholera of 1848 and 1849*

John Snow *On Cholera*

In the meantime, the most significant contribution to an understanding of the true causes and propagation of cholera was being made elsewhere. Dr John Snow (1813-58), an anaesthetist, who in 1843 began to practise medicine from premises at 54, Frith Street, Soho, published a paper *On the Mode of Communication of Cholera* in 1849 in which he suggested that water polluted by sewage might be the vehicle by which cholera was transmitted. He further argued that the practice of flushing sewers into the river made the 1849 epidemic worse[111] and developed this thesis in a series of articles in the *Medical Times and Gazette.*[112] He drew attention to the role of water closets in helping to spread the disease:

> "If the general use of water-closets is to continue and to increase, it will be desirable to have two supplies of water in large towns, one for the water-closets and another, of soft spring or well water from a distance, to be used by meter like the gas".[113]

During the 1854 epidemic Snow observed that a high incidence of cholera was occurring amongst persons drawing water from a well in Broad Street, Soho, near Golden Square, close to his medical practice. Further investigation revealed that a sewer passed close to the well. These observations supported the arguments of his papers of 1849. Snow persuaded the Parish Council to remove the handle which operated the pump.[114] While some medical authorities were prepared to acknowledge that polluted water had some role in the propagation of disease as a pre-disposing cause, acting with other environmental factors such as filth and moral depravity to weaken the system and make it vulnerable to attack by disease, few were prepared to acknowledge it as the specific cause, despite the evidence of Snow's observations and the lucidity of his arguments:

> "Rivers always receive the refuse of those living on the banks, and they nearly always supply, at the same time, drinking water of the community so situated...the water serves as a medium to propagate the disease amongst those living at each spot and thus prevents it from dying out through not

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111P.P. 1850, vol. 21, p. 543: *Report of the General Board of Health on the Epidemic Cholera of 1848 and 1849*

112E.g.: *On the Communication of Cholera by Impure Thames Water*, 1854, p. 365 and *Drainage and Water Supply in Connection with the Public Health*, 1858, pp. 161, 189, Wellcome Institute library

113Snow, J.,: *Medical Times and Gazette*; 1858, p.191

114*Dictionary of Scientific Biography*: American Council of Learned Societies; New York, 1975; vol. 12 p.503

> reaching fresh victims.....Many medical men, whilst they admit the influence of polluted water on the prevalence of cholera, believe that it acts by pre-disposing or preparing the system to be acted upon by some unknown cause of the disease existing in the atmosphere or elsewhere.....if the effect of contaminated water be admitted, it must lead to the conclusion that it acts by containing the true and specific cause of the malady". [115]

Few were convinced by his hypothesis so, in 1857, the year before his early death, Snow published a study of mortality rates in two South London parishes. He compared the incidence of mortality in Christ Church Lambeth, whose water was supplied mostly by the Lambeth water company, with that occurring in St. Saviour, Southwark, which was supplied by the Southwark and Vauxhall company. In the 1849 outbreak the mortality rates in the two parishes had been similar, with Christ Church, Lambeth being slightly higher. In the 1853-4 outbreak the position was reversed, the incidence in St. Saviour, Southwark being almost six times that of Christ Church, Lambeth. In the intervening five years James Simpson, engineer to the Lambeth company, supplying the healthier parish, had moved its water intake to Seething Wells, Thames Ditton, above Teddington Lock, as required by the Metropolis Water Act, 1852, where it was untainted by sewage borne upstream by the tideway. Simpson had also been responsible for creating the first sand filter beds for the Chelsea company in 1829.[116] The Southwark and Vauxhall company, however, continued to draw its water from the tidal stretch near Vauxhall. Snow offered this as further evidence that the cholera was waterborne.[117] The marked difference in the incidence of disease between the customers of the two companies, living in the same streets and breathing the same air, cast further doubt on the "miasmatic" explanation. Snow never identified the organism that caused cholera but in the same year, 1854, that he was conducting his study, the Italian microscopist, Filippo Pacini (1812-83) announced that he had identified a unique micro-organism in the faeces of cholera victims. Nevertheless the sanitary establishment remained unconvinced and, although the disease was the main item on the agenda of seven successive international sanitary conferences held between 1851 ands 1892 the work of neither man was considered. Snow advocated the use of filters by water companies and advised that water be boiled before use during cholera outbreaks.At this time the General Board of Health examined a number of filtration systems and engaged in a discussion of the relative

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115Snow, J.,: *On Cholera*, Wade Hampton Frost, New York, 1936, pp. 124 and 110

116Dickinson, H.W.,: *Water Supply of Greater London*, Newcomen Society, 1954, p.122

117Snow, J.,: *Cholera and the Water Supply in the Southern Districts of London*, British Medical Journal, 1857, vol. 2, p.864.

merits of different techniques, materials, thicknesses of filter beds and related matters, though the debate was uninformed by any discernible theories of disease propagation or of the chemical or physical processes involved in filtration processes.[118] The dilemma of the investigators is reflected in their comments on the capital's well water:

> "The waters from the shallow wells of London, perfectly bright as they are, frequently present, under examination, evidence of impurities derived from innumerable cesspools and sewers with which the metropolis is riddled and traversed: but those impurities may not be detected by the senses".[119]

In the absence of any clearly defined germ theory of the propagation of disease it must have been very tempting to conclude that epidemics were spread exclusively by foul-smelling air rather than by water which looked clean, unless examined under a powerful microscope. Moreover this appeared, to some observers, to account for the rapid spread of the disease. Another report on the 1854 outbreak observed that:

> "The suddenness of the outbreak, its immediate climax, the short duration, all point to some atmospheric or other widely diffused agent still to be discounted and forbid the assumption, in this instance, of any communication of the disease from person to person, either by infection or by contamination with the excretions of the sick".[120]

The Miasmic Orthodoxy Weakens

Slowly, some prominent believers in the miasmic orthodoxy began to modify their views without abandoning them. In 1855 (later Sir) Benjamin Richardson, F.R.S., (1828-96) wrote on the theory of propagation by water in the journal that he founded, *The Journal of Public Health and Sanitary Review*:

> "Although we are prepared to go to great lengths with Dr Snow in support of his peculiar views, we are obliged to stop whenever we meet with this absolute conclusion...we are glad to see supported by Dr William Budd the view that the specific cause of cholera may be carried by the air into the lungs".[121]

118P.P. 1856, vol. 52, *Reports to the Rt. Hon. William Cowper, M.P. on the Metropolis Water Supply*

119P.P. 1856,vol. 52, *Report on the Work of the Metropolitan Water Companies* p.345

120P.P. 1854-5, vol. 45, p.7, *Report of the Medical Council in Relation to the Cholera Epidemic of 1854.*

121*Journal of Public Health & Sanitary Review*, 1855, pp.134-5

Moreover at this time there was some evidence of an adjustment of attitudes in some official quarters in the *Report on the Last Two Cholera Epidemics of London as Affected by the Consumption of Impure Water* which drew attention to the effects of sewage discharge into the river and questioned whether it was wise that "that which would have been impure to inhale is to return as poison to drink".[122] Nevertheless the miasmic theory remained the orthodox one not only at this time but for many years afterwards. Pasteur published his germ theory in 1857 and, in the years that followed, the science of bacteriology became firmly established though twenty-seven years elapsed before the German bacteriologist Robert Koch isolated the cholera bacillus in 1884 and confirmed that it was transmitted in contaminated water. As late as 1894 the distinguished English epidemiologist Charles Creighton was still as sceptical as the Board of Health had been forty-five years earlier when Snow had published his findings. Creighton wrote of the virulent outbreak of cholera in Soho in 1854:

> "There was a pump in Broad Street, in the centre of this district, which was supposed to have dispersed cholera broadcast in its contaminated water; a death had occurred in Swain's Lane, at the foot of Highgate Hill, of a person who had drank [sic] the water of the Broad Street pump. The whole incident was seized upon and worked up by Dr Snow, who had written a speculative essay in 1849 upon the probability of cholera being conveyed by water...The Board of Health, having very full data before them of the Soho outbreak in all its aspects....did not adopt Snow's conclusion, although he had enthusiastic followers at the time and has probably more now".[123]

Clearly even in 1894 Creighton had his own reservations about Snow's hypothesis.

Towards a Germ Theory

As early as 1863, in his sixth *Report,* Simon had referred to the work of Pasteur in connection with germ theory and by 1873 he had modified his views on the miasmic theory to the point where he could acknowledge both the existence of invisible solid particles as vehicles of infection and also the soundness of Snow's hypothesis. In his Report for that year to the Privy Council, to which he had become Medical Officer in 1858 he wrote that:

> "It is of the utmost practical importance to recognise in regard of filth, that agents which destroy its stink may yet leave all its powers of disease

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122P.P. 1856: vol. 52, p.369

123Creighton, C.,: *A History of Epidemics in Britain,* O.U.P., 1894, p.854

production undiminished....waters which chemical analysis would probably not condemn may certainly be carrying in them very fatal seeds of infection".[124]

Referring to the means by which typhoid was transmitted (the typhoid bacillus was identified by Eberth in 1880) Simon wrote: "apparently its infection runs its course, as with successive inoculations from man to man, by instrumentality of the molecules of excrement, which man's filthiness lets mingle in his air and food and drink".[125]

And in a reference to Snow's theory concerning the spread of cholera through infected water he wrote that the public view of the theory was:"an attention at first quite incredulous, but which, at least for the last fifteen years, has gradually been changing into conviction".[126] In 1876 he published a monograph, *Filth-Diseases and their Prevention* which was entirely concerned with public sanitation and with the threats posed to human health by the ineffective disposal of human excrement. Simon eventually came to believe that cholera was transmitted in water by the experiments of a German scientist, Karl Thiersch, though he remained convinced that air was also a major vehicle for the spread of the disease.[127] Nevertheless, as Bynum observes in comparing the work of Simon and Chadwick "Simon made the transition into the bacteriological age, whereas Chadwick remained to the end of his long life a miasmatist of the 1840s".[128]

Nevertheless the policy measures that Simon proposed following his report into the 1849 cholera epidemic[129], although designed primarily to clean up London's foul air, had the eventual result of cleansing the water supply of the true source of infection. In particular better house drainage, once it had been linked to the intercepting sewers, removed from the subsoil infected sewage that had leaked from cesspools into the drinking water. Simon's proposals for an improved water supply, as reflected in the Act of 1852 which required London's water companies to move their intakes above

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124P.P. 1874, vol.31: *Report of the Medical Officer of the Privy Council and Local Government Board for the Year 1873*; pp. 9 and 11

125Ibid., p.14

126Ibid., p.15

127Pelling, M.:*Cholera, Disease & English Medicine, 1825-65;* O.U.P.,1978 pp.236/48

128Bynum, W.F.,: *Science and the Practice of Medicine in the Nineteenth Century,* C.U.P., 1994, p.83

129J.Simon: *Reports Relating to the Sanitary Condition of the City of London,* 1854, G.L.R.O.

Teddington Lock by 1855, and to install filtration beds, eventually placed London's drinking water beyond the reach of its sewage.[130]

The Conversion of William Farr

The work of William Farr, (1807-83) illustrates two of the critical changes which occurred in official attitudes towards sanitation in the mid-nineteenth century: first, an acceptance of public responsibility for the health of the population; and second a growing acceptance that certain diseases were water-borne rather than "miasmatic". On 15th March 1834 the Statistical Society of London (later the Royal Statistical Society) was established and its prospectus stated its purpose as that of "procuring, arranging and publishing facts calculated to illustrate the conditions and prospects of Society".[131] Similar societies were founded in Manchester, Birmingham and Glasgow.[132] Their members started to compile data on aspects of public health, population, income, housing, education and religion. In 1836, while employed as secretary to the Poor Law Commissioners, Chadwick had written an *Essay on the Means of Insurance* which argued for the registration of all causes of disease with a view to devising remedies or means of preventing them. In 1838 the Office of the Registrar-General was established with the task of registering births, marriages and deaths. Farr, who had studied medicine but never practised it, was appointed as the first compiler of abstracts (chief statistician) to the new office and quickly became the dominant influence in the organisation. He remained in the post until 1879, becoming president of the Statistical Society in 1871. He probably gained the post through Chadwick's influence.[133]

In the years that followed, Farr not only compiled abstracts which were published, notably in the *Annual Reports* of the Registrar-General. He also used his position to campaign for sanitary reforms and quickly established a reputation for his skills as an advocate of reform. His *Report on the Mortality of Cholera in England, 1848-49* was described by *The Lancet* in the year of its publication (1852) as "one of the most remarkable productions of type and pen in any age or country".[134] He drew attention

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130P.P. 1851, vol. 15,Q.3746:Simon's evidence, proposing filtration of water supplies

131Bonar, J., & Macrosty, H.,:*Annals of the Royal Statistical Society, 1834-1934*, p.22

132For a study of this movement see Asa Briggs's chapter, *The Human Aggregate*, in *The Victorian City, Image and Realities*, ed. H.J.Dyos & M.Wolff, Routledge & Kegan Paul, 1973

133An account of the events leading to Farr's appointment is given in S.E.Finer: *The Life and Times of Sir Edwin Chadwick*, Methuen, 1952, p.143

134*The Lancet*, 13th March 1852, p.268

to the wide variations in mortality between different areas and particularly emphasised the high death rates recorded in London, a feature that he attributed to the conditions in which most of the population lived. Like Chadwick and other campaigners he based his arguments for sanitary reform on the economic costs of disease as manifested in pauperism and he attempted to calculate the incidence of sickness as well as recorded deaths, arguing that "the numbers constantly sick in London were 122,000 and the annual attacks of sickness more than 1,220,000 during the seven years 1838-44"[135] [the population at the time being about two millions]. In the fifth Annual report Farr gave a clear definition of the miasmatic doctrine which he was to hold for more than twenty years:

> "Every population throws off insensibly an atmosphere of organic matter... this atmosphere hangs over cities like a light cloud, slowly spreading, driven about, falling dispersed by the winds, washed down by showers...and the density of the poison (for in the transition of decay it is a poison) is sufficient to receive and impart the processes of zymotic principles - to connect by a subtle, sickly medium, the people agglomerated in narrow streets and courts, down which the wind does not blow, and upon which the sun seldom shines".[136]

In the tenth Annual report, published in 1847, he estimated that in the capital "At least thirty-eight people died daily in excess of the rate of mortality which actually prevails in the immediate neighbourhood"[137]. He went on to offer the conventional "miasmatic" explanation for this phenomenon and to suggest that the legislature had a responsibility to introduce preventive measures:

> "This disease mist, arising from the breath of two millions of people, from open sewers and cesspools, graves and slaughterhouses, is continually kept up and undergoing changes; in one season it was pervaded by Cholera, in another by Influenza; at one time it bears Smallpox, Measles, Scarlatina and Whooping Cough among your children; at another it carries fever on its wings. Like an angel of death it has hovered for centuries over London. But it may be driven away by legislation. If this generation has not the power to call up the dead from their graves, it can close thousands of graves now opening. The poisonous vapour may yet clear away from London and from all the other towns of the kingdom. Some of the sunshine, pure water, fresh air and health of the country may be given to the grateful inhabitants of towns by the voice of the legislature".[138]

135Farr, W.,: *Vital Statistics*: ed. Noel & Humphreys, 1885, p.153
136P.P. 1843,vol. 21,*Fifth Annual Report of the Registrar General*,appendix, p.206-7
137Tenth Annual Report of the Registrar-General (1847), p. xv
138Ibid., p. xvii

Farr made a further significant contribution to the debate on disease causation in the sixteenth Annual Report of the Registrar-General in 1856 when he included a *Report on Nomenclature and Classification* of diseases in which he divided diseases into five groups of which one was *Zymotic* derived from the Greek word meaning "to ferment". In the Seventeenth Annual Report of the Registrar-General, written in 1855, Farr added his own comment that "The cholera matter or cholerine, where it is most fatal, is largely diffused through water, as well as through other channels".[139] This conditional and not entirely consistent statement amounted to a significant early concession to Snow's theory and was the first sign that Farr was modifying his views..

Following the work of Thomas Gresham on the diffusion of gases, Farr believed that zymotic particles floated in the air, like clouds or pollen[140], but that they were only harmful to populations which had been made vulnerable to them through living in insanitary conditions (Watson's *predisposing causes*, see above, note 28). He described these zymotic diseases as "synonymous with the class of epidemic, endemic and contagious diseases" and argued that their rapid diffusion through a population was caused by "the presence of certain impure conditions of the atmosphere" which pre-disposed a population to infection so that the presence in such a population of one or more infected persons would enable the infection to "act on that population zymotically, that is, as the leaven which sets in action the fermenting mass".[141] Pelling has argued that this diagnosis means that Farr believed that "zymotic" meant "preventable" since by removing the insanitary atmosphere which pre-disposed populations to infection the zymotic particles would, in effect, be rendered harmless.[142] In commenting upon the thoroughness of Farr's reports and upon their enunciation of miasmatic doctrines, J.M.Eyler has written that:

> "One is struck by their comprehensiveness and exhaustive numerical analysis, but even more by the realisation that the reports are intimately bound up with a theory of communicable disease and an attitude towards epidemiological research quite foreign to twentieth century medicine".[143]

The East London Epidemic

139*Seventeenth Annual Report of the Registrar General,*(1857) p.99

140Eyler, J.M.:"William Farr on the Cholera: the Sanitarian's Disease Theory and the Statistician's Method";*Journal of the History of Medicine*,April, 1973, p.85

141*Sixteenth Annual report of the Registrar-General*, (1856), pp. 71-105

142Pelling, M.,: *Cholera, Fever and English Medicine, 1825-65,* O.U.P., 1978, p.143

143Eyler, J.M.,: *William Farr on the Cholera: the Sanitarian's Disease Theory and the Statistician's Method*; Journal of the History of Medicine, April 1973, p.79

It was the failure of the East London water company to comply wholly with the requirements of the 1851 and 1852 Metropolis Water Acts, combined with the fact that its directors attempted to conceal its failure, that finally convinced Farr of the critical role of polluted water in the propagation of cholera. On 27th June, 1866, a labourer called Hedges and his wife, living at 12, Priory Street, Bromley by Bow, both died of cholera, aged forty-six. Most of Bazalgette's system of intercepting sewers was in operation by this time but the Northern Low Level Sewer, which would eventually take the sewage from this area, had not yet been completed. The Hedges' water closet therefore discharged into the river Lea at Bow Bridge, half a mile below the East London Water Company's reservoir at Old Ford. The incoming tide would have carried the infected sewage back upstream towards the reservoir. This should not have mattered since the company had installed filter beds for its new covered reservoirs and supposedly isolated these reservoirs from its older uncovered reservoirs which had pervious bottoms. Nevertheless Farr observed the degree to which the outbreak was concentrated in the area served by the East London company and wrote to Edward Frankland on 31st July asking him to try to trace the cause, commenting that "The mortality is terrible just in the area of East London supply".[144] The following day *The Times* carried a report of the Registrar-General's weekly report of deaths from cholera which drew attention to the fact that 924 people had died in six districts served by the East London company.[145] On the same day, upon the recommendation of the Registrar-General's Office, notices were displayed in the affected area advising that "The inhabitants of the district within which cholera is prevailing are earnestly advised *not to drink any water which has not previously been boiled*" as Snow had counselled in his paper of 1854, though the effectiveness of this advice may have been reduced by the fact that, according to the local medical officer, Orton, temperatures in sunlight were reaching 165 degrees fahrenheit.[146] The engineer of the Company, Charles Greaves, wrote to *The Times* on 2nd August 1866 to refute the suggestion that contaminated water had been allowed to enter the drinking water supply: Greaves wrote:[147]

"the water enters the filter-beds of the company at Lea Bridge, and is

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144P.P. 1867-8, vol. 37, p.88

145*The Times*, 1st August 1866, p.11

146P.P. 1867, vol. 37, pp. 295-6 and 294: *Ninth report of the Medical Officer to the Privy Council*, Appendix 7f

147*The Times*, 2nd August 1866, p.10

> conducted thence to their pumping establishments at Old Ford in an iron pipe and never sees light or risks pollution between the filter-bed and the consumer; and that the "canal" alluded to by the Registrar, having been since 1853 disused for all purposes of supply, is only maintained as a drain from the filter to a lower part of the river ...not a drop of unfiltered water has for several years past been supplied by the company for any purpose".

On 3rd August Farr visited Old Ford and, since Frankland was on holiday, he wrote to one of his assistants, a chemist called Valentin, to ask him to analyse the water supplied from the company's two distribution points: one at Lea Bridge, supplying the area to the North, where there was little cholera; and one at Old Ford which supplied the area chiefly affected by the epidemic.[148] Farr also observed that, though Greaves's letter to *The Times* had claimed that all its water was filtered, two customers of the East London company, Mr Ferguson and Mr Russell, claimed that they had found eels in their water pipes.[149] Farr also wrote to Bazalgette the same week about the possibility of waste entering the water supply and Bazalgette replied:

> "It is unfortunately just the locality where our main drainage works are not complete. The low-level sewer is constructed through the locality, but the pumping station at Abbey Mills will not be completed until next summer... I shall recommend the Board to erect a temporary pumping station at Abbey Mills to lift the sewage of this district into the Northern outfall sewer. This can be accomplished in about three weeks".[150]

In the same week that Bazalgette wrote this letter the Board approved his proposal to re-align some branches of the low level sewer and install a temporary pumping station powered by two twenty horsepower engines to lift the sewage into the outfall. Nevertheless Bazalgette observed, in his letter dated 2nd August, that this would only partially solve the problem as long as the local District Board continued to allow houses and factories to discharge their contents into the Lea instead of insisting that they be connected to the low level sewer.[151] The following October the East London Water Supply Association asked the Board to continue with this arrangement, although the cholera outbreak had by then abated and the Board's records show that the temporary works were still in operation in May 1867.[152]

148P.P. 1867-8, vol. 37, pp. 92-3 and p.95.

149 Ibid., p.95: *Narrative of Proceedings at the General Register Office during the Cholera Epidemic of 1866*

150Ibid., p.117: *Narrative of proceedings,* week ending Saturday, 4th August, 1866

151M.B.W. *Minutes of Proceedings*, 3rd August 1866, pp. 1062-3

152M.B.W.*Minutes of Proceedings*,19th October 1866,p.1296 and 10th May 1867, p.556

In September the number of deaths from cholera rapidly fell but the concerns raised about the East London company's supplies were sufficiently great for twenty-nine residents supplied by the East London company to sign a "memorial" to the Board of Trade in which they alleged that their water supplies were being contaminated by water from the river Lea. This occurred in November 1866[153] and led to the appointment of Captain Tyler to report upon the matter though a local medical officer based in Stepney, who had carried out some investigations of his own wrote at the time that:

> "The charge against the company consists, in an emergency, of distributing foul water from two old uncovered reservoirs at Old Ford...the water from the suspected reservoirs at Old Ford has not been used, and the subordinate employes [sic] are all ready to a man to come forward, if required, on oath, to declare that the sluice has not been opened for such purpose for the last two years."[154]

Tyler examined the company's reservoirs and found evidence that they were not effectively protected from infiltration by surrounding ground water which might itself have become contaminated. He also questioned the company's employees and discovered that on three occasions in 1866, in March, June and July, a twenty-four year old carpenter had admitted water to the company's closed reservoir (from which drinking water was drawn) from an old, uncovered reservoir which was vulnerable to contamination, in clear breach of the 1851 and 1852 Metropolis Water Acts.[155] Tyler wrote, in reference to the claims of the "memorialists":

> "I am of the opinion that the allegation has been proved, and that the water of the Lea finds its way into these covered reservoirs.....the use of such unfiltered water so stored in an uncovered reservoir is indefensible, and was a distinct infringement of the Metropolitan Water Supply Act of 1852....a case of grave suspicion exists against the water supplied by the East London company from Old Ford, and that proximity to absolute proof at which I hinted in commencing this subject, has thus been nearly reached"[156]

Tyler also made his own estimates of the number of deaths from cholera arising in the areas supplied by London's water companies in the two months period between 1st

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153P.P. 1867-8, vol. 37, p. 102, *Narrative of Proceedings*

154Ibid., p. 97 *Narrative of Proceedings*; Orton was the medical officer

155Ibid. p.100, Greaves's evidence

156P.P. 1867, vol.58: *Report of Captain Tyler to the Board of Trade, in Regard to the East London Waterworks Company*, pages 6, 8 and 20.

July and 1st September. He estimated that 4,363 deaths had occurred in this period, of which 3,797 had occurred in areas supplied only by the East London company and a further 264 in an area which it shared with the New River company. Thus ninety-three per cent of deaths had occurred in areas supplied wholly or in part by the East London company.[157]

Analysis of the company's water supply by Frankland, in an attempt to find pollutants, was inconclusive[158] and Tyler himself admitted that no absolute proof could be given. Indeed he suggested that the pollution of the water supply might have arisen from other causes than the admission to the covered reservoirs of contaminated water but these facts, and a determined public relations campaign by the company, failed to persuade the Board of Trade to modify its judgement that the company had been guilty of a serious infringement of the provisions of the 1852 Act. In response to the company's protestations that Tyler's findings were not absolutely conclusive the secretary to the Board of Trade wrote:

> "My Lords are unable to perceive, either in captain Tyler's report, in your reply, or elsewhere, any sufficient grounds for the objections.... which you reserve the right of making".[159]

The Lancet took a particularly censorious view of the responsibility of the water company. Commenting upon the Board of Trade Report it wrote:

> "the companies, in whose hands that supply [of water] is a monopoly, secretly infringe the law, trusting to the difficulties by which discovery is virtually rendered next to impossible.....greatly to be regretted that a heavy penalty has not been levied for the infraction of the law".[160]

Even the *British Medical Journal,* which at this time normally supported the miasmatic theory of disease propagation, was highly critical of the company. It had carried out its own investigation and concluded that the company's covered reservoirs had been polluted by unprotected sources in 1864 and 1865 in addition to the cases recorded in connection with the 1866 fatalities. It commented that "It is true that supervision by the state lessens private responsibilty" but added "Who has been

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157P.P.1867, vol.58, pp. 14-15

158See Luckin, W.,: *Pollution and Control: A Social History of the Thames in the Nineteenth Century*, Adam Hilger, 1986, pp. 89 et seq. for an account

159P.P. 1867, vol. 58; *Correspondence Relating to the East London Waterworks Company,* p.13

160*The Lancet*, 2nd November 1867

brought to account for the terrible result of the day's work at East London?"[161] Farr, whose own enquiries had helped to expose the company's attempts to conceal the truth, concluded that this was the means by which the infection had spread to other houses in the area and his anger, partly at the deaths which resulted and partly at the company's attempted deception, is reflected in the *Report on the Cholera Epidemic in England* which he appended as a supplement to the Registrar-General's Twenty-Ninth Annual Report.

Farr tabulated the death-rates per thousand population in the three cholera outbreaks of 1849, 1854 and 1866 and drew attention to the fact that, in most of London's parishes, the 1866 epidemic had been by far the least deadly, the marked exceptions to this trend falling in seven East End parishes, all of which were supplied by the East London company while three also received supplies from the New River company (abbreviated to N.R. in the table which follows, predominant supplier listed first):[162]

		Deaths per thousand population in:		
Parish	Water supply company	1849	1854	1866
Shoreditch	N.R., East London	76	23	11
Bethnal Green	East London	90	23	63
Whitechapel	East London, N.R.	64	45	76
St George's in the East	East London	42	36	97
Stepney	East London, N.R..	62	48	116
Mile End	East London	31	28	64
Poplar	East London	71	42	89
London Average		62	46	18

Commenting on these figures, he wrote: "It happened, too, that several districts in the group so heavily visited by cholera lie in the particular region which then derived no advantage from the contemplated low level sewer" and he drew attention to the consequences of the increasing adoption of the water closet at that time:

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161 *British Medical Journal*, 27th April 1867. An account of the controversy in given in *Luckin* p. 92 et seq..

162 P.P. 1867-8, vol.37, p.61

> "Almost co-incidentally with the appearance of epidemic cholera, and with the striking increase of diarrhoea in England, was the introduction into general use of the water-closet system, which had the advantage of carrying night-soil out of the house, but the incidental and not necessary disadvantage of discharging it into the rivers from which the supply was drawn".[163]

He wrote of the debate on the roles of air and water in disease propagation and gave much more favourable consideration to Snow's theory than he had in the past:

> "As the air of London is not supplied like water to its inhabitants by companies the air has had the worst of it both before Parliamentary Committees and Royal Commissions. For air no scientific witnesses have been retained, no learned counsel has pleaded; so the atmosphere has been freely charged with the propagation and the illicit diffusion of plagues of all kinds; while Father Thames, deservedly reverenced through the ages, and the water gods of London, have been loudly proclaimed immaculate and innocent.If diseases spread, they did it not, it was the air...In vain did the sewers of London and of twenty towns pour their dark streams into the Thames and the Lea; their waters were assoiled [sic] from every stain by chemists who had carefully analysed specimens collected by the water companies...Dr Snow's theory turned the current in the direction of water, and tended to divert attention from the atmospheric doctrine, which in London has received little encouragement from experience....the theory of the East wind with cholera on its wings, assailing the East End of London, is not at all borne out by the experience of previous epidemics...It ignores all past experience...The population in London probably inhaled a few cholera corpuscles floating in the open air, and the quantity thus taken from the air would be insignificant in its effects in comparison with the quantities imbibed through the waters of the rivers or of ponds into which cholera dejections... had found their way and been mingled with sewage by the churning tides...An indifferent person would have breathed the air without any apprehension; but only a very robust scientific witness would have dared to drink a glass of the waters of the Lea at Old Ford after filtration"[164]

This acceptance that cholera was primarily water-borne was a significant shift from Farr's position in the earlier outbreak of 1854 when, along with his fellow members of the Committee for Scientific Enquiries, he had explicitly rejected Snow's hypothesis[165] By 1866, faced by the evidence of the East London company's practices, and no doubt offended by their attempt to conceal them, Farr had clearly accepted Snow's explanation though he continued to believe that atmosphere played

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163P.P. 1867-8, vol. 37, p.lvi: W.Farr: *Cholera Report*
164Ibid., pp.79-80
165See above, p. 205 et seq.

some part since, elsewhere in his 1866 report, he attributed the small number of cholera cases in other parts of the capital to the Northerly and Westerly winds of July and August which, he believed, had carried the cholera from East London to other districts. Moreover he claimed that washerwomen could catch cholera and deduced from this that "it is not improbable that cholrine (sic) is to some extent carried up from warm liquids by watery vapour".[166] He thought that this could also explain why some cases of cholera had occurred outside the area supplied by the East London company, and made some confusing references to two of Snow's studies, stating:

> "As water conveys cholera matter which multiplies and reproduces itself in the population, it often opens fresh fountains of disease, which extend their operations beyond the direct limits of the water supply, either through the medium of well water, or personal contamination, or linen or sewers vapours. The Broad Street outbreak is an illustration...another instance of indirect diffusion is afforded by the experiment with the Southwark and the Lambeth water in coterminous streets in 1854".[167]

The Lancet was in no doubt about the strength of Farr's case. Commenting on his report it referred to the attempts made by water companies to argue that cholera effusions would be so diluted in water as to render them harmless but added:

> "We apprehend that, to an unbiased mind, the elaborate array of facts which Dr Farr has set forth with so much skill, as the result of great labour and research, will render irresistible the conclusions at which he has arrived in regard to the influence of the water-supply in the causation of the epidemic".[168]

Simon, who had served with Farr on the Committee for Scientific Enquiry into the 1854 outbreak, continued to have his doubts about the theory that water was the principal medium by which cholera was spread and continued for the moment to adhere to the miasmatic doctrine as expounded by von Pettenkofer, who attributed the cause to contaminated, fermenting soil. In 1867, commenting on the 1866 outbreak in the *Ninth Report of the Medical Officer to the Privy Council* Simon wrote that:

> "under some conditions water may be able to infect a soil and mediately a population, with cholera, and yet not necessarily at the same time be an immediate cause of cholera to those who drink it....von Pettenkofer's doctrine may admit of more or less plausible application to explain the particularities of the outbreak".[169]

166P.P. 1867-8, vol. 37, p.xiv; W.Farr: *Cholera Report*
167Ibid., p.xxxix; W.Farr: *Cholera Report*
168*The Lancet*, 15th August 1868, 2, p.223

Indeed Simon was at this stage sufficiently committed to von Pettenkofer's doctrine of a contaminated, fermenting soil, that he speculated that the East End outbreak might have been caused, in part, by the main drainage works themselves. The disturbance to the area caused by these works could, Simon postulated, have produced a "zeitliche predisposition"[170][Simon's phrase] to cholera in the soil.

Luckin, in discussing the 1866 outbreak, concludes that Farr's acceptance of the theory that cholera was water-borne "smacked of scientific error and social irresponsibility" and that "it was only an elite within an elite, notably William Farr, Edward Frankland and Netten Radcliffe [an epidemiologist who wrote a special report on the 1866 outbreak, see below] that was willing to subscribe wholeheartedly to the view that the cholera had been spread by unsafe water, distributed by the East London Water Company. Other progressive thinkers, and, most significantly, John Simon, chose to assess the epidemic in terms that were still heavily influenced by classical miasmatic doctrine".[171] Yet by 1868 Simon himself conceded that "water might be...capable of spreading cholera but chemists would be unable to identify the particular contaminant which produced that effect."[172] Nevertheless the ambiguity which continued to characterise official attitudes towards the effects of the Thames upon the health of the Metropolis are shown in the comments of the Royal Commission on Water Supply in the same year:

> "We have found, not only that opinions are divided upon it [the quality of the Thames water] but that the elements which enter into its determination are of a very subtle character, and by no means admit of the satisfactory kind of treatment which we are in the habit of expecting from the modern advanced state of physical science."[173]

The Commissioners contented themselves with considering the various theories surrounding the spread of cholera and typhoid and commenting simply that things could only improve when sewage was altogether excluded from the Thames.[174]

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[169]P.P. 1867, vol. 37, Appendix 7f, p.368: Simon's comment on Radcliffe's Report
[170]Ibid.
[171]Luckin, W.,: "The Final Catastrophe - Cholera in London, 1866": *Medical History,* vol. 21, 1977, pp. 32-42
[172]P.P. 1868-9, vol. 33, Q.2754: Simon's evidence to the Royal Commission on London's Water Supply
[173]Ibid., p.lix
[174]Ibid., p.cii

In this case science was not so "modern" and "advanced" as the writers supposed. A further twelve years elapsed before Eberth isolated the typhoid bacillus and fifteen years before Koch identified the cholera bacillus. In the meantime Simon shifted the focus of his attention from the "miasma" towards the water supply, though his main concern was with the failure of the water company to protect or filter its water supplies rather than upon the urgent necessity of ensuring that infected sewage was intercepted before it could enter watercourses. Other commentators took the same line including Netten Radcliffe who, in an appendix to the report of the Medical Officer to the Privy Council in the year of the East London outbreak wrote that:

> "The predominant lesson derived from the outbreaks of 1848-9 and 1853-4 was, that the localities of chief prevalence of the disease were mainly, if not solely, determined by the degree of impurity of the water supply".[175]

By 1870 Simon's views on the effects of infected water were unambiguous and were reported to the Privy Council in the following terms:

> "Not only is it now certain that the faulty water supply of a town may be the essential cause of the most terrible epidemic outbreaks of cholera, typhoid fever, dysentery and other allied disorders; but even doubts are widely entertained whether these diseases, or some of them, can possibly obtain general prevalence in a town except where the faulty water supply develop them".[176]

In the pages that followed Simon not only warmly endorsed Snow's theory but also tried to explain his own scepticism twelve years earlier as a member of the Committee for Scientific Enquiry. Of Snow he wrote:

> "Dr Snow, in 1849, was not able to furnish proofs of his doctrine...but afterwards (and happily in great part before his premature and lamented death in 1858) distinct experiments, as well as much new collateral information, established as almost certain that his bold conjecture [i.e. that cholera was waterborne] had been substantially right".[177]

Writing of his role on the Committee for Scientific Enquiry he commented on the phenomenon of the Golden Square outbreak, cited by Snow in support of his theory,

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175P.P. 1867, vol. 37 p. 295: *Ninth Report of the Medical Officer to the Privy Council,* Appendix 7f, Radcliffe's report on the London Cholera outbreak

176P.P. 1870, vol. 38, p.21: *Twelfth Annual Report of the Medical Officer to the Privy Council*

177Ibid., p.22

and excused the erroneous judgement of the Committee by explaining that, on the orders of the Committee:

> "Very copious details of information were in consequence asked for; but unfortunately these could not be collected before the time when the committee had to make its final report".[178]

The implication is that, if the committee had been in possession of the details requested, its conclusions would have been different from those reached that reflected the orthodox miasmatic view that: "on the whole evidence it seems impossible to doubt that the influences, which determine in mass the geographical distribution of cholera in London, belong less to the water than to the air".[179]

In the pages that followed in his 1870 Report Simon proceeded to refer to the experiments of Professor Karl Thiersch of Erlangen which, in 1856, had demonstrated that cholera could operate as Snow had suggested and Simon estimated the number of lives that would have been saved in the 1848-9 and 1853-4 cholera outbreaks if steps had been taken earlier to protect the capital's water supply as required by the 1852 Metropolis Water Act. He also lamented that the Act specified a fine of only £200 for contravening it. By 1874 similar views had reached the Rivers Pollution Commission which, in its sixth report on the Domestic Water Supply of Great Britain, commented favourably on the supply of well water by the Kent Water Company, and adding that "The supply of such water...to the Metropolis generally would be a priceless boon, and would at once confer upon it absolute immunity from epidemics of cholera".[180]

In July 1868 Abbey Mills pumping station was commissioned (Crossness on the South side having been operating since April 1865) and from that date the sewage from both sides of the river was conveyed to the outfalls where it continued to provoke occasional complaints from neighbouring communities but without posing a threat to their health. After 1866 there were no further epidemics of cholera or typhoid in London. The link between the construction of the intercepting sewers and the disappearance of cholera and typhoid was made either directly or implicitly by many of those concerned with public health. Farr, Frankland, Simon and Radcliffe, as demonstrated above, all came to acknowledge, in different ways and with varying reservations, that epidemic disease, water and sewage were in some ways linked. Yet they continued to assign to the miasmatic atmosphere a role, sometimes the primary

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178P.P. 1870, vol. 38, p.23,
179See above, p. 130, for an account of the Committee's conclusions
180P.P. 1874, vol. 33, pp. 624-5

role, in the propagation of disease. Even Charles Creighton, an acknowledged expert on epidemic disease, writing in 1894, was not convinced by Snow's hypothesis that infected water accounted for cholera epidemics (see above, note 123). His scepticism had survived for ten years beyond the date of Koch's discovery that the cholera bacillus existed and that it was carried in water.

Another chemist, Henry Letheby[181], Medical Officer for the City, was so convinced of the purifying power of oxydisation that, in evidence to the Select Committee on East London Water Bills, he denied that the 1866 cholera outbreak had been caused by contaminated water. He defended this view at a meeting of the Society of Medical Officers of Health and was supported by Orton, the Stepney Medical Officer who had investigated the cholera outbreak. According to the record of the meeting:

> "Dr Letheby said he had heard nothing in proof of the statement that the prevalence of cholera in East London was due to the water supply, and concluded that there was so much mystery attaching to the subject of cholera that they were not justified in forming any conclusion as to its origin or propagation".[182]

Moreover in evidence to the Royal Commission of 1893-4 Percy Frankland (son of Edward) and E.R.Lankester both testified that cholera and typhoid germs would be destroyed by sewage.[183] Frankland also wrote a paper which testified to the effectiveness of the water companies' filtration systems in removing harmful pathogens.[184]

Bazalgette himself seems to have made the connection between his work and the 1866 cholera epidemic, as reflected in his apologetic correspondence with Farr (see above page 150 and note 150) concerning the delay in lifting the low level sewage and his attempts to alleviate the problem by building a temporary pumping station at Abbey Mills. Moreover in his address to the Institution of Civil Engineers on 14th March 1865 *On the Main Drainage of London and* the Interception of the Sewage from the River Thames the detached character of the language he used concerning the causes of cholera do not conceal his own confidence that his works had played a significant part in its elimination from the metropolis:

181P.P. 1867, vol. 9, Appendix 11, Q. 3898-3911

182*Public Health*: Jubilee issue 1906, p.49, refers to the 1866 discussion of cholera

183P.P. 1893-4, vol. 40, Q. 10641-5, 10842, 11131: evidence to *Royal Commission on Metropolitan Water Supply*

184"The Upper Thames as a source of water supply": *Journal of the Royal Society of Arts*, 32, (1883-4), pp. 428-53

> "although great differences of opinion existed, and continue to exist, as to the causes of the disease, yet an inspection of the houses in which deaths occurred was sufficient to show that, however occult might be the connection between death and defective drainage, the places formerly most favourable to the spread of disease became quite free from it, when afterwards properly drained".[185]

His employers, the Metropolitan Board of Works, were also in no doubt that the main drainage had made a significant contribution to the health of the Metropolis. In its *Annual Report* for 1868-9, by which time both Abbey Mills and Crossness were in full operation, the Board commented:

> "A reference to the tables given in the Registrar-General's reports, shows that the deaths in the Metropolis, especially in the low-lying districts, have been fewer, since the execution of the Main Drainage Works than in previous years, which may be considered a result of the improved sanitary conditions in consequence of those works".[186]

The Registrar-General's report referred to is that for the year 1867 in which Farr had commented that 1867 had been the healthiest year for London since 1860, judged by the death-rate.[187] Subsequent reports confirmed the trend towards a healthier Metropolis. The Report for 1872 revealed that, in that year, the annual death rate in London was 21.5 for every ten thousand population, the lowest figure since 1850 and a lower rate than that achieved by Paris, Vienna, Berlin, Brussels, Rome or any other major European, American or Indian City despite the fact that, with a population of 3.3 million, London was by far the largest city in the world, and urban concentration had hitherto been closely related to high death rates.[188] After 1875 (the year in which the Main Drainage was finally completed with the opening of the Western area drainage), the Registrar-General discontinued the practice of commenting separately upon London's death rate but an examination of the Report for 1891, two years after the Board ceased to exist, shows that by that year London's death rate stood at 21.1 per ten thousand compared with a figure for England as a whole of 20.2. In 1896 cholera had become so rare that it was classified as one of a number of "exotic

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185M.P.I.C.E.: vol. 24, 1864-5, p. 285

186M.B.W. *Annual Report*, 1869-9, p.11

187P.P. 1868-9, vol. 16, p. liii, *Thirtieth Annual Report of the Registrar-General,*

188P.P. 1875, vol. 18, pp. xlix and lii.; paradoxically John Thwaites, chairman of the M.B.W. died in August 1870 of "an attack of English cholera and diarrhoea of only a few days' duration"; *The Times*, 9th August 1870, p.5 col. 5

diseases".[189] Even so, the very proximity of the dreaded disease continued to cause anxiety. In 1892 there was a severe outbreak on the continent, especially in Hamburg, from which Port many vessels traded with London. The authorities were sufficiently concerned to commission a report on the subject which attributed the eventual suppression of the Hamburg epidemic to the energetic steps taken by the authorities to provide a clean water supply in that city. In England one hundred and thirty five deaths occurred from a "disease reputed to be of the nature of cholera".[190] The deaths were distributed across sixty-four towns with seventeen occurring in the Metropolis. Most of the deceased were passengers arriving in ports who had contracted the disease abroad.[191]

Bazalgette's professional contemporaries, notably Simon, may have continued to entertain some doubts concerning the aetiology of cholera, and the precise role played by the main drainage in its elimination but other contemporaries at least recognised his central role. In August 1890, less than a year before his death, Bazalgette was interviewed at his home in Wimbledon for *Cassell's Saturday Journal.* The writer of the profile began with the following paragraph:

> "If the malignant spirits whom we moderns call cholera, typhus and smallpox, were one day to set out in quest of the man who had been, within the past thirty or forty years, their deadliest foe in all London, they would probably make their way to St. Mary's Wimbledon".[192]

In this confusing way it was thus recorded that the main drainage had played a critical role in banishing from the Metropolis epidemics that had plagued it for over thirty years though the writer of the profile, in including smallpox and typhus (rather than typhoid) in his inventory of diseases vanquished by sanitation reflected the fact that, even in the last decade of the nineteenth century there was an imperfect understanding of how this had been achieved.

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189 P.P. 1896, vol. 37, *Supplement to 24th Report of the Local Government Board, 1894-5, page v*

190 P.P. 1894, vol. 40, pp. vii-ix

191 An account of the Hamburg epidemic may be found in Evans, R.J.: *Death in Hamburg: Society and Politics in the Cholera Years, 1830-1910*, Pelican, 1987

192 *Cassell's Saturday Journal*, 30th August 1890, pp. 1160-61: *Representative Men at Home: Sir Joseph Bazalgette, C.B., at Wimbledon*

Chapter Four: Sewage, Manure and Money

> "Not to know the particulars of the last movements on the sewage question is to be quite unfit for the drawing-room where scientific and social subjects are freely mingled in the elements of elegant conversation".(*City Press,* 19th November, 1864, from a leading article on the Hope-Napier scheme for the utilisation of Metropolitan sewage).

> "An essential part of the long Victorian debate on improved sanitation was the belief that sewage was a valuable commodity, the agricultural utilisation of which would generate substantial income to offset the costs of sanitary reforms. It took nearly half a century for it to ' be established that optimism on this count was misplaced". (N.Goddard: " 'A mine of wealth"? The Victorians and the agricultural value of sewage'*; Journal of Historical Geography*, **22**, 3, (1996) page 274)

It is hard to imagine that proposals for the utilisation of sewage as manure would regularly engage the attention of leader writers in popular newspapers or, indeed, trade publications yet such was the case in the late 1860s as politicians, sanitary reformers, engineers and entrepreneurs debated the merits of one scheme after another. An examination of the pages of the leading trade publication, *The Builder,* in the year 1868, reveals that scarcely a week passed without correspondence or editorial commentary on the subject. Daily and weekly newspapers like *The Times* and *City Press* regularly joined the debate. This chapter will consider the origins of this interest in the concept of sewage utilisation; the many attempts in London and elsewhere to introduce successful schemes; the difficulties which these schemes caused both for their promoters and for the Metropolitan Board as it constructed the intercepting sewers; and the progressive acceptance of the view that, instead of being exploited as a source of income, opportunities for the utilisation of sewage should be regarded as an aid to overcoming the problem of disposal.

Economics: early experiments

As observed in Chapter One, it had been the practice since the Middle Ages to convey the contents of cesspools to the fields which surrounded towns and to sell the sewage to farmers as fertiliser for their crops. From the early nineteenth century large quantities of sewage had been conveyed up the Grand Union Canal to Hertfordshire for this purpose and this traffic continued into the twentieth century. Nevertheless, as early as 1842 Edwin Chadwick had commented on the increasing difficulty of finding a market for the contents of London's cesspools as the Metropolis grew larger and the fields, in consequence, more remote (*Report,* p.118). The problem was compounded

by the fact that, from about 1820, other forms of fertiliser were becoming available which were more easily handled and cheaper. The development of agricultural chemistry by the German chemist Justus von Liebig and the consequent availability of mineral fertilisers like sulphate of ammonia, together with the importation of guano from South America from about 1847[1] made sewage relatively more expensive and less necessary. However not everyone was satisfied with this arrangement. It has been estimated that the price of guano increased from £10 to £12 a ton between the late 1840s and the early 1860s[2] and at the same time developments in agricultural chemistry had made it possible to compare the fertilising ingredients of sewage and guano and thereby to estimate the theoretical value of sewage.[3] In November 1859, as Bazalgette began the work of construction on the intercepting sewers, *The Times* published one of many letters on the subject from J.J.Mechi, a London Alderman who was a regular contributor to correspondence on the subject of sewage utilisation. Mechi, of Tiptree Hall, Kelvedon, in Essex, quoted Liebig (described as "The Sir Isaac Newton of Agricultural Science") in support of his argument that failure to utilise sewage would lead to the exhaustion of the land. He wrote of:

> "the gradual but sure exhaustion of the soil of Great Britain by our new sanitary arrangements, which permit the excrements (really the food) of fifteen million people, who inhabit our towns and cities, to flow wastefully into our rivers. The continuance of this suicidal practice must ultimately result in great calamities to our nation".[4]

According to Mechi, Liebig had estimated that Britain was importing half a million tons of guano annually.

Three years later *The Builder* reviewed Liebig's book *Agricultural Chemistry* and quoted extensively from its introduction which criticised the harmful effects of English sanitary practices:

> "The introduction of closets into most parts of England results in the loss annually of the materials capable of producing food for three and a half million people; the greater part of the enormous quantity of manure imported

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[1]Smith, F.B.,: *The People's Health, 1830-1910*, Croom Helm, 1979, p. 220

[2]For an account of the development of the guano market see W.M.Mathew: "Peru and the British Guano Market 1840-70"; *Economic History Review*, 2nd series; **23** (1970), pp. 112-28

[3]Way, J.T.: "Composition and Money Value of guano"; *Journal of the Royal Agricultural Society of England* **10**, (1850) pp. 313-79

[4]*The Times*: 7th November 1859, p.6

> into England being regularly conveyed to the sea by the rivers...like a vampire it hangs upon the breast of Europe, and even the world; sucking its life-blood without any necessity or permanent gain to itself".[5]

Many of those who advocated the use of sewage as manure did so on clear economic grounds, a view plainly expressed in *The Builder* in 1875 in a few words: "The round of nature is ever a perfect circle. Food makes the muck-heap and the muck-heap makes food"[6].This view was attractive to utilitarians like Chadwick and to others who believed that the money to be made from sewage utilisation would pay much of the cost of drainage systems. As early as 1848 William Shaw, editor of the *Mark Lane Express* and an early member of the Royal Agricultural Society of England, made a generous estimate of the value of sewage to the London Farmers' Club, claiming:

> "I believe that we are wholly in the dark as to the mine of wealth which may be worked in connection with sewage manure - wealth which is unjustifiably, day by day, suffered to run to waste, whilst we are expending large sums in the purchase of foreign manure to enable us to produce the food of the people".[7]

In 1853 a Parliamentary Committee had considered evidence in support of a private Bill, promoted by John Morewood, to set up the Great London Drainage Company (see Chapter One, page 56 above), which proposed to sell sewage at a profit to farmers. Morewood claimed to have spent twelve thousand pounds on experiments which established the profitability of the scheme proposed and he called in evidence a chemist called William Higgs who was questioned by the committee on a process he had patented in 1846[8] and which, by adding lime to sewage, could precipitate the solid matter to be sold as fertiliser. Higgs claimed that, by this means, he could recover between one hundred and one hundred and twenty-five thousand tons of dry manure a year from the metropolis to be sold at three pounds a ton, yielding a profit of £190,000 a year, to be shared with the ratepayers. In support of his claim he cited a scheme using his process operated by prisoners at Cardiff gaol which, the governor confirmed, produced three or four tons of manure a year for local farmers.[9] When pressed, Higgs acknowledged that the release on to the market of one hundred and

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[5]*The Builder*: 8th November, 1862, p.800. See also the article by Baron Liebig and Alderman J.J.Mechi: *The sewage of towns*; Farmer's Magazine 3rd Series **17**, (1860) pp. 163-5.

[6]*The Builder*: 4th December 1875, p.1073

[7]*Farmers' Magazine*, 2nd Series **17**, (1848) p. 219, report of monthly discussion

[8]P.P.1852, (session 2), vol.20, p.93

[9]P.P.1852-3, vol.26, Q.2022

twenty-five thousand tons might depress the price he had achieved by making three tons at Cardiff.[10] The importance with which the matter was viewed may be judged by the number of eminent witnesses who gave evidence. William Miller, professor of chemistry at Kings College London, told the committee that he had visited Cardiff, had seen the scheme in operation and believed that it would be applicable to London, though a civil engineer, Joseph Gibbs, who had worked on drainage projects in Haarlem, argued that the highly diluted state of the Metropolitan sewage (one part in eight hundred being solids) would greatly reduce its value.[11] Bazalgette, Robert Stephenson and William Haywood (City Engineer) appeared before the committee as did I.K.Brunel who gave his opinion that:

> "I think it may effect one of the objects that is proposed, that of taking for manufacturing purposes a large quantity of the sewage; I do not think it does that in a way which would effect any great change, beneficial or otherwise, to the district".[12]

The committee was not persuaded that a scheme which produced three to four tons of manure annually at Cardiff would be applicable to the Metropolis and the Bill was dropped[13] though Morewood did not abandon his scheme. In 1859 he attempted again to promote in Parliament *A Bill to authorise the Great Tunnel Sewer Company to construct a tunnel sewer parallel to each side of the River Thames to receive the contents of the Sewers of the Metropolis".*[14] During the 1850s numerous schemes were discussed, notably in the columns of *The Builder*, many of them based more on good intentions than on ascertainable facts. A correspondent naming himself simply as "Londoner" advocated in 1858 the construction of railways within the sewers which would collect, compress and convey the manure to its point of sale "while the expense of the necessary works would be partially, if not wholly, covered by the sale of the same".[15] Other commentators were more extravagant in their claims, notably Liebig's collaborator and disciple, Alderman Mechi:

> "If the money value of our sewers could be shown to the British farmer in bright and glittering heaps of sovereigns he would gasp at the enormous

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[10]P.P. 1852-3, vol. 26, Q. 1833-46 and Q.2339

[11]P.P. 1852-3, vol. 26, Q. 1646

[12]P.P.1852-3; vol.26; Q.3311

[13]The expression *Sewage Farm* dates from this time; it is still occasionally used though the term *Sewage Treatment Works* is now in more general use.

[14]P.P. 1859, Session 2, vol. 26 contains a copy of the proposed Bill and twenty pages of correspondence with the MBW on the subject.

[15]*The Builder*: 10th July 1858, p.470

wealth, and make great efforts to obtain the treasure.[16]

1857 and 1858 were particularly busy years for such correspondence, a phenomenon which was no doubt prompted by the establishment of a Royal Commission on 5th January 1857 "to Inquire into the Best Mode of Distributing the Sewage of Towns and Applying it to Beneficial and Profitable Uses".[17] The commissioners included Robert Rawlinson, John Simon, Henry Austin, Dr Southwood-Smith and I.K.Brunel though the last asked to be released owing to pressure of other work before he had completed the first week. Commissioners visited six towns where sewage was being applied direct to land (Rugby, Edinburgh, Mansfield, Watford, Rusholme and Milan) and three others (Leicester, Tottenham and Cheltenham) where it was being purified. They also visited seven farms which were using sewage. The Commission drew a distinction between sewage irrigation (flooding fields with sewage, as practised at Craigintinny,[18] near Edinburgh, and Milan) and the more elaborate and expensive "hose and jet" method whereby sewage was pumped through underground pipes and applied under pressure when required. This was the practice at Rugby, a town of 7,000 inhabitants, where 470 acres was treated by this method.[19] They concluded that, in certain limited circumstances, sewage could be profitably used for agricultural purposes provided that the quantities of sewage involved were relatively small and that suitable agricultural land was near at hand. In other, less favourable circumstances, efforts should be directed at purifying the sewage by a precipitation process, leaving the remaining liquid sufficiently clean to be discharged into a river. On the economics of sewage reclamation they wrote:

> "Unless some new process of greater efficiency should be discovered, the formation of a solid manure from sewage will not be remunerative, that is to say that the amount raised by the sale of the manure will fall short of the cost of its production".[20]

This sensible conclusion was followed by a bizarre proposal for dealing with the sewage of the Metropolis. They proposed the construction of a series of reservoirs

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[16]Mechi,J.J.: *The Sewage of Towns as it affects British Agriculture*; Farmer's Magazine, 3rd Series, **17**, (1860) pp. 254-5

[17]P.P. 1857-8, vol.32, p.3

[18]This project, also spelt Craigentinny, was reviewed by many of the Victorian Commissions into sewage utilisation as the most celebrated example of the technique; for a review of the many contemporary accounts see P.J.Smith: "The foul burns of Edinburgh": *Scottish Geographical Magazine*, **91**(1975) pp. 25-37

[19]P.P.1857-8, vol. 32, pp. 16-17

[20]Ibid., p.24

standing out in the Thames with basins behind them which could be used by barges and other craft. The reservoirs would collect the sewage, precipitate it, release the de-odorised liquid into the river and either convey the relatively small quantity of remaining sludge out to sea or use it as manure. The terraces which separated the reservoirs from the bank could, it was suggested, form the foundation for a railway. Despite the conclusions of the commissioners that there was no profit in sewage utilisation, in February 1862 a Parliamentary Select Committee was appointed upon the motion of John Brady, M.P. with more optimistic terms of reference: "to enquire into the best means of utilising the sewage of the cities and towns of England, with a view to the reduction of local taxation, and the benefit of agriculture".[21]

The Select Committee examined fourteen witnesses before issuing its first report and was impressed by the evidence of John Lawes and Professor John Way, a member of the Royal Commission and consulting chemist for the Royal Agricultural Society, who reported on an experiment conducted at Rugby during 1861. One acre of land had been irrigated with sewage at the rate of three thousand tons per annum; one acre with six thousand tons; one at nine thousand tons; and the remainder had been left untreated. Way had calculated the number of cattle that each acre would support and the gallons of milk yielded, as follows:[22]

unirrigated land	350.7 gallons of milk
3,000 tons of sewage	562.3 gallons of milk
6,000 tons of sewage	807.8 gallons of milk
9,000 tons of sewage	947.4 gallons of milk

Way testified that, as a result of the higher yields gained by the application of sewage, the annual value of the land had been increased by between thirty and forty pounds an acre. He also estimated that the annual cost of imported guano was £2,500,000 to £3,500,000 and he referred to Liebig in support of his view that supplies would be exhausted within fifty years.[23] The Select Committee also heard evidence from another chemist, Dr Augustus Hofmann, who calculated that the annual value of Metropolitan sewage was £1,385,540, one of many similarly optimistic assessments which were to be a feature of the debate over the next two decades.[24] J.J.Mechi informed the committee that his land in Tiptree had increased in value by £3 an acre

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[21]P.P. 1862, vol.14, First Report, p.iii
[22]Ibid., Appendix One
[23]Ibid., Mins 714-21
[24]Ibid., Min 646

as a result of being treated simply with the waste from his own farm.[25] Sir Joseph Paxton, M.P., gave evidence based on his experience as former agent of the Duke of Devonshire and testified that, to gain full advantage of the sewage, it was necessary to grow crops which could develop at low temperatures and hence benefit from the application of sewage for much of the year. He recommended rye grass and mustard and cress[26]. James Hope gave evidence on the Craigintinny Meadows at Edinburgh, which had long been irrigated with sewage, claiming that the process had increased the value of the land from five shillings to five pounds an acre[27] but the town clerk of Manchester, Joshua Heron, reported a very different experience since in that town:

> "All attempts to catch and utilise the sewage waters have been utterly unsuccessful. Great expense has been incurred, and no return obtained, the product having been found valueless; so much so, that for agricultural purposes it has not proved to be worth the expense even of the cartage".[28]

Heron echoed Liebig's comments on the effects of the introduction of the water-closet, with its generous use of water, and he argued that the problem could best be solved by replacing the troublesome device with ash pits.

The Select Committee reached a balanced conclusion similar to that of the Royal Commission four years earlier, that in certain favourable conditions town sewage could be profitably applied, though they added that this was more likely to be the case in systems where waste water was kept separate from sewage, since the addition of large quantities of water to sewage increased its bulk and reduced its fertilising properties. They also concluded that the manufacture of solid manure from town sewage was unlikely to be profitable: "The evidence on this point leads to the conclusion that a solid manure cannot be manufactured from town sewage with profitable results".[29] They also added that each municipality should deal with its own sewage according to its own circumstances, with no blueprint for all.

The deliberations of this Select Committee, like those of the preceding Royal Commission, were accompanied and followed by a considerable volume of correspondence on the merits of various schemes. One of the most closely examined was that of Croydon, in Surrey, where the local authorities claimed that profits could

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[25]P.P.1862, vol. 14, Min 984
[26]Ibid., Q.2428
[27]Ibid., Q.3314-15
[28]Ibid., *Second Report*, appendix, p.91
[29]Ibid., p.xv

be made from irrigating fields with sewage and selling their abundant produce. James Fenton, Croydon's chief engineer, informed the Select Committee that three hundred acres of land irrigated with sewage was being let for £5 an acre, having previously been worth only one guinea an acre[30] and he wrote to *The Builder* with an account of the scheme, which applied sewage at the rate of eighteen thousand tons an acre:

> "I will conclude by stating, confidently, that if the local Boards were to make the irrigation system a part of their drainage scheme in the first instance, they would make a great profit by it".[31]

In 1865 the Third Report of the Royal Commission, like its predecessors, drew the conclusion that sewage could be profitably applied where local conditions were favourable: notably where topography permitted irrigation by gravity rather than by pumping; and where the soil was of the right kind since light, sandy soils benefited more from irrigation than did heavy clay soils. After considering numerous sewage utilisation schemes, notably that of Rugby, in which two members of the Commission, Lawes and Way, were closely involved, the Commission declared:[32]

> "Where local circumstances are favourable, and undue expenditure is avoided, towns may derive profit, more or less considerable, from applying their sewage in agriculture. Under opposite circumstances, there may not be a balance of profit; but even in such cases a rate in aid, required to cover any loss, needs not be a large amount".

Yet despite the qualified judgements of careful enquiries extravagant claims long continued to be made about the value of such schemes. In 1870 *The Builder*, in a leading article, presented a "Digest of Facts relating to the Treatment and Utilisation of Sewage" quoting W.H.Corfield (1843-1903) professor of hygiene and public health at University College, London, and claiming of sewage irrigation that:[33]

> "by it the value of land is enormously increased - at least doubled in every instance...it reduces to a great extent, or entirely renders unnecessary, the usual amount of artificial manures of all kinds; by it the farmer is rendered almost entirely independent of the weather, so that he can be practically certain of his crops".

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[30]Ibid., Min. 2018
[31]*The Builder*: 12th September, 1863, p.653
[32]P.P. 1865, vol.27, p.4
[33]*The Builder*, 29th October 1870, pp. 857-8

Plans for the Metropolis

While the debate on the general economics of sewage utilisation schemes proceeded, a series of proposals was put to the authorities charged with managing the sewage of the Metropolis. As early as 1843, at a time when Henry VIII's Bill of Sewers was still in force, a man called Richard Rowed proposed the construction of cast-iron sewers on either bank of the Thames which would conduct sewage to Kent and Essex where it would be discharged into receptacles similar to gas holders. Filters and quicklime would be used to separate liquids from solids and the latter would be "formed into blocks of any shape or size best fitted for conveying to any part of the empire". Street refuse would be swept into the sewers every twenty-four hours and Rowed quoted George Stephenson in support of his contention that "the soil of England, if properly treated, will produce four times the amount of food that it yields under the present system". Like many later advocates of similar schemes he made generous claims for the financial viability of his scheme, assuring the readers that "it would form a legitimate source of revenue of upwards of one million sterling annually".[34]

In 1848 a more definite proposal took shape in the form of the Bill for the establishment of the Great London Drainage Company which was announced as "A Bill to afford means for effectually draining the Metropolis; to preserve the Thames from the impurities at present passing into it, by diverting them into subterraneous main channel sewers, and to collect all the produce of the sewers for application to agricultural purposes". Such was the value attributed to the sewage that the three consultants appointed by the Metropolitan Sewers Commissioners (Henry Austin, John Roe and John Phillips) advised against passing to a private company the rights to the sewage.[35] It was 1853 before an enquiry was set up into the prospects of the company and the Bill was dropped but in the meantime another enterprise, the Metropolitan Sewage Manure Company, had established itself in West London and in 1848 the Metropolitan Commission of Sewers imposed a fine of £500 upon the company for cutting into a sewer at Counter's Creek to divert the contents. The company explained that "the market gardeners in the neighbourhood of London were anxious to make a trial of the sewage waters". The fine was revoked.[36]

As the First Metropolitan Sewers Commission began its deliberations in 1848 one of the plans before it was that of Henry Austin, who proposed to build a "converging

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[34]*The Builder*: 21st October 1843, p.444
[35]*M.C.S. Reports 1848-9*; M.C.S. ref. 476, documents 7 and 12, G.L.R.O.
[36]*The Builder*: 7th October 1848, p.489

system of drainage" by which districts of two hundred to five hundred acres within the Metropolis would channel their sewage to "centre wells" whence it would be pumped to neighbouring fields. Austin claimed this would be done "at a cost fully thirty per cent below that of the most improved and economical arrangements under the present system" because "the cost of engine power, and all the suction and distributory pipes, together with the annual expense of working, would not be a charge upon the public, as it would be borne by the parties to whom the application of the refuse to agriculture would be entrusted". He advised against accepting the plans of the Great London Drainage Company on the grounds that the Commissioners should not yield up their control over such a valuable commodity as sewage and Phillips, one of the Commissioners' surveyors, although a rival and critic of Austin (see Chapter One, page 45) took a similarly optimistic view of the value of the metropolitan sewage, writing of it that "an incalculable source of revenue would accrue therefrom, probably sufficient to obviate or meet the present sewers' rates".[37]

Other, more bizarre schemes showed similar confidence in the commercial value of the sewage. In June, 1848, Thomas Plum of Camberwell proposed that:

> "tight cesspools be formed, at certain intervals under the public roadways ...the emptying process is to be accomplished by means of the airtight nightsoil cart recently invented...the pecuniary value of the contents for agricultural purposes, which, upon the most moderate estimation, would produce sufficient to repay the original cost in a short time."

A critic of this scheme observed that it would require three thousand horses and carts worked by four thousand five hundred men every twenty-four hours if it were to work successfully.[38]

To this point, the tone of most of the correspondence on the subject of sewage utilisation in the Metropolis had shown great confidence in its commercial value but the following year a darker note was sounded by W.Tower, of Weald Hall in Essex, who rescinded his earlier request for sewage to be provided for his estates. He referred to "the late ravages of cholera" in London and declared "I fear the importation of such wholesale floods of London sewage, charged with noxious gases"[39]

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[37]M.C.S. Records; B.L. 8776 h 29 p. 1 et seq..
[38]*The Builder*: 3rd June, 1848, p.273; and 24th June 1848, p.309
[39]*The Builder*: 6th October 1849, p.477

From this time the level of interest in sewage utilisation schemes subsided, as the Metropolitan Commissions concentrated on the engineering, organisational and financial problems that were described in Chapter One. However in December 1851 interest was re-kindled by the General Board of Health which published a one hundred and sixty-seven page document entitled "Minutes of Information on the Application of Sewer Water and other Town Manures to Agricultural Production" which was distributed to local Boards of Health. The document was inspired, and probably largely written, by Chadwick who remained a strong believer in the potential profitability of sewage utilisation schemes in the face of mounting contrary evidence. Hamlin argues that Chadwick's advocacy of sewage utilisation helped to bring about his dismissal from the General Board of Health in 1854 but in reality schemes for sewage utilisation continued to be promoted with strong official approval for many years after Chadwick's downfall even though Chadwick himself was increasingly marginalised as an influence in the matter. As late as 1870, after many schemes had foundered in the face of engineering and financial difficulties, Chadwick led a delegation to Breton's farm, Hornchurch, Essex, which had been purchased by the Romford Board of Health to dispose of its sewage and he declared that "this movement would lead to an enormous increase of the productive power of the soil".[40]In 1877, at a discussion at the Institution of Civil Engineers on the application of town sewage to agricultural use, Chadwick defended another of his projects, tubular pipe sewers, on the curious grounds that they delivered faeces to water courses more quickly than brick sewers which, he believed, would become clogged, giving the faeces time to become putrescent. He argued that fresh faeces would produce fat, healthy fish and be good for agriculture whereas de-composed faeces from brick sewers would be harmful. This view was not supported by his fellow discutants.[41] The General Board's 1851 document contained elaborate descriptions of supposedly successful schemes at Ayr, Glasgow, Edinburgh, Tavistock, Mansfield and Milan and concluded that:

> "the value of land is quadrupled, the produce is largely increased, and no other manure is equal to it. Land manured with it will support half as much more stock as highly cultivated land on which solid manure is used".[42]

This document did have the effect of stimulating further interest in the disposal of Metropolitan sewage, one of the earliest responses coming from "C.E." (a civil

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[40]*The Builder*: 20th August 1870, pp.662-3
[41]M.P.I.C.E. vol.32, 1871, pp. 401-4
[42]P.P.1852, vol.19: *Minutes of Information...* p.144

engineer) who advocated a system of tubular quays along the banks of the Thames with points at intervals from which the contents could be drawn off into "manufactories" in which the waste would be converted into solid manure.[43]

The numerous commissions which had considered the question of sewage utilisation had identified some examples of successful practice in places like Edinburgh, Cardiff, Rugby and Croydon though the small scale of the enterprises and the relative proximity of agricultural land had left doubts about the applicability of such practices to the Metropolis, most of whose population of over two millions was far removed from agricultural land. As the construction of the main drainage proceeded other examples were offered both of successful and unsuccessful applications. The small town of Hyde in Cheshire had tried to avoid the expense of installing drains when the Eureka manure company had offered to pay householders for waste which the company would collect from receptacles placed in homes and sell it profitably as manure. After trying to make this pay they announced that they could no longer afford to pay for the waste but would collect it without charge. After a further interval the company was obliged to levy a charge of two shillings a year and when this failed to make the project economic they handed over responsibility to the local authority. They couldn't make it viable either so, in 1867, they decided that they would have to install drains after all. This had occurred in an agricultural area.[44] Moreover this scheme had been commended in glowing terms by the local Board of Nuisance Inspectors to the Select Committee five years earlier[45]. Other schemes did meet with some success. The Earl of Warwick took the sewage of Leamington on to his land, two miles South of the town, paying £450 a year, though the local Board of Health bore the cost of constructing and operating the pipes and pumping equipment required.[46]

The Metropolitan Board of Works

Members of the MBW had, from its earliest days, shown awareness of the need to consider the question of sewage utilisation. In April 1856, the fourth month of the Board's existence, the following motion was proposed by one of the members, a solicitor called Charles Few:

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[43]*The Builder*: 3rd January 1852, p.13

[44]J.Baldwin Latham, C.E.: A *Lecture on the Sewage Difficulty*, Spon, 1867; see also F.C. Krepp: *The Sewage Question* (London, 1867), pp. 90-93

[45]P.P.1862: vol.14, Second Report, Appendix 1, p.91

[46]*The Builder*: 3rd April 1869, p.272

> "That it is expedient to invite persons to send in to this Board, Essays on the practicability of applying the sewage of London to agricultural purposes, and that a committee be appointed to consider and report the best course to be pursued in order to obtain such Essays...and especially as to the amount of premiums to be given to the authors of those adjudged most excellent".[47]

The Observer applauded Few's initiative and drew attention to the fact that imported guano was sold very profitably at £8 to £10 a ton. It referred to the Craigintinny scheme, which was on the visiting list of most commissions and was frequently cited as an example of the successful application of sewage to poor soil. The paper criticised Bazalgette's plan on the grounds that it "proposes to leave this question unprovided for, and to throw into the Thames that which ought almost to defray the original cost of his intended works".[48] After discussion the motion was withdrawn. At the same meeting, the Board discussed a proposal from a Lambeth civil engineer called William Morris who proposed to construct an intercepting sewer on each bank of the Thames from which he would draw off the contents and manufacture manure. A condition of Morris's offer was that he should replace Bazalgette as the Board's Chief Engineer. The Board declined. Over the next few months the Board considered a series of "memorials" from numerous parties who expressed interest in utilising the sewage of the Metropolis and on 22nd October 1856 John Leslie, a member not noted for his tolerance, proposed a motion that the Board "not embarrass itself with De-odorizing or Sewage Manure schemes", a motion voted down by 17 votes to 15.[49] Two days later another member, called Seeley, proposed that the Board place a notice in newspapers to "make known its willingness to co-operate with any plans" proposed by other parties provided that such parties entered into the arrangement with their own capital and at their own risk.[50]This motion was withdrawn two months later and no further steps were taken in 1857 or 1858 beyond referring a number of unsolicited proposals to the Main Drainage Committee. At this time the Board was, of course, pre-occupied with securing the acceptance of the main drainage scheme, and in particular the position of the outfalls, by Parliament.[51]

On 27th May 1859 the Board, which by now had a backlog of schemes submitted by hopeful entrepreneurs, returned to the subject, resolving "That Dr Hofmann and Dr Frankland be requested to undertake the duty of advising the Board as to the various

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[47]M.B.W., *Minutes of Proceedings,* 1856, p.108
[48]*The Observer*: 20th April 1856, p.6
[49]M.B.W. *Minutes of Proceedings*, 1856, p.548
[50]M.B.W. *Minutes of Proceedings*, 1856, p.561
[51]See above, Chapter 2, pp. 100 et seq..

schemes of de-odorisation, and the several systems of dealing with sewage matter, which have been submitted to the Board", voting a fee of up to £100 to be paid to each.[52] The 38 schemes submitted were evaluated by these two chemists, both Fellows of the Royal Society, in a report which was presented to the Board in August 1859 and printed in full in *The Builder.* The two authors wearily commented that "not the least arduous part of our labours consisted in the careful examination of the numerous, and in many cases ponderous, documents addressed to the Board on this subject."[53] The proposals included one for distributing sewage by rail, another which involved the use of electricity, "a process for the precipitation of sewage in reservoirs, of which no further description was obtained" and another which was described as "not chemical, and is communicable only by personal interview". The chemists concluded that the de-odorisation of sewage would best be effected by the addition of quantities of perchloride of iron before discharging it to the river.[54] In the summer of 1859 the Board spent £17,733 on chemicals for this purpose[55]. The chemists' report made no recommendations on sewage utilisation so, the following January, the Board resolved to advertise for "tenders from parties who may be willing to treat with the Board for taking the sewage of London" and six months later, on 6th July 1860, the four communications submitted were opened and read. A note of scepticism may be detected in the Board's account of the response which it had received to its advertisements, a response which did not appear to reflect the amount of attention the matter had received in Parliament and elsewhere:

> "It has been very generally supposed that a large class of persons are so persuaded of the vast value of the sewage of the Metropolis, that they only await an opportunity of putting their schemes into practical operation; this has not, however, been borne out by the experience of this Board. They advertised extensively, inviting tenders for the Metropolitan sewage; and in answer to these advertisements they received only four proposals".[56]

Two of the tenders, from the London Sewage Utilisation Company and from John James Moore, who described himself as a "Scientific and Practical Agriculturalist", briefly described the capital they proposed to invest and the time period for which the sewage ought to be conceded while one from a Mr Charles Kirkman simply stated that "he has devised a plan for dealing with the sewage, so as to effect its de-

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[52]M.B.W. *Minutes of Proceedings*, 1859, pp. 354-5
[53]*The Builder*: 17th September 1859, p.619
[54]M.B.W. *Annual Report,* 1859-60, p.11
[55]Ibid..
[56]Ibid., p.12

odorisation and utilisation to the fullest extent, of which he is prepared to submit a more definite statement, if an adequate remuneration be secured to him for his plan".[57]The Board, and its engineer, were required to devote their attention to many such proposals in the coming years. The tenders were referred to the Main Drainage Committee for consideration and in the following months two other proposals were made to the Board which were also considered by the committee[58]

In January, 1862, the Board considered the Committee's report on the schemes, including two schemes which had been received after the deadline for the tender. One of these was from a Mr Thomas Ellis, an Irish solicitor, who proposed to pump the sewage to the top of Hampstead Heath on the North Side (close to the beginning of the Northern High Level intercepting sewer) and Shooters Hill on the South, allowing it to flow thence on to half a million acres of farmland. The other was from the Hon. William Napier and Lt.-Colonel William Hope, V.C., the latter being described as General Manager of the International Financial Society, Director of the Lands Improvement Company and of reclamation and irrigation works in Spain and Majorca.[59] This scheme proposed to convey the Northern Sewage by a forty-four mile culvert to Rawreth in Essex and thence via two branches to Dengie Flats and Maplin Sands where it would be used to reclaim an area of about twenty thousand acres from the sea on either side of the estuary of the river Crouch. The report described the six schemes proposed: those of the London Sewage Utilisation company; John James Moore; George Shepherd; Charles Kirkman; Thomas Ellis; and the Hope-Napier scheme. The Committee explained the priorities which it had set itself in evaluating the various schemes:

> "Two very material points were to be secured; the first, the absolute necessity for guarding the Board against the consequences which would arise in the event of a nuisance being created by the application of the sewage; and the second, the desirability of adopting, if possible, a scheme which should hold out a prospect of some benefit, in a financial point of view, ultimately accruing to the ratepayers of the Metropolis. These objects are, in the opinion of your committee, more likely to be effectually attained by the scheme propounded by the Hon. William Napier and Mr Hope than by either (sic) of the others which have been submitted to your Hon. Board".[60]

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[57]M.B.W. *Minutes of Proceedings*, 1860, pp. 488-90

[58]For example see letter from Messrs Tamplin & Tayler on behalf of client: 16th November 1860, M.B.W. *Minutes of Proceedings,* 1860, p.806; and from Thomas Ellis, March 1861, M.B.W. *Minutes of Proceedings*, 1861, p.236

[59]P.P.1865, vol.8, p. 58, Q.1601-5

[60]M.B.W. *Minutes of Proceedings*, 1862, p.10

Bazalgette, in his report to the Main Drainage Committee, also observed that this was the only scheme which was furnished with plans which were adequate for presentation to Parliament for its approval.[61]

The paramount importance assigned to guarding the Board against the consequences of nuisance was no doubt influenced by the long controversies which the Board had endured over the positions of the outfalls from 1856 to 1858, during which it had become clear that any plans which, like Ellis's, actually proposed to bring the sewage back through the Metropolis was less likely to be acceptable than one which took it as far away as possible. In this context the Hope-Napier scheme must have looked very attractive. Indeed in evidence to the Select Committee on Metropolitan Sewage in 1864 John Thwaites defended the choice of the Hope-Napier scheme on these grounds, observing that, whereas Ellis's scheme could create a nuisance within the Metropolis, the Maplin Sands which were the chosen outlet for the Hope-Napier scheme were uninhabited.[62] The success of the scheme was dependent upon the grant to the promoters, by the Crown, of the reclaimed land and the committee also commented that there was some doubt about whether the Board could legally assign the Metropolitan Sewage in this way to a third party: "the question whether the Board are empowered, under the provisions of their Acts, to enter into an arrangement of the nature now under consideration, is not free from doubt".[63] Nevertheless Bazalgette had approved the engineering details of the scheme and it was observed that any doubts on the legal points would be resolved by the passage through Parliament of the Bill which would authorise the creation of the company. The Committee therefore recommended that the Hope-Napier scheme be accepted without delay so that the promoters could deposit the necessary Bill.

Despite this exhortation to make haste the Board, on 14th February 1862, resolved to postpone a decision on the matter out of deference to the decision of Parliament to establish a Select Committee "to enquire into the best means of utilising the sewage of the cities and towns of England, with a view to the reduction of local taxation, and the benefit of agriculture" (see above, page 167). Following the publication of the Select Committee's report the Board advertised again for tenders in February 1863[64] and repeated the exercise that it had almost completed two years earlier of receiving tenders, examining them and referring them to the Main Drainage Committee for a

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[61]M.B.W. document 967, 1st January 1862, pp. 441-44; G.L.R.O.
[62]P.P. 1864, vol.14, p.109
[63]M.B.W. *Minutes of Proceedings*, 1862, p.11
[64]M.B.W. *Minutes of Proceedings*, 1863, p.224

recommendation. On 7th August 1863 the committee reported on nine schemes - the six which it had considered nineteen months earlier together with three newly submitted tenders, from Dr Thudichum, M.R.C.P., Mr David Curwood and a tender submitted by a consortium headed by Viscount Torrington.[65] In the meantime the Board received numerous resolutions from vestries expressing opinions on the matter, many of them showing a strong conviction that the Metropolitan sewage was a valuable commodity which ought not to be assigned to other parties too generously.[66]

At this point a further delay intervened, again caused by Parliamentary action. The Board's solicitor informed the members that Lord Robert Montagu had proposed yet another Select Committee, this time specifically "to Enquire into any Plans for Dealing with the Sewage of the Metropolis and other Large Towns, with a View to its Utilisation for Agricultural Purposes".[67] Once again, in deference to the Select Committee, the Board postponed further consideration of the matter.[68]

On 9th May, 1864, this Select Committee subjected Thwaites and Bazalgette to searching examinations on their handling of the question of sewage utilisation. The Committee criticised the Board for including, in its invitations to tender for the utilisation of the sewage, a requirement that "All tenders must contain a full description of the works proposed, and must be accompanied by a plan and section showing the several details". They also questioned the necessity for the Board's insistence that "the tender must contain the names of two or more sureties, to be approved by the Board, who shall be jointly and severally bound in competent sum for the due performance of the contract", and for specifying that, in the event of the failure of a contractor, any partly-completed works would revert to the Board for it to dispose of as the Board saw fit. The Committee suggested to Thwaites that such clauses might discourage some parties who might otherwise have submitted tenders. In defence of these procedures Thwaites assured that "The Board were anxious to be secured against mere speculators"[69]. In defence of this position he drew attention to some of the stranger schemes which had been submitted, notably the one put forward by John Thudichum, M.R.C.P., who proposed the construction of a completely separate system for the collection of urine from London's buildings, to run in parallel with the intercepting sewers. Bazalgette had estimated that, if this scheme were

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[65]M.B.W. *Minutes of Proceedings*, 1863, p.781
[66]Ibid., pp. 449, 664, 781-4 and 1084-5
[67]P.P.1864, vol.14, p.iii
[68]M.B.W. *Minutes of Proceedings*, 1864, p.447
[69]P.P.1864, vol.14, p.347

adopted, it would cost six million pounds to install a separate collecting drain in each building of the Metropolis, a sum which exceeded the estimated total cost of the main drainage.[70] Another tender, from a consortium led by Viscount Torrington and Sir Charles Fox, had informed the Board that "in a document whose contents must become public, we cannot explain the precise nature of our intended operations".[71] In the circumstances the insertion of such clauses by the Board may be regarded as no more than prudent. Thwaites informed the Committee that the only scheme he had asked Bazalgette to evaluate fully was the Hope-Napier scheme since "I believe that was the only one presenting any thing like a complete scheme for the utilization of the sewage...the engineering details of the other schemes were so scanty".[72] Bazalgette, in his report to the Board, had judged that the Hope-Napier scheme was:

> "the only one yet suggested to the Board where, from its position, extent, and the nature of its soil, there would be a reasonable prospect of its receiving advantageously so large and constant a discharge of sewage, without creating a nuisance to the surrounding district".[73]

Thwaites further observed that the small-scale experiments which were often cited as evidence of the profits that could be made from sewage utilisation were of little value when attempting to devise a scheme for a drainage system which generated eighty-seven million gallons a day. The Select Committee was again impressed by the evidence of Professor Way who reiterated his fears that the soil, and the reserves of fertilising guano, were in danger of being exhausted and again quoted Liebig and other eminent chemists, this time in support of his contention that the annual value of the Metropolitan sewage amounted to an average of ten shillings and tenpence per person. Since income and property taxes averaged ten shillings, three and three quarter pence per person he concluded that, if applied nationally, "the sewage would be equal to the local taxation of England, Ireland and Scotland".[74] Way was not alone in making such calculations. Two chemists called Hofmann (referred to earlier in this chapter in connection with the value of London's sewage) and Witt, using data gathered from the bodyguard of the Grand Duke of Hesse estimated that each human being generated sewage to the annual value of eleven shillings and ninepence farthing[75] though J.J.Mechi, in evidence to the Select Committee on the Sewage of

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[70]P.P.1864, vol.14, p.179
[71]Ibid., pp. 299 and 315
[72]Ibid., Minutes of evidence, No.85
[73]Ibid., p.440
[74]Ibid., Q.4785-9.
[75]An estimate quoted in the *Journal of the Royal Agricultural Society of England*

Towns, had estimated the value as sixteen shillings per annum.[76] Indeed the chairman of the Select Committee, Dr Brady, referred to a suggestion that the annual value of sewage would pay half the interest on the national debt. Dr Thudichum, referred to above, pronounced that each chamber pot was "a penny savings bank"[77] Such reasoning must have been as attractive to Members of Parliament in 1864 as it would be in the 1990s since the Select Committee summarised its findings in terms which were far more optimistic than those of earlier enquiries:

> "Your Committee has come to the conclusion, that it is not only possible to utilise the sewage of towns, by conveying it, in a liquid state, through main [sewers] and pipes to the country, but that such an undertaking may be made to result in pecuniary benefit to the ratepayers of the towns whose sewage is thus utilised. That benefit may, in a few years, be greatly increased; for the amount of artificial manures is even at present insufficient, and the sources whence some of the most important are obtained will, in a few years, be exhausted...Your committee, having examined the chairman and engineer of the Metropolitan Board of Works, are of the opinion that more might have been done by that Board towards the profitable use of the sewage of London; and that the completion of the outfall sewerage of the Metropolis ought, at the earliest possible moment, to be followed by the adoption of a system which may convert that sewage from a nuisance into a permanent and increasing source of agricultural fertility."[78]

Goddard suggests that the reason for the widely differing estimates of the value of sewage which were made by the Royal Commission (see above page 166) and the 1864 Select Committee, despite the fact that each body had heard similar evidence, can be attributed to the fact that the authors of the Commission's report were professional men, including a medical officer and two engineers, who understood the problems of moving sewage and extracting its beneficial ingredients; whereas the later Select Committee was more strongly motivated by a desire to see a financial return from financial utilisation which would help to justify the necessary investment in sanitary improvements.[79]

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second series, **3**, (1867), PP. 474-5

[76]P.P.1862,vol.14, Select Committee on the Sewage of Towns,First report,Q.1129-57

[77]Thudichum, J.L.W.:" On an improved mode of collecting excrementitious matter, with a view to its application to the benefit of agriculture and the relief of local taxation"; *Journal of the Society of Arts*, **11**, (1862-3), p.441

[78]P.P. 1864, vol.14, p. v

[79]Goddard, N.,: " 'A Mine of Wealth"? The Victorians and the Agricultural Value of Sewage'; *Journal of Historical Geography*; **22**, 3 (1996) pp.278-9

The Hope-Napier Scheme

Following the deliberations of the Select Committee the Board, on 15th November 1864, voted to accept the Hope-Napier scheme,[80] despite a late and well-orchestrated protest by the City of London. On the same day that they resolved to accept Hope and Napier's tender the Board was informed that the Coal, Corn and Finance Committee of the Court of Common Council had concluded that the scheme was wasteful. This Committee had calculated that the Metropolis would generate 266,052,440 tons of sewage per annum; that this was the equivalent of 212,842 tons of Peruvian guano; and that it had an annual value of £2,899,972. The sewage irrigation method, they concluded, was wasteful compared with the "hose and jet" methods employed by Lord Essex on his land at Cassiobury Park, Watford and by Alderman Mechi at Tiptree. They called for "further and thorough investigation"[81] In support of this contention they produced a letter from Professor Liebig dated 4th October 1864 in which the eminent German agriculturist, writing from Munich, was dismissive of the Hope-Napier scheme:

> "It is in vain to think of transforming the Maplin Sands into a fertile soil... The project of Messrs Napier and Hope is one of the most curious...It appears to me like a soap bubble, glistening with bright colours, but inside hollow and empty. There is not the slightest doubt that every penny expended in that frivolous undertaking would be irretrievably lost. The carrying out of this scheme would not only be a squandering of an enormous amount of money, but before long would be looked on as a national calamity."[82]

Liebig claimed that Maplin had the wrong kind of soil to benefit from sewage irrigation and this encouraged the City men in their belief that the Metropolitan Board was making appropriate use of such a valuable commodity by allowing it to be applied merely to "redeeming twelve thousand acres of quicksand on the shores of the German Ocean".[83] In correspondence with the Lord Mayor, Liebig had hypothesised that the London sewage could be worth £4,081,430.[84] The committee of the Common Council accordingly insisted that:

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[80]M.B.W. *Minutes of Proceedings* 1864, p.1128
[81]Ibid.,pp. 1112-15
[82]M.B.W. *Minutes of Proceedings*, 1865, p.367
[83]*The Times*: 16th November 1864, p.8, col.5
[84]Baron Liebig: *Letters on the Subject of the Utilisation of the Metropolitan Sewage Addressed to the Lord Mayor of London* (London, 1865), p.13

> "The scheme of Messrs Hope and Napier, if it could be carried out, would be a glaring violation of the laws of agricultural science, from which the least possible increase to our home supplies of food would be obtained."[85]

The Times sided with the Board, writing that:

> "The Corporation, instead of rejoicing as it would have done three years ago, over the bargain which the Board had made for them, now cry out with extraordinary indignation on this wasteful anticipation of Metropolitan resources".[86]

The scheme required the introduction of its own Bill and this was the subject of a separate Select Committee on the "Metropolis Sewage and Essex Reclamation Bill" which reported in March 1865.[87] Thwaites was again examined and explained that, having examined similar but smaller schemes at Rugby, Edinburgh, Carlisle and Croydon, the Board had voted to accept the Hope-Napier scheme by twenty-six votes to nine, though the City had opposed it. In its decision the Board had been influenced by the fact that, for much of its forty-four mile length, the culvert conveying the sewage would run through agricultural land which would itself be suitable for irrigation and that, if these adjacent areas did not want the sewage, it could be discharged upon the barren and uninhabited Maplin Sands, well beyond the Metropolis itself. Frederick Wagstaffe, a farmer from South Ockendon and Thomas Watershaw, a farmer from Romford were produced to the committee to testify that they would be interested in taking the sewage as did Henry Petre though, when pressed, he declined to confirm that he would be prepared to pay twopence a ton for it. Professors of chemistry appeared before the committee to lend their support to the advocates of the scheme and on 27th March Lt.-Colonel William Hope, V.C., joint promoter, explained his proposals for letting the reclaimed Maplin Sands at a rent of £150,000 a year to London dairy farmers while earning £250,000 a year from selling the sewage to farmers like Wagstaffe whose fields were situated close to the culvert. The capital cost of the scheme was estimated as £2,100,000 and the cost of pumping as £10,000 to £13,000 a year. Hope estimated that total operating expenses would amount to £35,000 a year, giving profit before interest of £365,000, which would be shared with the ratepayers of the Metropolis[88]. Hope expected to be able to let the

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[85]*The Builder*: 18th February 1865, p.120
[86]*The Times*: 2nd March 1865, p.8, col.6
[87]P.P. 1865, vol.8, pp.1-78
[88]Ibid., vol.8, Minute 1681; P.P.1864, vol. 8, pp. 423-39 describes the scheme

reclaimed land to dairy farmers at a rent of up to £40 an acre.[89] To satisfy themselves that they were supporting the best scheme the committee also examined Thomas Ellis, proponent of the rival scheme to pump the sewage to the top of Hampstead Heath. Ellis's assurance that he had modified his scheme to spare Hampstead in favour of pumping the sewage to Brentwood instead, well outside the Metropolis,[90] failed to persuade the committee who concluded of the Hope-Napier scheme that: :

> "the scheme which has been submitted to them is a useful and profitable mode of applying the sewage in the Northern portion of the Metropolis, and they have no reason to suppose any more useful or profitable scheme could be devised".[91]

Despite the reservations of the City the scheme was greeted with lyrical enthusiasm by the *City Press* which pronounced that "There can be no doubt that the Maplin Sands can be made to smile with golden harvests by means of the fertilising slush that has so long been devoted to the poisoning of the Thames".[92] The Bill was passed on 19th June 1865[93], specifying that the main conduit should be completed within four years and the company was formed under the name of "The Metropolitan Sewage and Essex Reclamation Company". In the meantime the Board had drawn up Articles of Agreement with the company. These conceded the Northern sewage to the company for fifty years, provided for division of the profits between the Board and the company according to a formula which enabled the company to pay interest on its capital on a sliding scale and prudently included a requirement for a deposit of £25,000, to be repaid by the Board when the construction work was completed, five years being stipulated as the maximum time for this to be accomplished.[94] The work began towards the end of 1865, the company entering into a contract with Webster, a very experienced builder who executed many contracts for the Main Drainage itself. At this time the Board itself seems to have been reasonably confident about the prospects of the scheme since in its Report for the year ending 25th March 1866 it wrote that it had rented ten acres of land at Barking to Hope and Napier who had covered it with Maplin sand, irrigated the sand with sewage and succeeded in growing rye grass. The Board added that "There appears to be no reason whatever to doubt the

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[89]P.P. 1864, vol.14, p.641
[90]P.P.1865, vol.8, Minute 1854
[91]Ibid., p.iv
[92]*City Press*, 19th November 1864
[93]P.P. 1884, vol. 41 p. xxxi
[94]M.B.W., *Minutes of Proceedings*, 1865, p.263, and *Annual Report*, 1864-5, pp. 115 and 119, Articles 1, 4 and 24

ultimate success of the larger undertaking to be carried out by the company on the Maplin Sands". In 1866 the company purchased a tract of land at Lodge farm, at Barking in Essex which was used as an experimental sewage farm, the experiments yielding satisfactory crops of strawberries, celery and wheat.[95] A further experiment was carried out at Breton's farm, Romford.[96] However construction work soon ended, difficulty being experienced in raising the necessary capital at a time which coincided with the financial crisis precipitated by the Overend Gurney collapse[97] whose default, in the words of L.H.Jenks, meant that "the whole brood of finance and contracting companies were swept into the court of Chancery".[98]. Hope made a final attempt to raise the capital by public subscription by drawing attention to the possible consequences of failure but this was unsuccessful[99]. In its Report for 1867-8 the Board reported that "the construction of these works has been in abeyance for some time",[100] a comment which provoked a protesting letter to the Board from William Hope, complaining that the Board's scepticism had influenced:

> "that large section of the shareholders in the Metropolis Sewage Company, who, for reasons that I cannot explain, have determined that they will not proceed with the work".[101]

This was not quite the end of the affair. In 1866 the company secured an amending Act which extended the permitted completion date to 1876 and in 1871, no further progress having been made, the company proposed a further Bill which would have re-directed the sewage from Maplin to Canvey Island via Upminster and Pitsea and required the Metropolitan Board to underwrite interest and dividends on one million pounds of capital which it proposed to raise since, in the words of the applicants:

> "in the absence of sufficient practical evidence of the agricultural value of the sewage...it would be hopeless to attempt to carry out at present any project for dealing with so vast a quantity as two hundred and seventy-five

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[95]M.B.W. *Annual Reports*, 1865-6, p.22; and 1866-7, p.20

[96]For a contemporary account of the schemes see: *Farmer's Magazine*, third series, **33**, (1868) pp. 438-40; and J.C.Morton *Experience with 300,000 tons of London Sewage at the Lodge Farm Barking* (London 1868)

[97]Kynaston, D.,: *The City of London, 1815-90*, Chatto & Windus, 1994, pp. 235-9

[98]Jenks, L.H.,: *The Migration of British Capital to 1875*, Nelson facsimile reprint (1971) of 1927 publication by Knopf, New York

[99]Hope, W.,: *River Pollution Versus Food Manufacture* (London 1875) p.29; Hope also made the point that local boards could raise loans for sewage works but were forbidden to do so for associated farming operations; see pp.46-7

[100]M.B.W. *Annual Report*, 1867-8, p.13

[101]I.C.E. Archives: Octavo Tract Vol. 478, No. 20

thousand tons a day without direct financial assistance from the Board".[102] Unsurprisingly the Board opposed this move, countering with a Bill of its own to set aside its agreement with the company. Both Bills were rejected by the Select Committee that examined them.[103] After 1871 there is no further reference to the Hope-Napier scheme in the Board's reports and the plan was dropped, though as late as 1882, in a letter to the Home Secretary William Hope was still advocating the revival of the scheme devised by himself and his "late relative" the Hon. William Napier. He continued to insist that it "provided for diverting the Northern and most offensive as well as vuluminous [sic] portion of the sewage for ever from the Thames without expense, and even with profit to the ratepayers".[104] The Board retained the £25,000 bond.[105] In the Board's own words "This, it may be mentioned, is the only money the ratepayers of London have ever received in respect of their sewage, which was once considered to be of so much pecuniary value".[106] But the failed scheme was not the last one that the Board had to consider. In April 1865 it invited tenders for utilisation of the Southern Sewage and received five tenders, three of which bore familiar names: Thomas Ellis, Charles Kirkman and George Shepherd. The Board, in its Report, characterised the proposals as "suggestions unaccompanied by plans", none of them being sufficiently detailed to permit a full evaluation to be undertaken.[107] The Board entered into negotiations with Thomas Ellis who proposed to use the sewage to irrigate 196,000 acres in Kent, their precise whereabouts being unspecified beyond the fact that they were in the vicinity on Higham Creek, near Gravesend. Within a few months, on 27th July 1866, Ellis reported to the Board that he had been unable to raise funds to support his scheme owing to the financial crisis, (the Overend Gurney crisis)[108] and in December Bazalgette reported that he had met Ellis's engineer, Hopkins, who confessed that the estimates for the scheme were nowhere near ready for presentation to Parliament. Nothing more was heard of the scheme beyond brief references in the Board's Minutes and in its 1868-9 Report to the effect that no progress had been made.[109]

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[102]P.P.1884, vol.41, p.xxxi; M.B.W. *Annual Report*, 1870-1, p.36; and *The Builder*, 28th January 1871, p.63

[103]M.B.W. *Annual Report*, 1871, p.17

[104]P.P. 1884, vol. 41, p.690

[105]P.P.1864, vol.14, p.429, clause 12, and M.B.W. *Annual Report,* 1870-1, p.36

[106]M.B.W. *Annual Report*, 1888, p.21,

[107]M.B.W. *Annual Report,* 1865-6, p.23

[108]Ibid., p.27

[109]M.B.W. *Minutes of Proceedings*, 1865, pp. 515, 819, 1249-52 and 1409

On 23rd December 1869 the Board received a communication from the Native Guano Company [110]seeking a concession of the Southern Sewage for conversion to manure by its "ABC process" which involved the involved the addition of alum, blood and clay and certain other chemicals. At the invitation of the company the Board visited its works at Leamington where it saw the process operating on a small scale and, despite the inconclusive nature of its observations, the Board resolved in January 1871 that:

> "the Native Guano Company be permitted to erect, at their own expense, and for a period not exceeding twelve months, works at Crossness for the purpose of treating by their ABC process about a half a million gallons of sewage daily".[111]

In January 1873 the company's activities were checked by Bazalgette and the Board's chemist, Keates, who reported on the experiment. concluding that:

> "The quantity of manure resulting from the operations was about 142 tons....and the total expenditure was £895 3s 3d, which made the cost of manufacture £6 6s 4d per ton...On the other hand, with the exception of a few shillings, the company's books showed no returns in the shape of sales of manure".[112]

The most generous estimate that Keates could place on the value was one pound a ton. Moreover an analysis by Augustus Voelcker of the "native guano" thereby produced concluded that the product was almost worthless for agricultural purposes.[113] The scheme was pronounced a failure and the Native Guano company's works at Crossness was removed. In 1880 some promoters secured a private Act, the Dagenham and District Farmers Sewage Utilisation Act, to sell sewage pumped through conduits to Essex farmers. The Act provided for profits to be equally divided between the Board and the company once 5% had been paid on the company capital but the scepticism which now informed the Board's view of the matter is reflected in its comments that "Previous experience did not lead the Board to anticipate any

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110M.B.W. *Minutes of Proceedings,* 1869, p.1320

111M.B.W. *Minutes of Proceedings,* 1871, pp.135-6

112M.B.W. *Annual Report,* 1873, pp.18-19,

113Voelcker, A.,: "On the composition and practical value of several samples of native guano prepared by the ABC sewage process of the native guano company", *Journal of the Royal Agricultural Society of England*, second series, **6**, (1870), pp. 415-25

favourable results from the scheme, and, as a matter of fact, after the promoters had obtained their statutory powers, the Board heard nothing more of it."[114]

Sewage Utilisation in Retreat

By the early 1870s a more critical attitude towards the search for financial and other rewards from sewage utilisation was evident, not least at Croydon where, as previously mentioned, the practice of sewage irrigation was long-established. Alfred Smee, FRS, a scientific and medical writer, had a garden close to the Beddington Meadows where Croydon's sewage irrigation project was operating and, influenced by the offensive smell which he experienced, he began to campaign against the practice.[115] He was not unopposed, the chairman of the Beddington sewage farm, Alfred Carpenter, himself a doctor, arguing that sewage irrigation produced healthy ozone which, by some undefined process, counteracted sewage miasmas.[116] William Hope, still struggling to construct the Hope-Napier scheme, went further and proposed that sewage farms had restorative properties so that:

> "London beauties might come out to recruit their wasted energies at the close of the season, and, attired in a *costume de circonstance*, with coquettish jack-boots, would perhaps at times listen to a lecture on agriculture from the farmer himself, while drinking his cream and luxuriating in the health-restoring breeze".[117]

Despite Hope's enthusiasm, more prosaic assessments were beginning to prevail.On 16th May 1871 a paper was read at the Institution of Civil Engineers "On the treatment of Town Sewage" in which the author, Arthur Jacob, dismissed earlier fears that sewage would spread disease but emphasised that successful sewage irrigation depended upon the proximity of land of suitable size and composition. He quoted Dr Voelcker's estimate that the value of manure produced from sewage by the ABC process, as at Crossness, was nineteen shillings a ton, very close to the earlier estimate of Bazalgette and Keates and he emphasised that it was much easier to

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[114]M.B.W. *Annual Report,* 1888, p.23

[115]Smee, A.,: *Proposed heads of legislation for the regulation of sewage irrigation grounds*; Journal of the Society of Arts, **24**, (1875-6), pp. 39-40

[116]Carpenter, A.,: *Preventive Medicine in Relation to the Public Health* (London 1877) pp. 272-3

[117]Hope, W.,: *The use and abuse of town sewage*; Journal of the Society of Arts, **18**, (1869-70), p.302

render sewage innocuous by spreading it in large quantities on a small area of soil than it was to make it profitable by fertilising large areas. He drew attention to the successful application of sewage to 121 acres of land at Romford, a town of seven thousand people on the experimental farm managed by Lt.-Colonel William Hope and to other successful small-scale projects. Hope claimed that his enterprise was profitable.[118] In the discussion which followed Jacob's paper Voelcker himself expressed scepticism that profits could be made from sewage:

> "As long as men regarded the sewage as a mine of wealth he was inclined to think they would be far from the solution of the very difficult question how to dispose of it in the most profitable, or rather the least expensive way".[119]

Rawlinson, who was about to take up his appointment as chief engineer to the newly created Local Government Board gave a similarly balanced judgement, arguing that, despite some failures, it was worth persisting with sewage utilisation schemes.[120]

Six years later the Institution heard a more comprehensive paper on the subject, read by Norman Bazalgette, son of the Chief Engineer, based on a study of eleven towns, in which he concluded:

> "that where land can be reasonably acquired, irrigation is the best and most satisfactory known system for the disposal of sewage. That no profit must be expected from the cultivation of crops by the sanitary authority and only a moderate one by the farmer".[121]

He also argued that towns on coasts or tidal rivers would find that disposal to the coastal waters would offer the most economic and efficient solution. Discussion of the paper extended over five evenings and in its summary of the discussions *The Builder* commented:

> "There is a very strong, and we believe a spreading conviction, that the advance of the sanitary question has been more hampered and throttled by the idea that sewage is to be utilised than by anything else. The idea is certainly becoming more general that what is wanted is not utilisation but destruction".[122]

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[118]M.P.I.C.E.; vol. 32, 1871, pp. 381-6, and p.407
[119]Ibid., p.399
[120]Ibid., pp. 411-14
[121]M.P.I.C.E. vol. 48, 1877, p.158
[122]*The Builder*: 19th May 1877, p.493

During the 1870s many of the schemes which had earlier been cited as examples of the successful utilisation of sewage at a profit were themselves found wanting. In May 1873 the directors of the Croydon Irrigation and Farming Company, whose scheme had been frequently offered as a model for the Metropolis, proposed winding up the company when they failed to secure a reduction from £3,600 to £1,400 per annum in the rent they were paying to the Croydon Board of Health for the use of land.[123] In 1876 the local Board of Health at Crewe reported a loss of "not less than four thousand pounds" on their scheme[124].In 1872, one of the first acts of the newly established Local Government Board had been to denounce sewage irrigation schemes as uneconomic and to turn down a plan submitted to them by the West Ham local board on these grounds, paying particular heed to its chief engineer Robert Rawlinson, (who had installed sewers in the area twelve years previously) and whose report contained "a distinct denial of the commercial success of irrigation, which should only be adopted under the pressure of absolute necessity" .[125] Three years later, in June 1875, the Local Government Board directed Rawlinson to investigate the matter. A committee of the Board, including Rawlinson, visited thirty-eight British towns as well as Leyden, Amsterdam, Berlin, Brussels and Paris and its report, published in 1876, concluded that:

> "so far as our examinations extend, none of the manufactured manures made by manipulating town refuse, with or without chemicals, pay the contingent costs of such treatment....town sewage can best and most cheaply be disposed of and purified by the process of land irrigation for agricultural purposes, where local conditions are favourable to its application; but that the chemical value of sewage is greatly reduced to the farmer by the fact that it must be disposed of day by day throughout the entire year, and that its volume is generally greatest when it is of the least service to the land" [126]

The Metropolitan, commenting favourably upon the practical view taken by Rawlinson's report, reminded its readers that "since the year 1856 there have been no fewer than 417 patents obtained for dealing more or less with sewage and manures" and that the protagonists of the schemes had believed that:

> "all there was to do was to extract [the chemicals], pack them up, and offer them for sale, when a grateful host of farmers would rush to give well-filled bags of gold for the wonderful stuff".[127]

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[123]*The Builder*: 31st May, 1873, p.434
[124]Ibid., 25th November 1876, p.1155
[125]Ibid., 15th June 1872, p.469
[126]P.P.1876, vol.38, p.xii, Conclusions 6 and 7

The idea gradually became established that plans for making a profit out of sewage manure were secondary to that of safe disposal. By 1878 Voelcker had concluded that exceptionally favourable circumstances were required for sewage to be turned to favourable account[128]

The debate continued intermittently over the next few years and was revived when the Royal Commission on Metropolitan Sewage Discharge was asked to investigate the system by which sewage was discharged into the Thames and to propose possible remedies for any harmful consequences which might arise from the practice.[129] The conclusions of the Royal Commission were sceptical about the possibility of earning significant profits from sewage utilisation. In 1885 J.Bailey Denton published a book called *Sewage Disposal: Ten Years Experience*[130] which reviewed the various methods available of treating and disposing of sewage and described four successful small-scale schemes still in operation. Nevertheless the reviewer of the book referred to a lecture at the Society of Arts on the subject by Captain Douglas Galton in which the principal contributors to the debate had "tended rather to the view that the best and cheapest plan was to carry the sewage of the metropolis to the sea and bury it out of sight altogether".

Two years later Bazalgette, who had more experience than most of evaluating schemes of widely varying merits, commented on the wisdom of incorporating sewage utilisation provisions in a drainage scheme to cover the Beckenham area of Kent. He wrote:

> "The purification of the sewage of towns by chemical or mechanical agents has been fairly tested during the last quarter of a century in this country and, as a practical means of dealing with the sewage it has, in every case I am aware of, failed. The disposal of sewage by irrigating lands has, to a considerable extent, been successful; but it is not a system which can be applied, without objection, to a suburb of London, thickly studded with the ornamental residences of those who are daily engaged in business in

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127*The Metropolitan*, 24th February 1877, pp. 120-1

128Voelcker, A.,: "Influence of chemical discoveries on the progress of English agriculture"; *Journal of the Royal Society of Agriculture of England*, second series, **14**, (1878) p. 830

129P.P. 1884, vol. 41, p.ix

130Published by Spon in 1895; see also I.C.E. Archives Octavo Tracts Vol. 307; numerous papers on the subject by denton and others

the metropolis".[131]

The subject continued to be discussed until well into the 1890s. On 18th December 1889 Rawlinson delivered a paper on the subject at the Royal Society of Arts in which he argued that chemical treatment of sewage was not always appropriate. This was in reference to the precipitation works which were being constructed at the outfalls at Barking and Crossness. Rawlinson, in his paper, continued to advocate the reclamation of Maplin Sands, an enterprise which had been effectively abandoned almost twenty years earlier. An agriculturalist called Clare Sewell Read wrote to *The Builder* to express a view which, while not universally accepted in theory, was beginning to prevail in practice:

> "The idea that was prevalent many years ago that sewage was a mine of wealth had been the cause of a great deal of injury to those who entertained it and foisted it on other people. If they had gone on the broad principle that sewage was a nuisance that must be got rid of at any price, the sewage question would have settled itself long ago".[132]

The following year Read himself gave a paper on the subject to the Society of Arts in which he affirmed that sewage should be regarded as "simply a nuisance to be got rid of rather than being in itself a mine of wealth".[133] The Board had earlier expressed the same sentiments in its final report, writing that:

> "The idea of making substantial profits out of town sewage is now generally regarded as an illusion, and the unsuccessful endeavours of the Board to turn the London sewage to profitable account have doubtless done much to dispel the illusion."[134]

Post-script

Despite the final verdict of the Board on the prospects of making a profit from the utilisation of sewage, others have not been deterred from similar enterprises, albeit on a more modest scale than Hope and Napier. In the 1950s a writer called J.C. Wylie calculated that 200,000 tons of nitrogen was lost annually in the process of sewage disposal, an amount that approximated to the quantity purchased in the form of

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131 *The Builder*: 10th April 1875, p.331

132 *The Builder*, 1st February 1890, pp.78-9

133 Read, C.S.,:"The disposal of sewage by small towns and villages"; *Journal of the Royal Society of Arts*, third series, **1**, (1891) p.86

134 M.B.W. *Annual Report*, 1888, p.19

chemical fertilizers[135] and at about the same time a processing plant was built at Bazalgette's outfall works at Beckton where a proportion of the solid matter was dried, bagged and sold direct to the public as "Dagfert" ("Dagenham fertiliser") to be used as garden manure. The experiment was discontinued in the 1970s in the face of competition from chemical fertilisers which, like the South American guano of the 1860s, could be produced more economically than could treated sewage.

Advances in techniques for processing sewage, together with more favourable public attitudes towards "green" or re-cycled products encouraged Thames Water, the ultimate successors to the Metropolitan Board of Works, to undertake further experiments in the 1980s. In 1987 Thames Water established a pilot plant, as a Research and Development project, at its Little Marlow sewage treatment plant in Buckinghamshire which processes the sewage for a population of about ninety thousand in the vicinity of High Wycombe. The use of the waste is governed by a Department of the Environment Code of Practice which reflects the fact that, as processing techniques have advanced, so have the problems which they have to overcome, not least because of the increasingly complex industrial chemicals which can find their way into sewage treatment works.[136] In 1992, the plant was transferred from Research and Development to the status of a manufacturing processing operation under the name *Terra Eco Systems.* The waste is held in conventional settlement tanks after which the liquid is run off for further treatment before being returned to watercourses while the sewage sludge is offered for sale in four forms. The most basic product is *Terra Organic Fertiliser* which is sold to farmers (some of them in the locality of the treatment works but many in East Anglia) by the tanker load as a general fertiliser to be spread on fields. Further processing, including the addition of lime, produces *Terra Lime Plus*, a bulk solid which is used to balance lime-deficient soils and *Terra Soil Builder* which is used for landfilling and for landscaping. The highest added-value product is *Terra Multi-Purpose Compost* which is produced by mixing sewage sludge with straw and leaving it to break down before being sold under that name through garden centres. In the summer of 1996 this was incorporated into a Grow-Bag for sale through the same channels. *Terra Eco Systems* does not publish accounts separate from those of Thames Water but Dr Tim Evans, who has supervised the project, explained that the process is seen as an alternative to other methods of disposing of waste in appropriate topographical areas. The enterprise is being extended to other areas where the additional cost of processing

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[135]Wylie, J.C.,: *Fertility from Town Waste* (Edinburgh 1955) p.25

[136]D. of E. *Code of Practice for the Agricultural Use of Sewage Sludge*, 1989

and marketing the waste is more than compensated by the sale value.[137] These schemes are thus perceived as a useful financial contribution to the continuing problem of disposing of sewage in a way which is ecologically acceptable, rather than as a money-making device per se, as conceived by the Victorians like Hope and Napier.

As the Victorian promoters discovered, one of the greatest difficulties associated with making money from sewage utilisation arises from the fact that a comparatively small proportion of nutritional material is conveyed in huge volumes of water. This makes it difficult to move to the point of consumption and also requires expensive processing to extract the small volume of saleable matter. However, in areas where water itself is a scarce commodity this characteristic is being exploited as a water conservation measure and this particularly applies in Australia, the world's driest inhabited continent. Within the Australian Capital Territory, Canberra, research is being undertaken into means of re-cycling "grey water", the waste from baths and domestic appliances, with a view to using it for toilet flushing and irrigation and thereby conserving fresh water for drinking and food preparation.[138] Small-scale treatment technology is being developed which can be installed to re-cycle the waste water for small neighbourhoods. Research is also being undertaken into the use of "composting toilets" for urban use, a device which would enable individual households to re-cycle their own waste products for use in their own gardens and which would, in effect, mark a sophisticated reversion to the mediaeval practice of using human waste to fertilize neighbouring fields.[139] The concept of "water mining" is also being explored whereby effluent is extracted from sewers and separated into liquid and "sludge". The water is diverted to irrigation, thereby conserving fresh supplies, while the small volume of sludge is returned to the sewer, freed of most of its liquid content, and conveyed to the treatment works. An experiment of this kind has been conducted at Townsville, Queensland.[140]

Each of the Victorian schemes had to be considered, researched and reported upon by Bazalgette and his team at a time when they were heavily engaged in designing and

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137 *The Management of water and wastewater solids for the 21st century: a global perspective*; Dr T. Evans; World Economic Forum, Washington DC, June 1994; and interview with Dr Evans, at Little Marlow, 25th September 1996

138 *ACT Future Water Supply Strategy*, 1994, pp.15-16

139 Ibid., p.11

140 *Environmental Factors for Domestic On-Site Waste Water Recycling within Urban Canberra, Preliminary Assessment Report,* August 1994

constructing the main drainage. Some of them may now appear to have been a foolish distraction and they must often have seemed so at the time to those whose working hours were spent evaluating them. Yet the numerous attempts to devise successful schemes and the extravagant claims that were made for them are evidence of the attractions they held for people like Chadwick, Way and Liebig who believed not only in the restorative qualities of the sewage when applied to the soil but also in its powers to reduce or eliminate the need for local taxation. In the twentieth century the development of more sophisticated processing techniques and the heightened awareness of the environmental consequences of dumping untreated sewage have led to a revival of interest in schemes which Bazalgette and his contemporaries would no doubt have recognised as being descended from those upon which they had to pass judgement, though their twentieth century promoters are prompted more by ecological and less by financial motives than were their Victorian predecessors.

Chapter Five: Constructing and Testing the System

> "In various parts of the metropolis, small wooden sheds, surmounted by tarpaulings [sic] may be seen...in these spots has been commenced, within the last week, one of the heaviest operations London has witnessed in recent times ...For good or for evil, the metropolis has entered upon a work of no common magnitude". The *Builder*, 30th April 1859, page 292

> "It speaks volumes for the thoroughness of the opinions of the old Board's advisers, subjected to great criticism at the time, that the main features of the scheme as then laid down and initiated, remain to-day in their original form, have stood the test of over fifty years working, and have an equally long prospect of utility before them". (Sir George Humphreys, M.P.I.C.E., 1916-7, vol. 204, page 5)[1]

This chapter will consider the construction of the system, the problems that arose during that long process, extending in all over almost twenty years, the ways in which the numerous contracts were managed, and the changes that were made as the construction progressed. It will also examine the reaction to the project of the public, as reflected in the comments by politicians, newspaper writers and other parties. The volume of such comments and the prominent places in which they were found, including leading articles in major newspapers, may be interpreted as an indication of the high degree of public interest that the project aroused but also as a reflection of the ways in which the Metropolitan Board of Works maintained public support and interest by cultivating influential politicians, vestrymen and writers. The chapter will also consider the extent to which the system responded to early demands on its capacity and the changes that were finally forced upon a reluctant Board and Engineer.

Bazalgette's plan, which was modified in some details as construction progressed, proposed a network of main sewers, running parallel to the river, which would intercept both surface water and waste, conducting them to the outfalls at Barking on the Northern and Crossness on the Southern side of the Thames. A particular difficulty arose from the fact that much of London, especially the area around Lambeth and Pimlico, lies below high water mark, thus making it necessary to lift the sewage from these areas to a level at which it could flow by gravity into the rest of the system. This feature necessitated a significant alteration to the original plans in order

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[1] Sir George Humphreys, as Chief Engineer to the L.C.C., was one of Bazalgette's successors as the engineer responsible for maintaining and developing the Main Drainage

to deal with the sewage from the Hammersmith / Pimlico area. The principal contracts under which the drainage was constructed are shown in Appendix 3 , which gives details of cost, contractor, construction time and the length of each sewer. Together, they formed the system whose broad outline is as follows[2] and which is illustrated in map 3.

Bazalgette's Plan: the Northern Drainage

The Northern drainage called for the construction of three main intercepting sewers, the high level, middle level and low level sewers, the last two having a number of branches. The **high level** sewer ran from Hampstead Heath to Old Ford on the River Lea, a distance of almost nine miles, intercepting the sewage and surface water from the Northern part of the Metropolis. It lay at a depth of twenty to twenty-six feet below the surface and its fall was rapid, at least four feet per mile. For this reason it was lined with specially hard Staffordshire Blue bricks to withstand the scouring arising from the rapid fall. Amongst the hazards the sewer encountered were the New River, the Great Northern Railway and the Grand Union Canal, each of these being traversed by means of a tunnel. The sewer came into operation in May, 1861 and its construction was beset by strikes. At Old Ford it formed a junction with the **middle level** sewer which drained the central area. At the junction was a penstock[3] chamber from which the contents of both sewers could be discharged into the Northern outfall. At times of heavy rain storm waters could be diverted into the River Lea. The middle level sewer ran at a depth of up to thirty-six feet from Kensal Green to its junction with the high level sewer at Old Ford, with a branch from Piccadilly which joined the main line near Gray's Inn Road, giving a combined length of about twelve miles. Much of the sewer was formed by tunnelling, including a section beneath the Regent's canal but the greatest engineering problem was presented by the need to cross the Metropolitan Railway without stopping the traffic. This was done by constructing an aqueduct five feet above the intended level and then lowering it into position a few inches above the engine chimneys. The original contractor for this sewer was a man called Rowe whose business failed within a few months of his starting the work in

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[2]These details are taken from the *Annual Reports* of the Metropolitan Board of Works, 1860-86, which are available in the Greater London Record Office or Guildhall Library and from Bazalgette's paper given in 1865 to the I.C.E. (M.P.I.C.E., vol. 24, 1864-5, pp. 280-358); further details from J.E.Worth and W.S.Crimp, M.P.I.C.E., vol. 129, 1897

[3]Penstock: a gate which can be raised or lowered to divert liquid between different channels

1860. It was eventually completed by Thomas Brassey and Co. in 1864. The Northern **low level** sewer was a much more complex enterprise since it lay for much of its length in the Northern (Victoria) Embankment which, besides the intercepting sewers themselves, was to house a subway, the Metropolitan underground railway, gas pipes and other services. As early as 29th June 1858 the Board had recognised the advantages of incorporating the Northern low level sewer in such an embankment and had passed a resolution declaring its readiness to pay for its share of the work[4]. The following year, in its Report, the Board stressed that "it becomes of extreme urgency that an early solution of this important question should be arrived at".[5]

After the passing of the Thames Embankment (North) Act (25 & 26 Vict. cap. 93) the Board entered into protracted negotiations with wharfingers, property owners and numerous other parties before work could begin. The passing of the Metropolitan District Railway Act, 1864, confirmed that the Embankment would accommodate the underground railway but this proved to be a source of delay since, in the words of the Board, "The railway company's works proceeded very slowly in consequence of the difficulties of raising sufficient capital, and the Board had frequently to urge upon the company the necessity for greater expedition".[6] Numerous references in meetings and special reports bear witness to the Board's long and sometimes impatient correspondence with the company on its slow progress.[7] Work on this portion of the sewer began in 1864. It began in Pimlico and followed the line of the river from the vicinity of Vauxhall Bridge. From Westminster Bridge to Blackfriars it was one of the many structures contained in the Victoria Embankment and from Blackfriars it headed North beneath Queen Victoria Street and on to Tower Hill, Cable Street and Bow. It passed beneath the river Lea in a tunnel. Two branches extended to Homerton and the Isle of Dogs, giving a combined length of about twelve miles. The low level sewer was, for these reasons, built under several contracts, Furness and Ritson each handling one contract for the Embankment while William Webster fulfilled seven contracts in connection with this sewer and the associated pumping station at Abbey Mills in West Ham. At Abbey Mills the station's eight beam engines lifted the low level sewage thirty-six feet into the outfall sewer where it joined the contents of the high and middle level sewers and flowed, with them, a distance of five miles to the outfall reservoirs at Barking and thence into the Thames. The Northern outfall was a

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[4]M.B.W. *Minutes*, 29th June 1858, p.448
[5]M.B.W. *Annual Report*, 1859-60, p.3
[6]M.B.W. *Annual Report*, 1888, p. 29
[7]E.g.: M.B.W. *Minutes,* 1868, p.1191 and 1869, p.94; also *Miscellaneous Reports,* No.31, pp. 1-20, G.L.R.O.

particularly complicated project since it required the construction of massive embankments to carry the outfalls across low-lying, marshy land and it also had to negotiate a dense network of roads, rivers and railway lines. It was built by Furness and was the most costly contract of the whole system, requiring the construction of a temporary cement works to make the large quantities of material the project required and a temporary railway along the top of the outfall itself, as it advanced, to convey the cement to the points at which it was required. The Barking and North Woolwich railway lines had to be lowered to enable the outfall to be carried over it without an excessive fall in the sewer. Similarly, five roads had to be raised by between six and sixteen feet to enable the outfall to pass beneath them. It cost £669,762 and took five years to complete. Furness also constructed the Northern outfall reservoir at Barking, where the sewage was stored until it could be released at high tide.

The Western Drainage

This left the low-lying Western area around Fulham, Pimlico and Hammersmith which could not discharge by gravity into the rest of the system. Bazalgette's original plan proposed that the sewage from this area of about twenty-one square miles should be conducted to a reservoir at Fulham Fields where it would be de-odorised by the addition of perchloride of iron and discharged into the Thames to the North of Chelsea Bridge.[8] The population of this area at this time was relatively small and it was estimated that about one and a half million cubic feet per day of liquid would need to be discharged in this way whereas the system as a whole was designed to cope with sixty-three million cubic feet a day.[9] The Board presumably hoped that this modest discharge would be acceptable, though it clearly contravened the provisions of the Metropolis Local Management Act which stipulated that sewage should not be discharged within the Metropolitan boundary. Although the plan was published in the Board's Annual Report in 1859 it did not become an issue until 1862 when it came to the notice of Dr Burge, the Fulham Medical Officer. On 20th December Burge called a special meeting of the Society of Medical Officers of Health which took place ten days later. The members, having discussed the matter, passed a resolution condemning the proposal as:

> "ineffective in its operation, pernicious in its influence on the river, and entirely subversive of the principle on which the intercepting scheme was

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[8]M.B.W. *Annual Report* 1858-9, p.7
[9]M.P.I.C.E., vol. 24, 1864-5, p. 313

originally based".[10]

Two weeks later, on 14th January 1863, the Society sent a deputation to the Board to protest about the proposed arrangements. The Board immediately altered its decision and announced that it would build a pumping station in Chelsea which would lift the Western Area sewage nineteen feet into the Northern low level sewer at an additional cost of £180,000.[11]

The Southern Drainage

The **Southern drainage** was similar in conception to the Northern though the area covered was smaller and the population little more than a third of the numbers living North of the river. The Southern **high level** sewer ran from Clapham High Street nine and a half miles to Deptford Creek where it was joined by a branch linking it to Dulwich via the old Effra sewer. It took four years to build and was completed in 1864. Like the Northern high level sewer it was laid to a steep gradient, and the invert was formed from Portland cement. It flowed into the Northern outfall at Deptford. The Southern **low level** sewer ran from High Street Putney to Deptford, with a branch to Bermondsey and the two sewers drained an area much of which was below high water mark. The combined length of the sewer and branch was a little over twelve miles and the work was completed in 1866. The sewer was carried in tunnels beneath the Greenwich railway and Deptford Creek. At Deptford the Board built a pumping station with four beam engines which opened in 1864 and lifted the sewage twenty feet to the Southern outfall sewer which ran from Deptford to Crossness. Of the seven and a half miles, almost one mile of this sewer was built in a tunnel beneath Woolwich. William Webster completed the sewer in 1863 and also built the outfall works and reservoir at Crossness. At high tide the sewage was discharged directly into the river but at other times it was lifted twenty-one feet into a reservoir to await high tide, this being accomplished by four beam engines.

Bazalgette conveyed the scale of the work and the engineering problems involved in his paper to the Institution of Civil Engineers in 1865 by which time much of the system was in operation.[12] Referring to experiments elsewhere, his own observations and academic authorities he estimated that the sewers would be kept clear of deposit if the flow achieved "a mean velocity of one and a half miles per hour, in a properly

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[10]*History of the Society of Medical Officers of Health*: pub. by the Society, 1906. p.36

[11]M.B.W. *Annual Report*, 1862-3, p.8

[12]M.P.I.C.E., vol. 24, 1864-5, p. 314

protected main sewer, when running half full". This was achieved by laying the sewers to a minimum fall of two feet per mile.[13] The intercepting sewers were in total eighty-two miles in length and had consumed three hundred and eighteen million bricks and eight hundred and eighty thousand cubic yards of concrete, requiring the excavation of three and a half million cubic yards of earth. The system itself placed strains upon the suppliers of materials. In the second year of the work Bazalgette commented in his annual report on the shortage of bricks: "the supply became quite unequal to the demand created by the extensive character of your works, and thus the price of bricks was enhanced from forty to fifty percent".[14] The eventual cost of the Main Drainage was £4,107,277 including £2,582,163 for the Northern drainage and £1,525,114 for the Southern drainage. For details of individual contracts see appendix 3. In addition the Victoria Embankment cost £1.156,981, the Albert Embankment £1,014,525;the Chelsea Embankment £269, 591. Between them the three embankments reclaimed fifty-two acres from the river which were used as roads, walkways and parks.[15] A close examination of the contracts and drawings prepared for the Embankments reveals the complexity of the task.[16] For most of their length they were constructed within Coffer Dams. Piles were sunk in the bed of the river and the gaps between them were filled in with a mixture of clay and spoil. The water behind them was pumped out leaving a dry area, protected from the river, within which the embankments and their tunnels could be built. However for the stretch of the Victoria Embankment between Westminster and Waterloo bridges boreholes revealed that solid ground was so far beneath the river bed that piling would be difficult and would have to be driven so deep that damage might be done to the foundations of the bridges. For this stretch, therefore, Bazalgette specified the use of caissons. These bottomless metal chambers were lowered into the water at low tide and work was executed from within the air-filled cavity. The lower edge of the caisson was designed to sink further into the mud as excavation progessed until it reached solid ground. The foundations of the Embankments were, in this way, built

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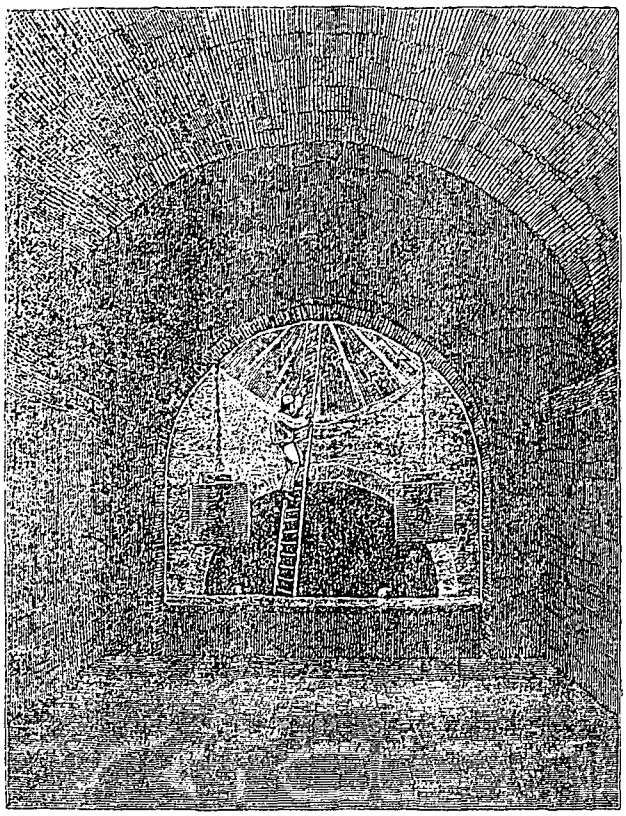
[13]M.P.I.C.E., vol. 24, 1864-5, p.301

[14]M.B.W. Annual *Report* 1860-61, Engineer's Report p.23 See also K.Maiwald in *Economic History Review* 2nd series, vol. vii, 2, pp.187-203, "An Index of Building Costs in the United Kingdom, 1845-1938"

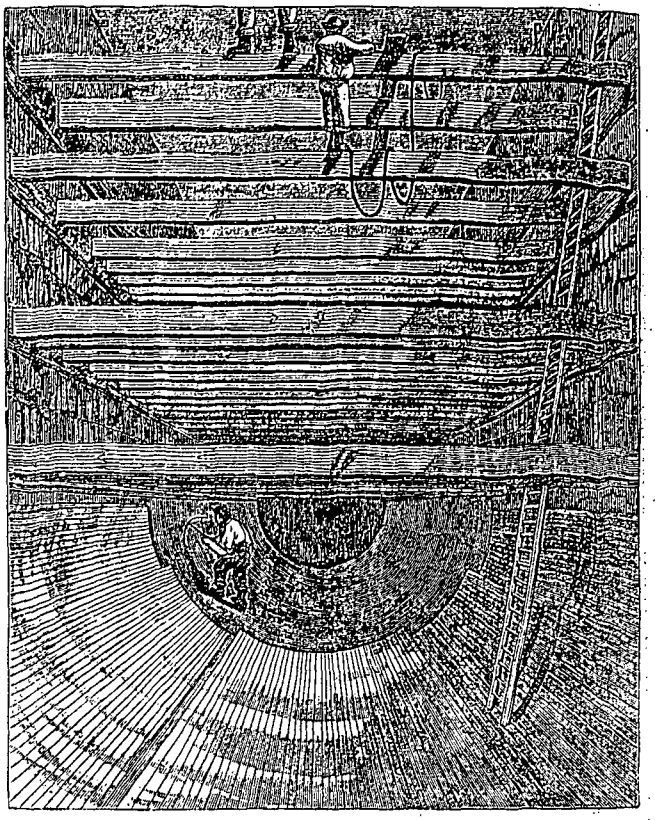
[15]M.B.W. *Annual Report*, 1888, pp. 30-33; also M.P.I.C.E. Vol. 54, 1877-8: *The Victoria, Albert and Chelsea Embankments of the River Thames;* paper by Edward Bazalgette, Sir Joseph's son.

[16]M.B.W. documents; 2422 et seq. (contracts); 2530 et seq.; drawings; see also Edward Bazalgette's paper on the Embankments in M.P.I.C.E., Vol. 54, 1877-8

Constructing the system: *Illustrated London News*, 30th November 1861



THE PENSTOCK CHAMBER AT OLD FORD.



CONSTRUCTING THE INVERT FOR THE SOUTHERN HIGH-LEVEL SEWER.

(*Continued from page 551.*)

the returning tide will not be able to bring any portion of it nearly back again to the point from which it started.

As the levels of the land upon which London and its suburbs are built are exceedingly variable, sometimes reaching to a great elevation, as at Hampstead and Highgate on the north, and at others being down below the tide-level of the river, as portions of Lambeth on its south side, it may easily be imagined that great consideration was necessary in laying out the plans for overcoming these and the numerous other difficulties which were likely to arise. Innumerable schemes were discussed and the subject was thoroughly ventilated. The result was the adoption of the plan which is now being carried out by the Metropolitan Board of Works, under the direction of Mr. J. W. Bazalgette, engineer-in-chief to the board. This plan cannot be said to be the particular design of any one, but is rather the result of all the intelligence, science, and practical and theoretical knowledge that exist in the country; for almost every one who had or thought he had any knowledge of the subject at one time or other gave his opinion. The plan adopted had the approval of the most eminent engineers of the day. The present main-drainage scheme was commenced in February, 1859; the estimate was £3,000,000, and works to the amount of £2,000,000 have been contracted for. Some of these are completed, others nearly so, and the rest rapidly progressing.

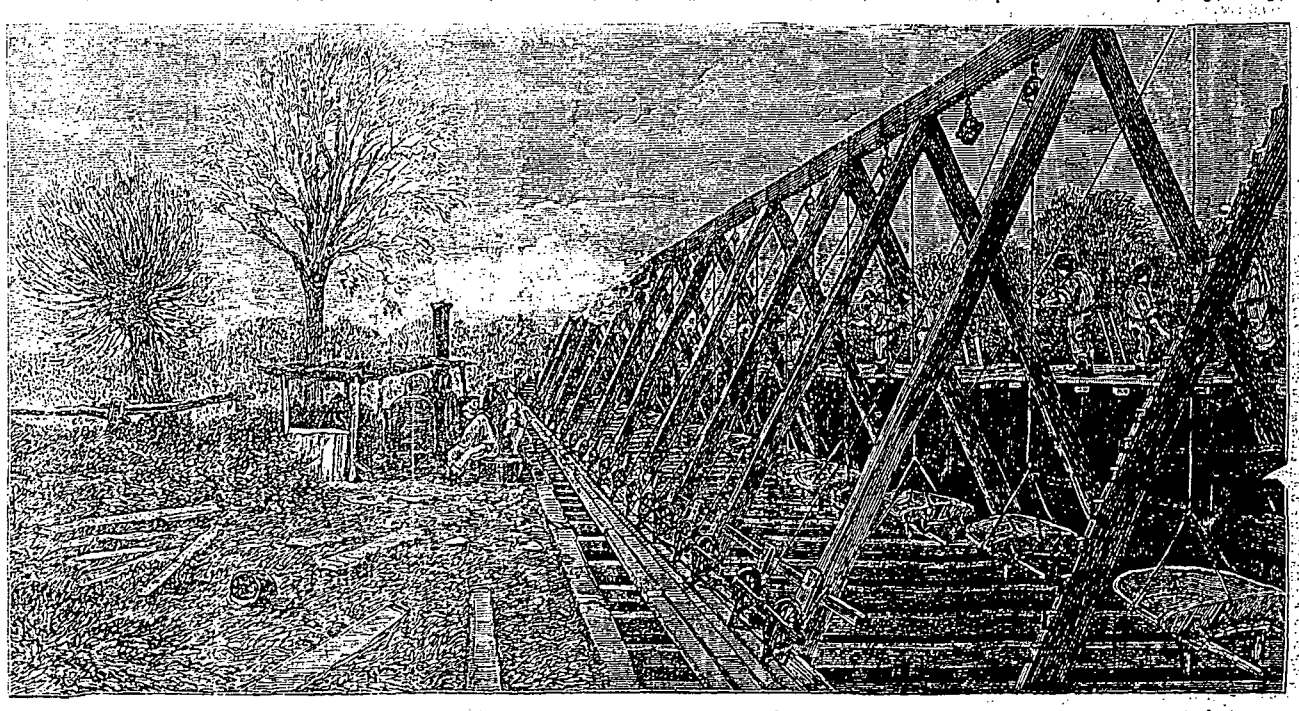
These contracts embrace fifty miles of main intercepting sewers, for the most part under ground; consequently but little is seen of them, and as little generally known. They are great works, nevertheless, requiring much more skill and care in their execution than is usual or necessary in the more showy works of engineers when executed above ground. In some places, however, the great drainage works are above the natural level of the earth, and there they have to be carried over navigable rivers, canals, railways, and public roads; great works, also, have to be erected to lift whole rivers of liquid sewage from a lower to a higher level; aqueducts have to be erected to carry it over the avenues of traffic, penstocks to regulate its course with nicety and discretion, tide-gates to shut out the returning waters; and numberless other works have been or have to be completed before the great work is finished.

THE NORTHERN MAIN DRAINAGE.

The main-drainage system on the north side of the Thames is divided into three distinct drainage areas, called respectively the high, middle, and low level areas. Each of these districts is separated from the one below it by a main sewer, generally running from east to west, which cuts off, at right angles, all the local drains which run into the Thames by their old outfalls, and carries their contents instead away to an outfall situated fourteen miles down the river.

The northern high-level sewer is nine miles in length, its head being at Hampstead. It passes through Stoke Newington, and intercepts in its way the old Fleet-river sewer, which now empties itself at Blackfriars-bridge, and also the Hackney-brook drain, finally arriving at Old Ford, on the River Lea, having drained an area of ten square miles. In its downward course it passes under both the Great Northern Railway and the New River. At its upper end the diameter of the sewer is about 4ft. This is increased from time to time as subsidiary sewers are connected with it, until it finally grows to 12ft., which is its diameter at Old Ford.

It may, perhaps, assist our non-professional readers to form an estimate of the immense amount of work that has to be done to complete only one of these great drains if we give an approximation to the quantity of materials used in it:—For the northern high-level sewer half a million yards of earth had to be excavated to form the trench in which it was constructed; 40,000,000 of bricks had to be laid with the greatest care and accuracy; 100,000 cubic yards of concrete had to be deposited to form foundations, backings, coverings, &c.



BARROW-HOIST ON THE SOUTHERN HIGH-LEVEL SEWER AT PECKHAM.

Northern outfall reservoir in course of construction *(Illustrated London News*, 30th November 1861)

L O N D O N M A I N D R A I N A G E.

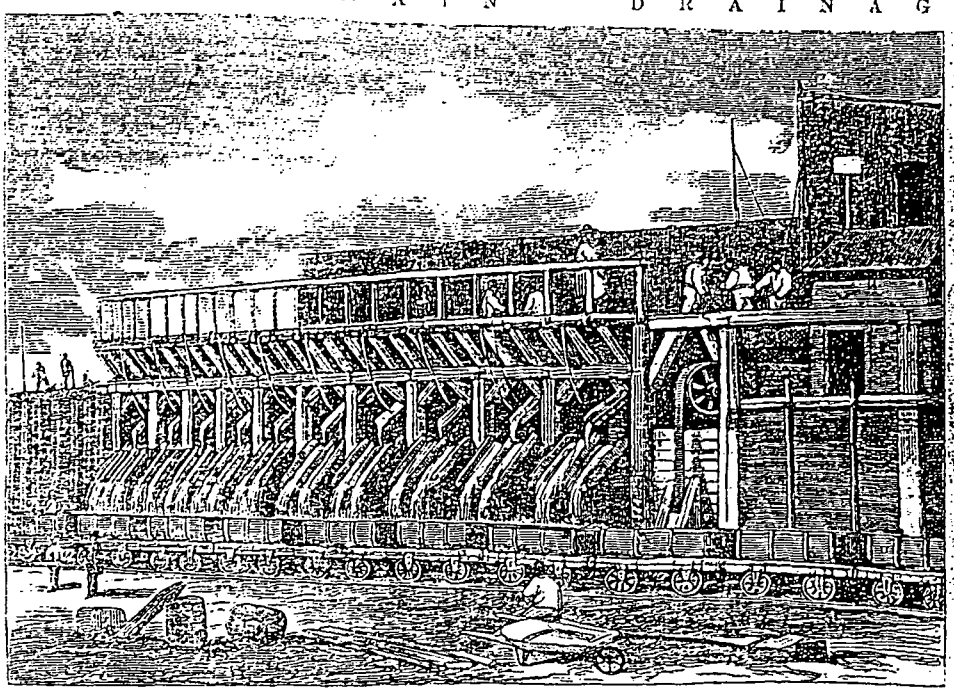
Forty years ago good salmon were taken in the upper reaches of the Thames, and good fish of various kinds caught between Vauxhall and London Bridges; indeed, a thriving community of fishermen resided there in those picturesque old streets about the Archbishop's Palace who prosecuted their calling in the immediate neighbourhood. The walks along the shores of the Thames were pleasant places in those days, where the Londoners wandered on summer evenings to enjoy fresh air. The river was a comparatively clear stream, bearing on its surface hundreds of pleasure-boats; and the houses which had back gardens or lawns extending down to the river were highly prized as dwellings by the wealthiest citizens. How changed now is both the river and its banks! The former has become a filthy sewer, the fish have been destroyed, and those who travel on it do so only as a matter of business; on the latter the dwellings are abandoned and property immensely deteriorated in value, unless occupied by wharfingers and others whose necessities compel them to locate there. And what has brought all this great change about? Simply the fact that there is poured into the River Thames every day about forty millions of gallons of sewage, the filthy washings, scourings, and cleansings of the three millions of people who inhabit the mighty city that has grown up on its [illegible]

[illegible] with not a little pleasure, that we have taken up for illustration and description the main-drainage works now being carried out, because, according to the report of the engineer who superintends them, we may hope in the course of two years or thereabout to see the Thames assume its original character. We cannot make sure of catching salmon at London-bridge so soon as that, but we may certainly expect at the expiration of the time stated to see the Thames a clear, wholesome stream, attractive for its natural beauties and adding to the healthiness of the metropolis generally.

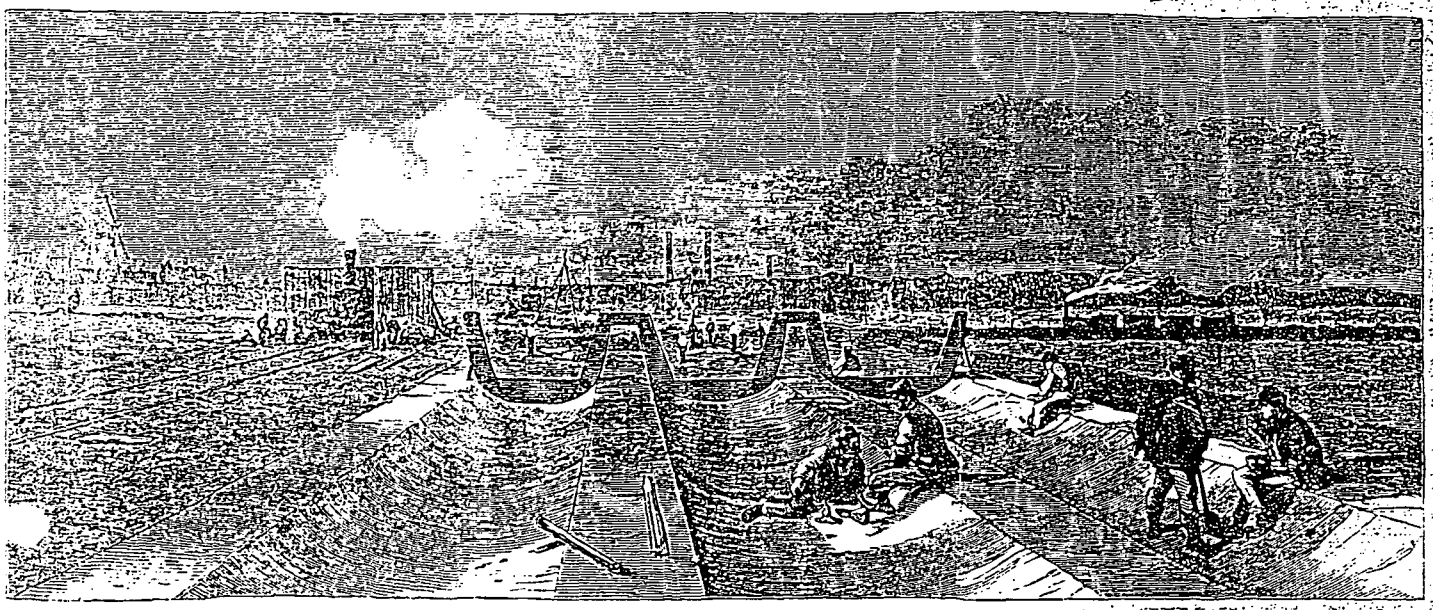
The object sought to be carried out by the works called the London Main Drainage is to intercept the sewage in its progress towards the river, and divert it by covered channels to Barking Creek, on the north side, and Erith Marshes on the south. These points are about fourteen miles below London-bridge, and it is intended that the entire mass of sewage shall be cast into the bottom of the river here during the first two hours of the ebb tide only. The period of discharge is restricted to these hours because then the sewage would be deodorised and diluted by a volume of water twenty times greater than that which now dilutes it at London, and because each ebb tide would, in returning to the sea, convey it to points twelve miles below the outfalls, or twenty-six miles below London-bridge, through a constantly-enlarging flood.

When once this system is got into working order there will be no reason why the Thames may not ebb and flow through London a perfectly clean stream, as the whole of the sewage launched at the first of the ebb will have got so far down before low water that

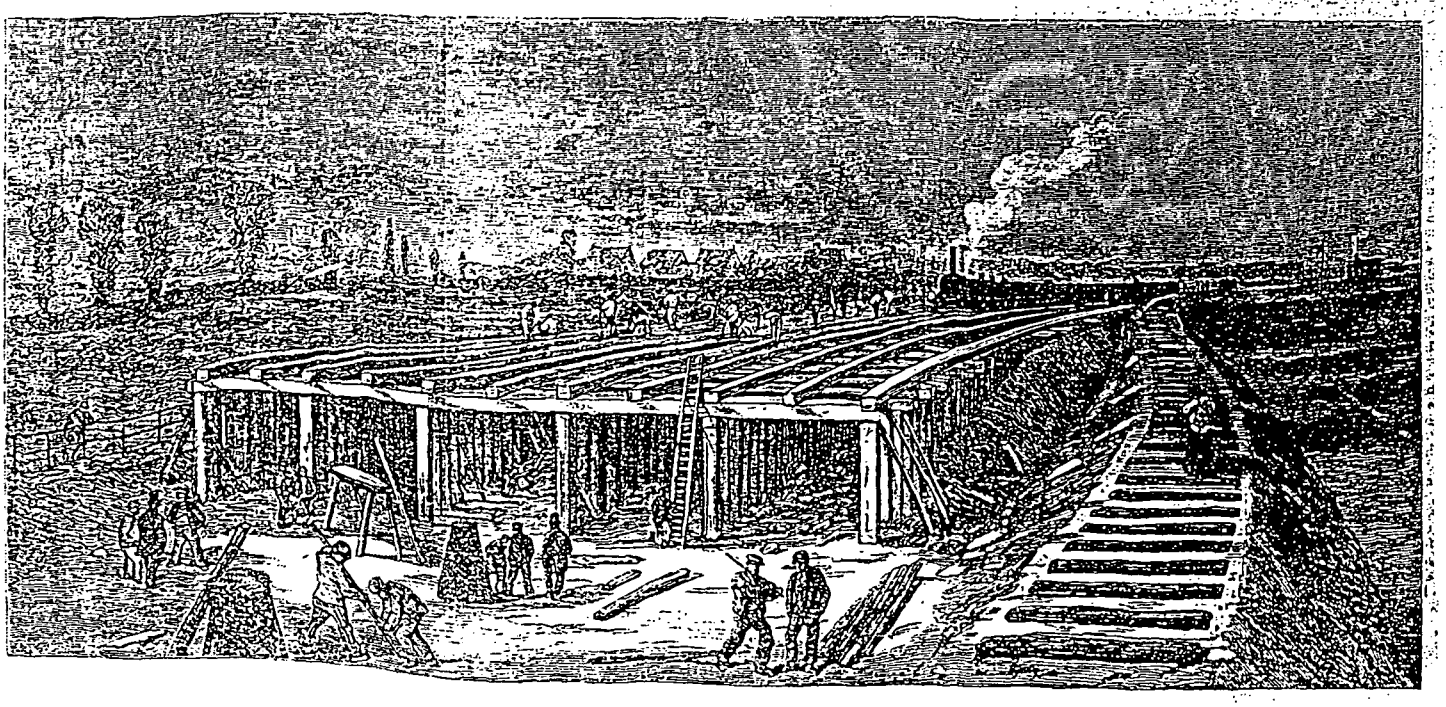
(Continued on page 556.)



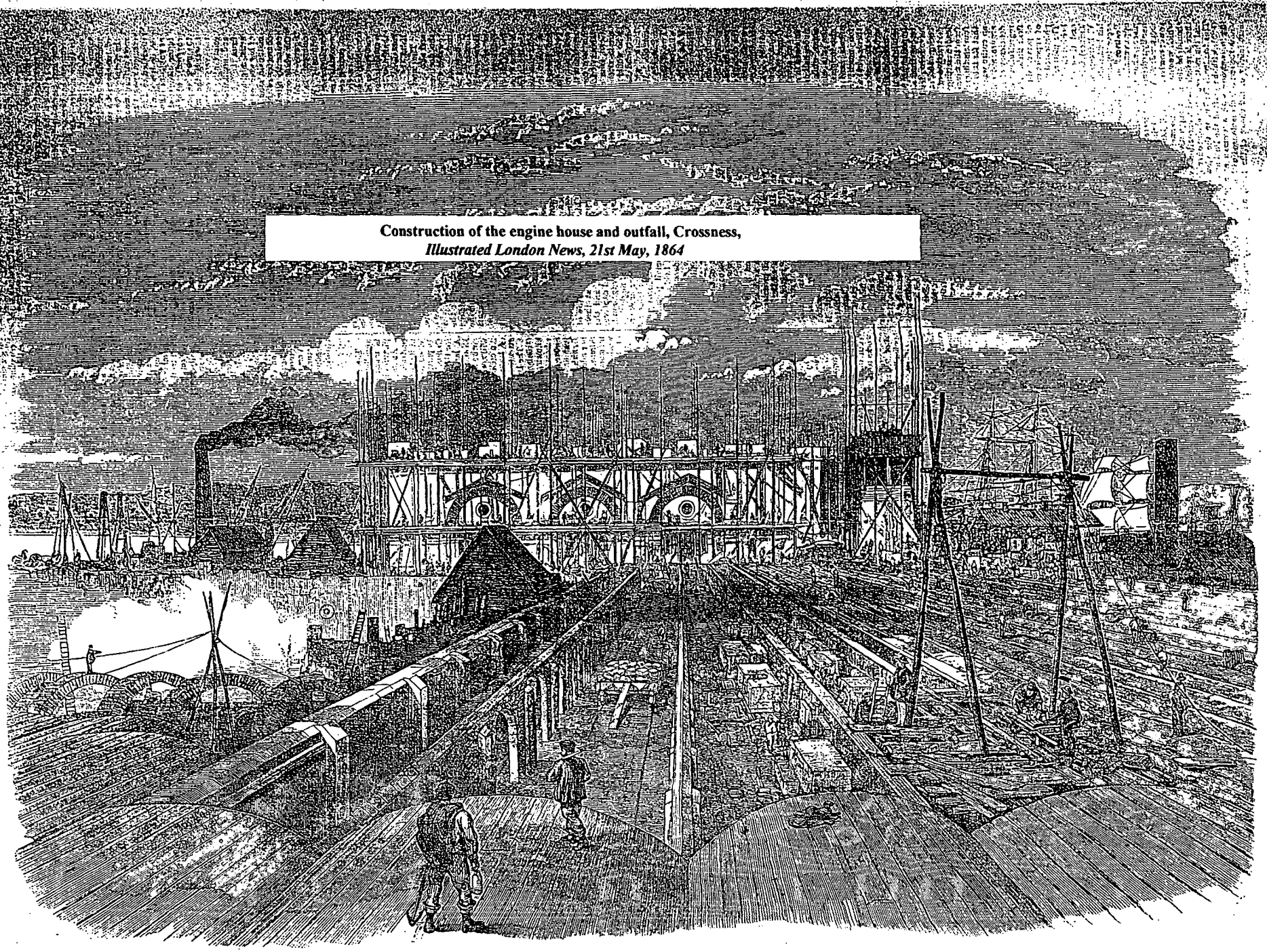
THE CONCRETE MILLS AT PLAISTOW.



CONCRETE FOUNDATION FOR THE NORTHERN OUTFALL TUNNELS.

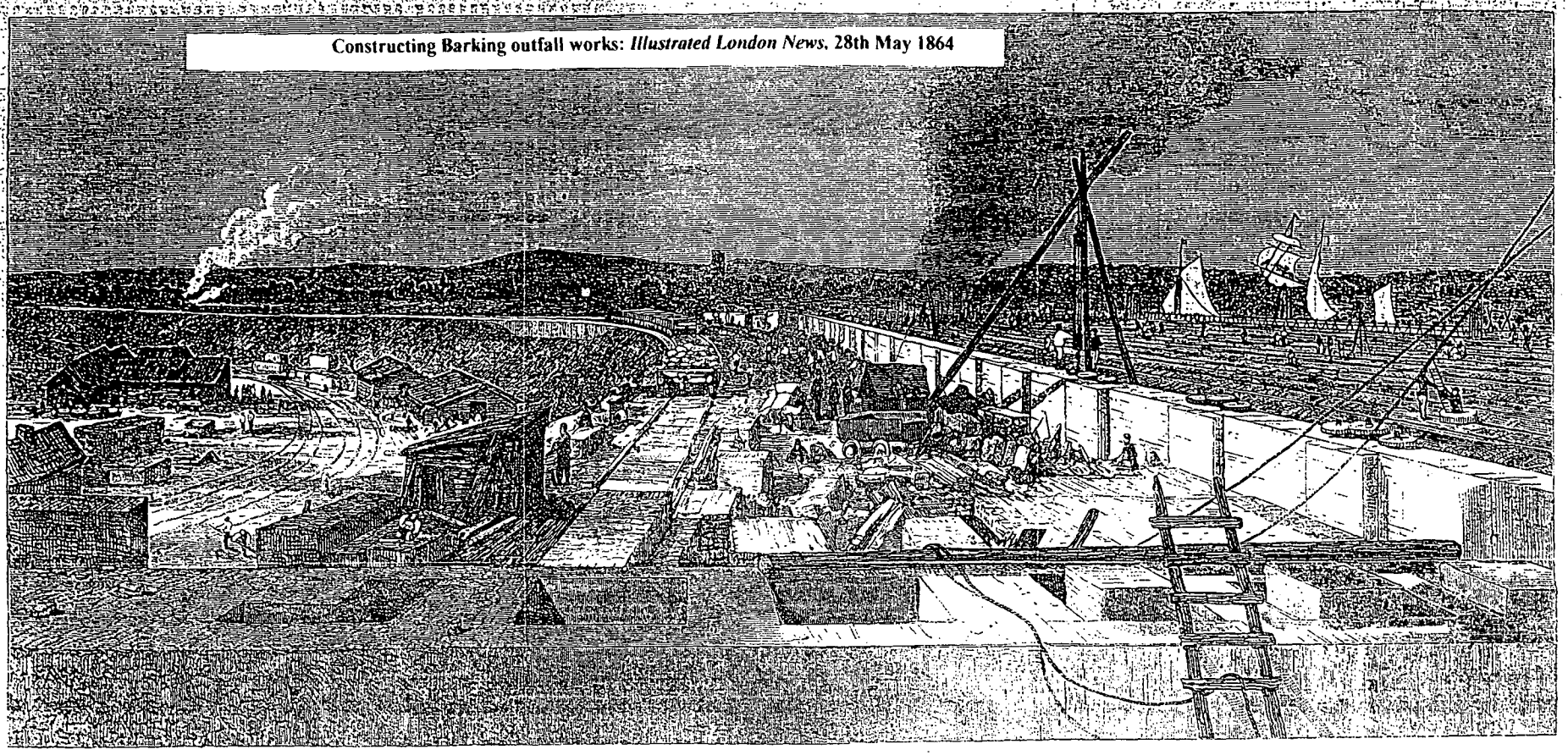


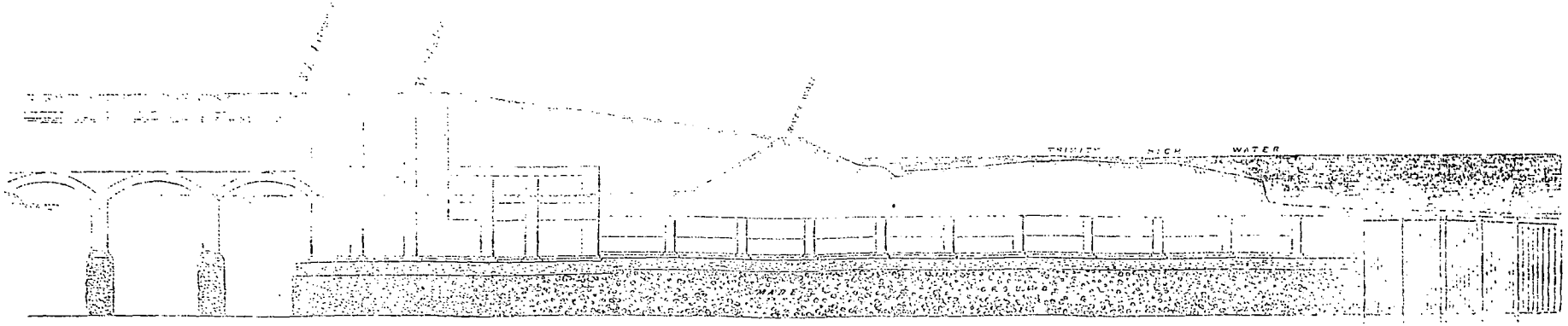
Construction of the engine house and outfall, Crossness,
Illustrated London News, 21st May, 1864



THE METROPOLITAN MAIN-DRAINAGE WORKS AT CROSSNESS.—SEE PAGE 501.

Constructing Barking outfall works: *Illustrated London News*, 28th May 1864





LONDON MAIN-DRAINAGE WORKS: VIEW AND SECTION OF THE OUTFALL OF THE NORTHERN DRAINAGE AT BARKING CREEK.—SEE PRECEDING PAGE.

inside the caissons which were left in place once the work was completed, thus adding further strength[17].

The stress involved in the work eventually affected Bazalgette. On 29th October 1869, with all but the Western drainage in operation, the Board declared that the engineer "be authorised and requested to absent himself from all his duties for a period of three months, with a view to the restoration of his health" and a week later John Grant was appointed to deputise for Bazalgette during the latter's absence. Bazalgette returned to his duties after a little more than a month.[18]

Raising the Money

Bazalgette estimated that the cost of constructing the intercepting system would be £2,836,601.[19] The Metropolis Local Management Amendment Act of 1858 had authorised the Board to borrow three million pounds, underwritten by the Treasury, to be repaid from the proceeds of a threepenny rate over forty years but as the work progressed it soon became clear that additional funding would be required. Bazalgette presented evidence of increases in the prices of materials and labour to meetings of the Board in May and June 1863, in the form of letters and receipts from Messrs Brassey, Webster, Moxon, Furness and Dethick, all of whom were engaged on major contracts for the Board. He referred to the "remarkable rise in the value of materials and labour", attributing these to "the memorable combination and strike amongst the London artisans, coupled with the unusually wet summer of 1860, which prevented the manufacture of the ordinary quantity of bricks, particularly of those of the superior class used in the Main Drainage" and went on to refer to the pressure on demand caused by the large number of railway works being executed as well as the demands of the Main Drainage itself. Bricks had in some cases doubled in price between 1858 and 1863, and to this was added an increase in wages following an artisans' strike as a result of which bricklayers had seen their wages rise from five shillings a day to six shillings or more.

In May the Board reviewed its financial position and estimated that the increase in the rateable value of properties within the Metropolis, averaging £164,000 a year, would

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[17]A.L. Little: *Foundations*; Arnold, 1961, pp. 221-49 and 260-93. describes and illustrates the characteristics and uses of caissons and coffer dams

[18]M.B.W. *Minutes*: 29th October 1869 p.1118; 5th November, p. 1139; 10th December p.1264

[19]M.B.W. *Annual Report*, 1856-7, p. 7. The eventual cost was £4.1 million.

enable the Board to support an additional loan of £1,200,000, this being sufficient to cover the additional costs of the works as estimated by Bazalgette.[20] On 13th June 1863 Thwaites wrote to the Chancellor, Gladstone, requesting authority to borrow this sum against the security of the additional rates, giving as his reasons the increases in costs which Bazalgette had presented to the Board and citing also the debts inherited from the former Commissioners of Sewers. This request was granted by Parliament in July 1863.[21] To these burdens were added the additional costs associated with the construction of the three Embankments. In April 1859 Thwaites had written to Metropolitan MPs drawing their attention to the inadequacy of the Board's resources to meet all its commitments, with particular reference to the possibility of constructing the Embankments, and arguing that the Coal and Wine duties should be assigned to the Board for these purposes.[22] In 1861, 1863 and 1868 Coal and Wine Duties Acts were passed, assigning most of these ancient duties to the Board for the "Thames Embankment and Metropolis Improvement Fund" for construction of the Embankments and for freeing bridges from tolls.[23] The Board was also, by the Thames Embankment Acts, empowered to borrow against the security of the duties, one million pounds being permitted for the Victoria Embankment; four hundred and eighty thousand pounds for the Albert Embankment; and two hundred and eighty five thousand for the Chelsea Embankment.[24]

Managing Contractors

The early nineteenth century witnessed the emergence of concepts of contract management which were necessary before large-scale engineering works could be undertaken. Large-scale contracting had developed in response to government

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[20]M.B.W. *Minutes*, 15th May, 1863, pp. 466-7; 5th June, pp. 534-45; the *Annual Report* 1863-4, Appendix C, p. 70 contains further details

[21]P.P. 1863, vol.50, M.B.W. *Annual Report,* 1861-2, pp. 1-2

[22]M.B.W. *Annual Report*, 1858-9, pp. 6-11 includes a copy of Thwaites's letter

[23]The three Acts (24 & 25 Vict. cap. 42; 26 & 27 Vict. cap. 46; and 31 Vict. cap. 17) effectively conferred these duties on the Board until April 1889. This course of action had been recommended by Sir Joseph Paxton's Select Committee Report on *The Best Means of Providing for Increasing Traffic of the Metropolis by Embankment of the Thames* P.P. 1860, Vol.20. 9d per ton on coal brought to London by rail and sea; 4/- per tun on wine brought to the Port of London by sea; see M.B.W. *Annual Report*, 1888, pp. 60-74

[24] Thames Embankment (North) Act, 1862, 25 & 26 Vict. cap. 93; Thames Embankment (South) Act, 1863, 26 & 27 Vict. cap. 75; Thames Embankment (Chelsea) Act, 1868; 31 & 32 Vict., c.135.

contracts for the construction of barracks during the Napoleonic wars, a contractor called Alexander Copland earning over £1,300,000 for such contracts between 1796 and 1806 while Telford, in his canal work, introduced the system of monthly

payments to contractors for work completed, with sums retained for work that was incomplete or unsatisfactory.[25] Thomas Cubitt, (1788-1855) whose early career had been that of a ship's carpenter, is cited as an early example of the large-scale general contractor with a permanent workforce of craftsmen which at times numbered more than two thousand. This made possible the development of open competitive tendering for large projects and replaced the earlier arrangement whereby the client made arrangements with each master craftsmen.[26] In the words of a recent writer:

> "Cubitt gathered the entire business under his belt, organising the first large-scale building firm, with some two thousand employees, and hiring all craftsmen from plumbers to painters."[27]

Cubitt built the London Institution by these methods in 1855 and, in the 1840s, the new Houses of Parliament were built largely by such general contracts though the architect, Barry, showed some preference for the earlier system of contracts with individual tradesmen for specified work at agreed prices.[28] In the period between 1844 and 1862 a series of legislative measures governing joint stock and limited liability companies made it much easier for large enterprises like Cubitt's to be established and thus removed "an important limitation on the growth and ultimate size of the business firm when it destroyed the connection between the extent and nature of a firm's operations and the personal financial position of the owners."[29] In the 1851 Census there were three builders in London with more than three hundred and fifty employees and a further nine with more than two hundred.[30] Bazalgette and the Board of Works depended upon these larger firms, notably Thomas Brassey, William Webster and George Furness to execute much of the work on the Main Drainage.

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[25]Pollard, S.: *The Genesis of Modern Management*, Edward Arnold, 1965; Ch.3 describes these early developments

[26]Church, R., (ed.),: *The Dynamics of Victorian Business*: Allen & Unwin, 1980; Ch.7, *The Building Industry,* by E.W.Cooney

[27]Porter, R.,: *London, a Social History*, Hamish Hamilton, 1994, p. 210

[28]Church,R.,(ed.),:*The Dynamics of Victorian Business:*Allen & Unwin,1980,p.155

[29]Penrose, E.T.,: *The Theory of the Growth of the Firm*; O.U.P. 1959, p.6

[30]Census, vol.xxx p.cclxxvi quoted in *The Dynamics of Victorian Business,* Ch.7

By the time that the main drainage work was being undertaken there had emerged three types of contract.[31] The first was the *measure and value* contract in which a full specification was given of all items to be completed and the materials to be used. The contractor specified the cost of each item and the total cost of the contract. The second type of contract was the *cost plus profit* method and the third was the *lump sum and contractor's risk* in which the contractor quoted a fixed sum which included his profit and made no allowance for contingencies. The emergence of the general contract created the distinction between the client's engineer and the contractor and a further consequence was that no reputable builder would tender for a contract unless quantities had been calculated by a reputable surveyor. Bazalgette used the *measure and value contract* in most of the Main Drainage works, and it is possible to gain some insight into the means by which contracts were awarded and managed by examining the contracts themselves and by reading Bazalgette's monthly progress reports.[32]

For each contract a set of drawings was produced in plan and section showing the depth and line of the sewer, dimensions at each point, the method of construction and the materials to be used. The plans were superimposed on the Ordnance survey map, thus clearly showing the position of the sewers in relation to the streets above them. The contract drawings for the Northern Middle Sewer may be taken as an example.[33]They comprise the main sewer itself from Kensal Green to Old Ford and two branches, one running beneath Piccadilly and the other beneath Coppice Row, East of Gray's Inn Road: about twelve miles of sewer altogether. At Kensal Green the dimensions were specified as four feet six inches by three feet, increasing to nine feet six inches by twelve feet at the junction with the high level sewer at Old Ford. The main line was to be by the "cut and cover" method, with the exception of the four mile section from Saffron Hill to Notting Hill via Oxford Street, where the contours of the land prompted Bazalgette to specify tunnelling. About two thousand feet of the two branches were also made by tunnelling. The materials to be employed were specified, taking as an example the following clause covering the largest part of the main sewer:

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[31]Middlemass, R.K.,: *The Master Builders*; Ch. 2 *Anatomy of a Contractor*

[32]For Bazalgette's monthly reports see M.B.W. documents 2321; for contracts and contract drawings see M.B.W. documents 2421 tp 2520, G.L.R.O. See for example the specification for the Northern high level sewer, executed by Moxon, M.B.W. documents 2421/1, 4th January 1859, G.L.R.O.

[33]M.B.W. document 2503, G.L.R.O.

> "Construct in Open Cutting, 4,430 feet run, of brick sewer, 9'6" in height by 12' wide, of the form and dimensions shown in Section, Drawing no. 4; the upper arch in mortar, the rest in cement, from a junction with the Northern High Level Sewer..."[34]

Having completed the drawings and specification of materials, Bazalgette passed them to a quantity surveyor who calculated the quantities of work required to complete each contract. A number of these Bills of Quantities have survived including one for the Southern Low Level Sewer prepared by a surveyor called D.W.Young, John Grant being named as the resident engineer.[35] For this sewer Young's calculations included:

400,317 cubic yards of excavation
250,287 cubic yards of infill
57,410 cubic yards of concrete
3,505 rods of brickwork

The estimated quantities were then issued to tenderers together with details of payment methods. Accounts were to be submitted monthly, within a week of the month's end. Ninety per cent of the estimated value would be paid; a further five per cent after three months; two and a half per cent after six months; and the balance after a year. The work was to be completed by 24th December 1863, a penalty of £50 a day being imposed for late completion.

In evidence to the *Royal Commission Appointed to Inquire into Certain Matters Connected with the Metropolitan Board of Works*, Bazalgette described the procedures he followed when contracts were put out to tender.[36] Having secured the agreement of the Board to his proposed works he would advertise for tenders in publications such as *The Builder*.[37] The documents were printed and issued for a fee of £5 to every tenderer and the tenders, when received, were opened at the Board meeting immediately following their receipt.

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[34]M.B.W. doc. 2503, contract drawing, Northern High Level Sewer page 5, G.L.R.O.
[35]M.B.W. document 2429a, G.L.R.O.
[36]P.P. 1889, vol. 29; there is also a bound copy of the Commissioners' Report in the Greater London Record Office
[37]Newcomen Society *Transactions* vol. 58 1986-7, pp. 93-4 gives a description of the process

The contractors then submitted bids based on the quantities calculated by the surveyor and these were incorporated in the contract in the form of a Schedule of Prices. The schedule for the Northern Middle Level contract included the following:[38]

Digging, shoring and fencing: 2/6d per cubic yard
Tunnelling: 6/6d per cubic yard
Lime cement: 6/6d per cubic yard
Portland cement: 13/- per cubic yard
Brickwork: £14 per rod (two types were specified; one for the inner ring and one for the outer
Stockbricks: 35/- per thousand
Staffordshire Blue bricks: 84/- per thousand
Day labour rates per ten hour day:
Labourer: 3/6d
Miner: (for tunnelling): 5/6d
Bricklayer: 6/- [39]

An examination of Bazalgette's sectional drawings shows that he used the tunnelling method where the sewers were thirty feet or more beneath street level, preferring the "Cut and cover" method for most of the system. In this choice he was no doubt influenced by the greater costs of tunnelling, as reflected in the figures given above both for tunnelling and for the higher wages paid to "miners". Tunnelling could also be dangerous, a number of fatalities being incurred in the five thousand foot tunnel beneath Woolwich.

The Board did not always accept the lowest tender since, as Bazalgette explained:

> "if there is a contractor whom they well know, and whose tender is not materially above the lower one, they will naturally prefer it. It is a very great mistake to employ a contractor who has not the means of carrying out his contract thoroughly. It always leads to constant wrangling, difficulty, stoppage and very often eventual failure".[40]

In this judgement Bazalgette was no doubt influenced by the early failure of Rowe, the original contractor for the Northern Middle Level sewer who gained the contract

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[38]M.B.W. document 2521/5; Northern Middle Level contract, page 28
[39]See Bazalgette's monthly reports for 1861; M.B.W. document 2321, G.L.R.O.
[40]P.P. 1889, vol. 29; Bazalgette's evidence to the Commission, given on 10th July 1888, is on pp. 321-22 of the Commissioners' Report

on 24th February 1860 and failed shortly after beginning, having executed only £12,451 of work. The contract was eventually completed by Thomas Brassey for £349,869. In his evidence to the Royal Commission Bazalgette claimed that his advice to the Board on the choice of contractors was confined to informing them whether the tenderer had previously worked for the Board, whereas checking credit worthiness was undertaken by the Board's solicitor, though this view, that Bazalgette exerted little influence on the selection of contractors, was challenged in the "Odessa contract" (see below page 218).

When a disagreement arose between the Board and one of its contractors over interim or final payments for works completed then, in Bazalgette's words:

> "I have the assistant engineer and the clerks of works with the contract drawings and specifications before me, and the contractor and his agents, and I hear what each has to say, and look to the specifications and drawings and determine those points. After that is done the account is sent to the accountant, certified as to quantities, and the accountant compares the prices with the schedule of extra works...and eventually signs it as correct. Then I sign the certificate for the Board."[41]

In his annual reports to the Board Bazalgette gave the details of monies spent on each contract. Many of these contain the entry "account under investigation" prior to payment and some of these investigations continued for years before payment was made.

Despite these precautions there were some early problems. The failure of Rowe to execute the Northern Middle Level sewer has already been noted but even before Rowe's bankruptcy the ever-vigilant John Leslie drew attention to some discrepancies in payments for the Northern high level sewer. Leslie suggested, at a Board meeting, that the estimate of quantities made by Richard Roberts and Edward Gotto, the quantity surveyors engaged for the purpose were "a gross swindle on the ratepayers". Leslie was censured for this language but an independent surveyor called William Pole was appointed to check their calculations and Leslie's allegations were largely substantiated.[42]

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[41]Ibid.:Bazalgette's evidence, p. 322, Q.9825

[42]M.B.W. *Minutes*, Jan-Oct. 1859; pp. 138, 245, 330, 641-2; reported in *The Builder*: 14th May 1859, p.322; 13th August 1859, p.539

New Materials

Other significant changes in the early nineteenth century concerned the development of new materials,and new methods of making old ones,which were necessary for the economical completion of large-scale works. Until the early nineteenth century bricks had normally been made on the site at which they were to be used but, in response to the huge demands for bricks in the construction of railways, sewers and other large works the business became concentrated in locations close to the source of the raw material.[43] The Main Drainage used 318,000,000 bricks and 880,000cubic yards of concrete[44] and the peculiar needs of some of its structures required the manufacture of special materials. The *City Press* referred to this in reporting on the Northern Outfall Sewer across marshland in 1861 when it wrote that "For this work there were no bricks to be had good enough; and Messrs Brassey are engaged in the manufacture of bricks for the purpose".[45] Early in its deliberations the Board had decided to appoint a consultant to advise on the materials which should be employed on the main drainage works.[46] A particular innovation was the use of Portland Cement. In the first half of the nineteenth century engineers like Telford and Brunel had used "Roman Cement" in major civil engineering works.[47] This material, used by the Romans in their great works, consists mostly of lime but in the late eighteenth century some engineers experimented with different processes to produce a stronger cement, especially one which could withstand immersion in water. Smeaton used a compound of clay and carbonate of lime for the Eddystone lighthouse in 1756 and patents were registered by James Parker in 1796 and James Frost in 1822.[48] In 1824 a Yorkshire bricklayer called Joseph Aspdin patented a technique for making a stronger cement for which he coined the name "Portland Cement" because of its resemblance to

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[43]*The Dynamics of Victorian Business*: ed. R.Church, Allen & Unwin, 1980, p.143

[44]M.P.I.C.E., Vol. 24, 1864-5, p. 314, Bazalgette's paper on London's Main Drainage

[45]*City Press*: 14th September 1861, p.4

[46]Thus on 9th, 16th and 23rd November 1858 the Main Drainage Committee corresponded with Lewis Thompson and Dr Richardson, both of Newcastle, with a vew to securing their services. There is no record of the advice they gave. M.B.W. document 965, G.L.R.O.

[47]A.J.Francis: *The Cement Industry, 1796-1914*; David & Charles, 1977, p.12

[48]For an account of the pioneers in the development of new materials see A.C Davis: *A Hundred Years of Portland Cement, 1824-1924*; Cement Publications, 1924, chapters 1 and 2

Portland stone.[49] The patent (no.5,022) which Aspdin obtained in 1824 described the manufacturing process in terms which combined wordiness with lack of precision:

> "I take a specific quantity of limestone, such as that generally used for making or repairing roads, and I take it from the roads after it is reduced to a puddle, or powder...I then take a specific quantity of agrillaceous earth or clay, and mix them with water..." [the water having evaporated] "Then I break the said mixture into suitable lumps, and calcine them in a furnace similar to a lime kiln till the carbonic acid is entirely expelled".[50]

This process produced cement which was exceptionally strong. Aspdin manufactured it in his works in Wakefield from 1825 though his son William later transferred the business to Northfleet in the Medway valley, in Kent, where the industry quickly became concentrated because of the ready availability of suitable chalk and clay. The new material gained acceptance very slowly despite the attempts of some prominent advocates to promote its use. With the encouragement of the Duke of Wellington, Major-General Sir C.W.Pasley, director of studies for the Royal Engineers at Chatham, carried out a series of experiments with a view to making reliable cement from lime and clay. The experiments were unsuccessful, probably because of impurities in the clay he collected from the Medway area and his work was of little value in promoting the use of the new material.[51] The firm of J.B.White of Swanscombe, Kent, was also interested in the new material and commissioned the manager of its works to analyse a sample of Aspdin's concrete and conduct experiments to find out how it should be made. The manager, I.C.Johnson, identified the critical role of temperature in the process: the compound had to be heated to the point of vitrification if the cement was to attain maximum strength. The proprietor of the firm, John Bazley White, built a house from the concrete at Swanscombe to illustrate the qualities of the material but it made little headway in its attempt to dislodge the older Roman cement from its leading position in the execution of major civil engineering works. The firm of Charles Francis, manufacturers of Roman cement, solicited and obtained from prominent engineers a number of testimonials to the qualities of this long-established product. I.K.Brunel testified to its effectiveness in constructing the Thames Tunnel "and many other large Works, where the quality of your cement has undergone the most severe tests" and other endorsements were received from James Walker and Robert Stephenson in buildings and railways

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[49]M.P.I.C.E., 62, 1880, p.67

[50]Quoted in A.C.Davis: *A Hundred Years of Portland Cement 1824-1924*: Concrete Publications Ltd., 1924, pp.35 & 37

[51]Ibid., pp.39-43 describes Pasley's experiments

respectively[52]. By contrast, the new material's properties were untested, it was about one and a half times as expensive as Roman cement and it was sensitive to errors in the production process. A small change in the mixture of materials, the temperature of the kiln or in the grinding process significantly affected the strength of the finished product in an industry where production control and quality control processes were still rudimentary.[53] Nevertheless the new material attracted much professional interest. On 15th July 1848 *The Builder* reported on a series of experiments on J.B.White's Portland cement and on 30th September it followed this up with a similar report on experiments at Aspdin's works. In May 1852 the material was the subject of a paper presented at the Institution of Civil Engineers by G.F.White but it had still not been adopted for any major civil engineering project.

One of its characteristics was that, once hardened, it was not affected by immersion in water. Indeed there was some evidence that it actually became stronger through such immersion and that it also gained in strength over time, both of these being features which were attractive to an engineer responsible for a massive engineering project whose structures would be continuously exposed to water. Bazalgette therefore specified that it should be used in laying the brickwork for the sewers - the first use of the material in a large scale public work.[54] However he also specified that every batch received from his suppliers should be tested for strength before it was used. He delegated this task to John Grant, one of his three assistant engineers. Percy Boulnois, one of Bazalgette's pupils, gives an account of this process which he carried out under Grant's supervision.[55] Grant later gave three papers to the Institution of Civil Engineers on the results of his experiments which were to prove critical to the future of this important material. In the words of the industry's two historians:

> "Probably no event did more to set the Portland Cement industry on its feet and demonstrate the importance and capabilities of the new material than a series of tests commenced in 1860 by John Grant, assistant engineer to the Metropolitan Board of Works."[56]

and

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[52] Ibid., pp.73-5 reproduces the testimonials

[53] For an account of the development of Portland Cement see A.J.Francis: *The Cement Industry, 1796-1914*, David & Charles, 1977, esp. chapter 8; also A.C.Davis (above)

[54] L.T.C.Rolt: *Victorian Engineering*; Penguin, 1970. pp.145-6

[55] H.P.Boulnois: *Reminiscences of a Municipal Engineer*; St. Bride's Press, 1920, p.29

[56] A.J.Francis: *The Cement Industry, 1796-1914,* David & Charles, 1968, p.132

> "The experiments of the late Mr John Grant, the engineer of the Metropolitan Board of Works in connection with the London drainage scheme of 1859, gave an impetus to the use of Portland Cement which saw many new factories spring up and originated an industry which has never flagged to this day".[57]

Grant's first paper was given to the Institution in December 1865 under the title *Experiments on the Strength of Cement, chiefly in reference to the Portland Cement used in the Southern Main Drainage Works*,[58] and the degree of interest in the topic may be gauged from the fact that the discussion continued for four evenings to the exclusion of all other business. Grant introduced the subject by reminding the members that, prior to 1859, Roman cement had been used in all major civil engineering projects, with Portland cement confined mostly to the external rendering of houses and some harbour projects on the South coast and Channel Islands where its advertised ability to withstand prolonged immersion in water had encouraged engineers to use it. Between January and July 1859, therefore, Grant had carried out 302 experiments on batches of Portland cement from twelve manufacturers. Some batches had been prepared neat and some with sand, and each had been immersed in water for a period of ten to fourteen days before being subjected to a breaking test. The tests revealed that, while Roman cement in these conditions broke at a pressure of about two hundred pounds, Portland Cement broke at a pressure exceeding six hundred pounds. As a result of these experiments the material was specified for the main drainage contracts, beginning with contract number one, for the Northern high level sewer[59] though as work progressed the specifications became more detailed and demanding, the density of the material increasing from 106 to 112 lbs. to the bushel as the trials progressed. The following specification was inserted in contract number one for the Northern Embankment:

> "The whole of the cement for these works, and and herein referred to, to be Portland Cement, of the best quality, ground extremely fine, and weighing not less than 112 lbs to the imperial bushel. It is to be brought on to the works in a state fit for use, and is not to be used therein, until it shall have been upon the ground for three weeks at the least, not until it has been tested by taking samples out of every tenth sack, at the least, gauging these samples in moulds, and by apparatus similar to those heretofore in use by the said Board, placing the cement at once in water, in which it is to remain for seven clear

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[57]A.C.Davis: *A Hundred Years of Portland Cement, 1824-1924*; Concrete Publications, 1924, p. xix

[58]M.P.I.C.E., 25, 1865-6, pp. 66-159

[59]M.B.W. documents, ref. 2421/1, 4th January 1859, G.L.R.O.

> days, and testing it at the end of that time by the application of a weight or lever. All cement that shall not bear, without breaking, a weight of five hundred pounds, at the least, when subjected to this test, shall be peremptorily rejected and forthwith removed from the works".[60]

A simple machine had been devised to subject two and a half square inches of the product to breaking tests and workmen had been trained to operate the machine on site under the supervision of Grant, assisted by pupils like Boulnois. Such was the success of the process that, for some later contracts, the material was used, not for cementing bricks in place but for forming the sewers from concrete.[61] When he delivered his paper in 1865 Grant was able to report that batches from fourteen suppliers, amounting to seventy thousand tons, had been subjected to 11,587 tests for the Southern drainage alone. The average breaking weight had been 606.8 pounds and the tests had confirmed that the cement strengthened both with age and through immersion in water. After three months the strength of the product had doubled and a further strengthening was observed after twelve months. Amongst Grant's twenty-five conclusions were the following, which were of great importance for the future use of the material:

> "Portland cement has been proved to be peculiarly suitable for hydraulic works, and may be procured in any quantity, and of the highest quality... Cement kept in water was one-third stronger than that kept out...the author would warn anyone against its use, who is not prepared to take the trouble, or incur the trifling expense of testing it; as if manufactured with improper proportions of its constituents chalk and clay, or improperly burnt, it may do more mischief than the poorest lime".[62]

In discussing Grant's paper a manufacturer, G.F.White, observed that the engineers of the Metropolitan Board were the first public officials to use testing procedures in this way. In his comments Bazalgette "believed that great good had been done by the tests; that the manufacture of cement had been improved thereby; and that Portland cement was destined to be used to a much larger extent than it had been hitherto in engineering works." Grant commented that testing machines had been adopted by the manufacturers for use at their works, in order to ensure that their supplies met the

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[60]M.B.W. documents 2431/1 Thames Embankment, Middlesex Side, contract no. 1, clause 45, 27th October 1863

[61]For example the Hackney Wick branch of the Northern Low Level sewer, M.B.W. document 2421/23, 15th July 1864, G.L.R.O.

[62]M.P.I.C.E., 25, 1865-6, pp. 77-8

specification - a significant advance in the adoption of quality control procedures in this young industry.

Five years later Grant gave a second paper to the Institution entitled *Further experiments on the strength of Portland cement*[63] in which he reported that, following its successful use in laying brickwork for the sewers, the Board had adopted the policy of making sewers entirely from Portland cement concrete, eliminating altogether the use of bricks. A concrete sewer measuring four feet by two feet eight inches, costing ten shillings per linear foot had been used as an alternative to a brick sewer costing sixteen shillings and sixpence for the same dimensions. Specifications for such sewers were now standard in the Board's contract documents.[64] Moreover the material was now being employed in much larger quantities in the construction of the Embankments. The original plans for the Albert Embankment had planned to use brickwork for the substructure, with granite facing. Instead, after one quarter of the contract was completed, the specification was changed to substitute Portland cement for the brickwork. 14,335 cubic yards of the material were used at a cost of eleven shillings a cubic yard instead of bricks at thirty shillings a cubic yard though the planned granite facings were retained. A further forty thousand cubic yards were subsequently used in the Victoria and Chelsea Embankments.[65] . Bazalgette observed, in commenting on Grant's paper that, though Roman cement was two thirds of the price of Portland cement, it had only one third of the strength, making the new material effectively cheaper. This, combined with the greatly improved quality standards which the industry had attained as a result of the Board's rigorous testing regime, meant that Portland cement was becoming the standard material for many industries. Grant reported that, following the Board's example, the material was now being extensively employed in the construction of houses and roads. An engineer called Parkes testified that Portland cement manufacturers now routinely employed "samplers" to test batches. This statement was made in support of Bazalgette's claim that:

> "The improved manufacture of Portland cement up to the present time has been promoted by the careful experiments of Mr Grant. Portland cement concrete could now be used with advantage and safety where brickwork and stonework were previously used, thus effecting a large economy in engineering works".[66]

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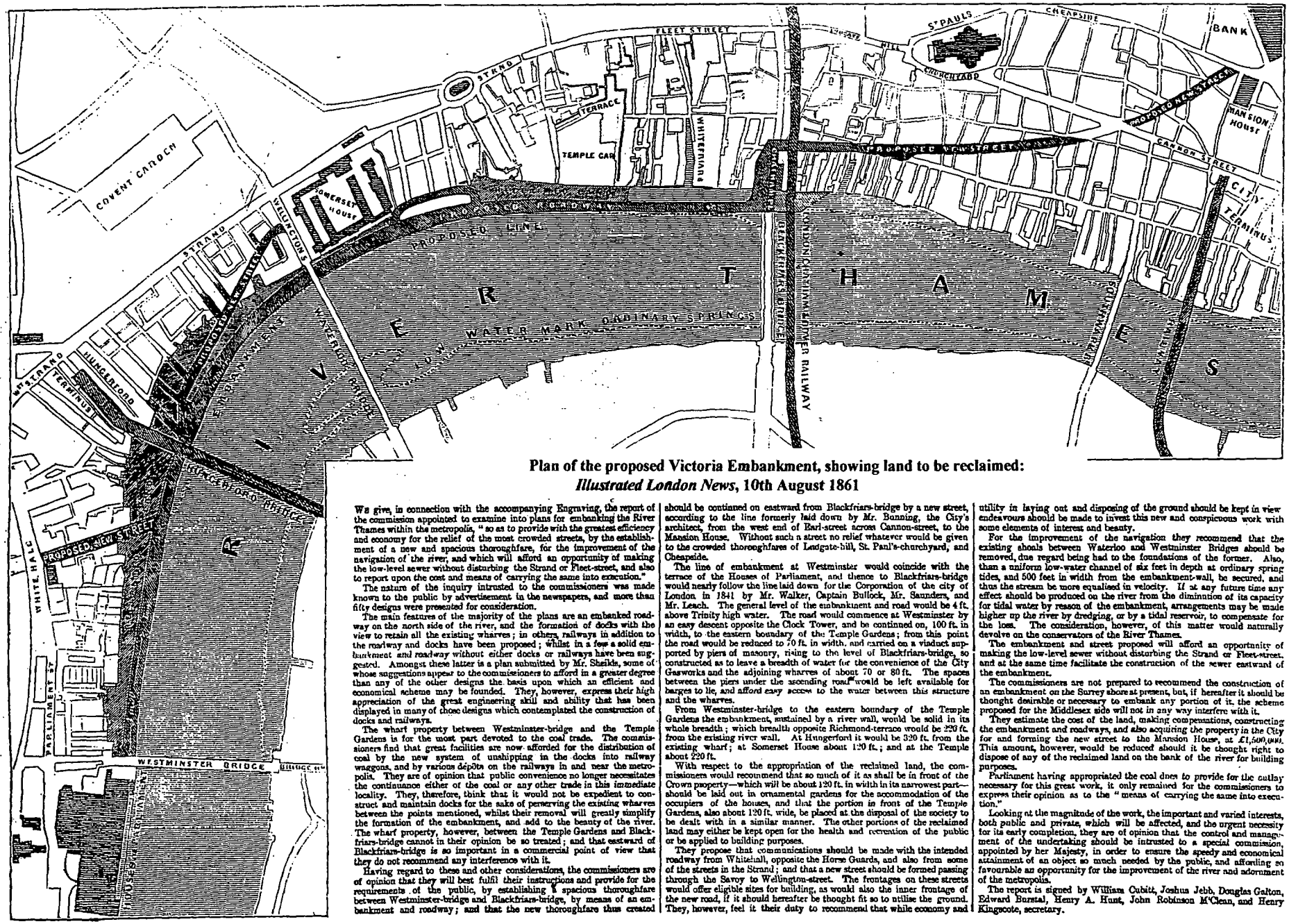
[63]M.P.I.C.E., 32, 1870-1, pp. 266-328
[64]M.P.I.C.E., 32, 1870-1, pp. 278 and 304
[65]Ibid., p.276
[66]Ibid., pp. 311 & 314



Plan of the proposed Victoria Embankment, showing land to be reclaimed: *Illustrated London News*, 10th August 1861

We give, in connection with the accompanying Engraving, the report of the commission appointed to examine into plans for embanking the River Thames within the metropolis, "so as to provide with the greatest efficiency and economy for the relief of the most crowded streets, by the establishment of a new and spacious thoroughfare, for the improvement of the navigation of the river, and which will afford an opportunity of making the low-level sewer without disturbing the Strand or Fleet-street, and also to report upon the cost and means of carrying the same into execution."

The nature of the inquiry intrusted to the commissioners was made known to the public by advertisement in the newspapers, and more than fifty designs were presented for consideration.

The main features of the majority of the plans are an embanked roadway on the north side of the river, and the formation of docks with the view to retain all the existing wharves; in others, railways in addition to the roadway and docks have been proposed; whilst in a few a solid embankment and roadway without either docks or railways have been suggested. Amongst these latter is a plan submitted by Mr. Sheilds, some of whose suggestions appear to the commissioners to afford in a greater degree than any of the other designs the basis upon which an efficient and economical scheme may be founded. They, however, express their high appreciation of the great engineering skill and ability that has been displayed in many of those designs which contemplated the construction of docks and railways.

The wharf property between Westminster-bridge and the Temple Gardens is for the most part devoted to the coal trade. The commissioners find that great facilities are now afforded for the distribution of coal by the new system of unshipping in the docks into railway waggons, and by various dépôts on the railways in and near the metropolis. They are of opinion that public convenience no longer necessitates the continuance either of the coal or any other trade in this immediate locality. They, therefore, think that it would not be expedient to construct and maintain docks for the sake of preserving the existing wharves between the points mentioned, whilst their removal will greatly simplify the formation of the embankment, and add to the beauty of the river. The wharf property, however, between the Temple Gardens and Blackfriars-bridge cannot in their opinion be so treated; and that eastward of Blackfriars-bridge is so important in a commercial point of view that they do not recommend any interference with it.

Having regard to these and other considerations, the commissioners are of opinion that they will best fulfil their instructions and provide for the requirements of the public, by establishing a spacious thoroughfare between Westminster-bridge and Blackfriars-bridge, by means of an embankment and roadway; and that the new thoroughfare thus created should be continued on eastward from Blackfriars-bridge by a new street, according to the line formerly laid down by Mr. Banning, the City's architect, from the west end of Earl-street across Cannon-street, to the Mansion House. Without such a street no relief whatever would be given to the crowded thoroughfares of Ludgate-hill, St. Paul's-churchyard, and Cheapside.

The line of embankment at Westminster would coincide with the terrace of the Houses of Parliament, and thence to Blackfriars-bridge would nearly follow the line laid down for the Corporation of the city of London in 1841 by Mr. Walker, Captain Bullock, Mr. Saunders, and Mr. Leach. The general level of the embankment and road would be 4 ft. above Trinity high water. The road would commence at Westminster by an easy descent opposite the Clock Tower, and be continued on, 100 ft. in width, to the eastern boundary of the Temple Gardens; from this point the road would be reduced to 70 ft. in width, and carried on a viaduct supported by piers of masonry, rising to the level of Blackfriars-bridge, so constructed as to leave a breadth of water for the convenience of the City Gasworks and the adjoining wharves of about 70 or 80 ft. The spaces between the piers under the ascending road would be left available for barges to lie, and afford easy access to the water between this structure and the wharves.

From Westminster-bridge to the eastern boundary of the Temple Gardens the embankment, sustained by a river wall, would be solid in its whole breadth; which breadth opposite Richmond-terrace would be 220 ft. from the existing river wall. At Hungerford it would be 320 ft. from the existing wharf; at Somerset House about 120 ft.; and at the Temple about 220 ft.

With respect to the appropriation of the reclaimed land, the commissioners would recommend that so much of it as shall be in front of the Crown property—which will be about 120 ft. in width in its narrowest part—should be laid out in ornamental gardens for the accommodation of the occupiers of the houses, and that the portion in front of the Temple Gardens, also about 120 ft. wide, be placed at the disposal of the society to be dealt with in a similar manner. The other portions of the reclaimed land may either be kept open for the health and recreation of the public or be applied to building purposes.

They propose that communications should be made with the intended roadway from Whitehall, opposite the Horse Guards, and also from some of the streets in the Strand; and that a new street should be formed passing through the Savoy to Wellington-street. The frontages on these streets would offer eligible sites for building, as would also the inner frontage of the new road, if it should hereafter be thought fit so to utilise the ground. They, however, feel it their duty to recommend that while economy and utility in laying out and disposing of the ground should be kept in view endeavours should be made to invest this new and conspicuous work with some elements of interest and beauty.

For the improvement of the navigation they recommend that the existing shoals between Waterloo and Westminster Bridges should be removed, due regard being had to the foundations of the former. Also, than a uniform low-water channel of six feet in depth at ordinary spring tides, and 500 feet in width from the embankment-wall, be secured, and thus the stream be more equalised in velocity. If at any future time any effect should be produced on the river from the diminution of its capacity for tidal water by reason of the embankment, arrangements may be made higher up the river by dredging, or by a tidal reservoir, to compensate for the loss. The consideration, however, of this matter would naturally devolve on the conservators of the River Thames.

The embankment and street proposed will afford an opportunity of making the low-level sewer without disturbing the Strand or Fleet-street, and at the same time facilitate the construction of the sewer eastward of the embankment.

The commissioners are not prepared to recommend the construction of an embankment on the Surrey shore at present, but, if hereafter it should be thought desirable or necessary to embank any portion of it, the scheme proposed for the Middlesex side will not in any way interfere with it.

They estimate the cost of the land, making compensations, constructing the embankment and roadways, and also acquiring the property in the City for and forming the new street to the Mansion House, at £1,500,000. This amount, however, would be reduced should it be thought right to dispose of any of the reclaimed land on the bank of the river for building purposes.

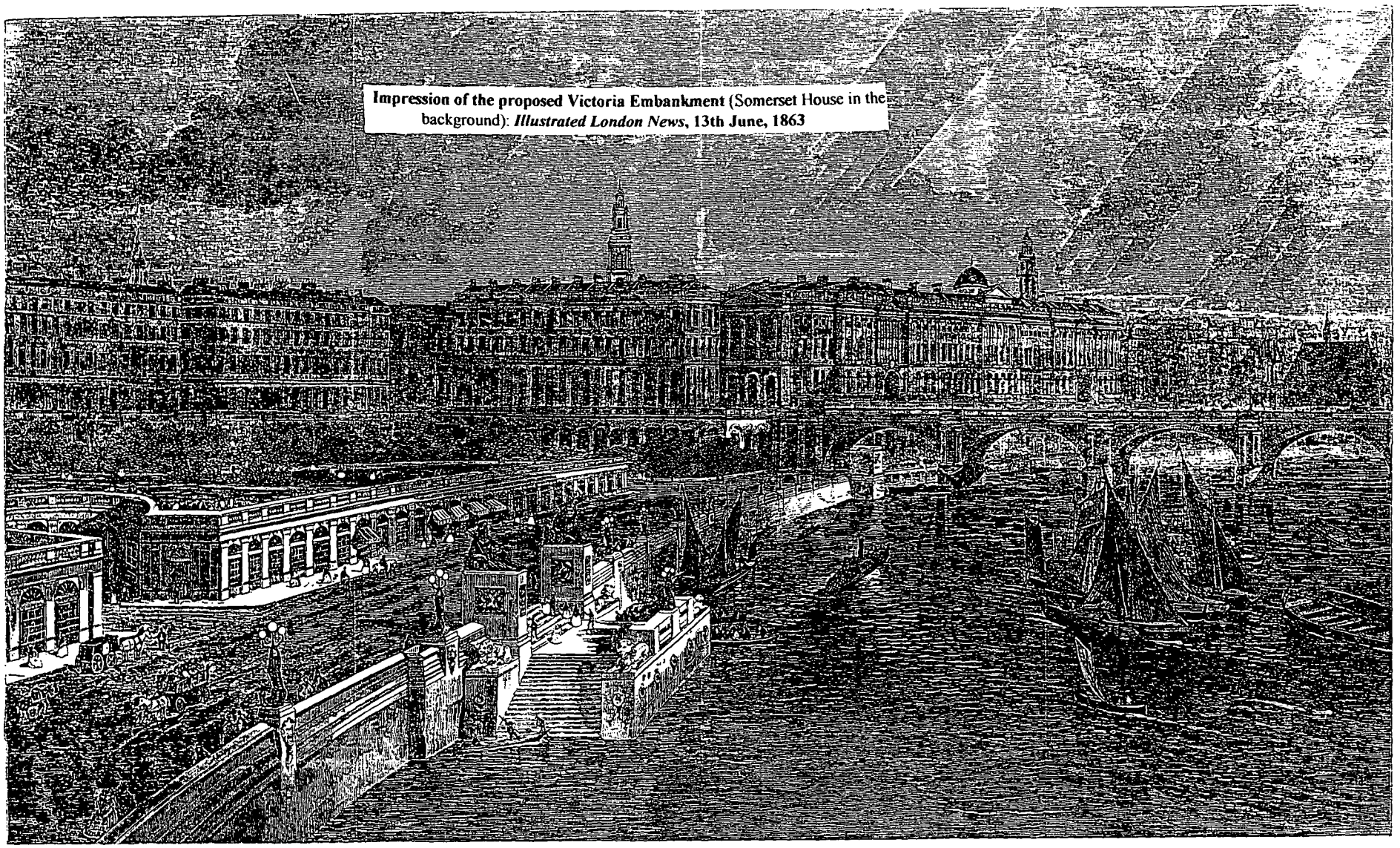
Parliament having appropriated the coal dues to provide for the outlay necessary for this great work, it only remained for the commissioners to express their opinion as to the "means of carrying the same into execution."

Looking at the magnitude of the work, the important and varied interests, both public and private, which will be affected, and the urgent necessity for its early completion, they are of opinion that the control and management of the undertaking should be intrusted to a special commission, appointed by her Majesty, in order to ensure the speedy and economical attainment of an object so much needed by the public, and affording so favourable an opportunity for the improvement of the river and adornment of the metropolis.

The report is signed by William Cubitt, Joshua Jebb, Douglas Galton, Edward Burstal, Henry A. Hunt, John Robinson M'Clean, and Henry Kingscote, secretary.

LONDON: Printed and Published at the Office, 198, Strand, in the Parish of St. Clement Danes, in the County of Middlesex, by OSBORN C. LAMBERT, 198, Strand, aforesaid.—SATURDAY, AUGUST 10, 1861.

Impression of the proposed Victoria Embankment (Somerset House in the background): ***Illustrated London News*, 13th June, 1863**



LANDING-STAIRS, ROADS, AND ORNAMENTAL GARDENS BETWEEN HUNGERFORD AND WATERLOO BRIDGES, DESIGNED FOR THE METROPOLITAN BOARD OF WORKS BY MR. J. W. BAZALGETTE.

one section to the other. The first section is from Westminster to Hungerford Bridge, the second from Hungerford Bridge to Waterloo, and the third from Waterloo to Blackfriars Bridge.

"A continuous line of embankment wall would not in itself be productive of much architectural effect. The present landing-places for steam-boats are extremely ugly, and there would be much difficulty in connecting the river wall with the existing bridges so as to produce an effective and consistent design.

"At each of the bridges there are, and must be, landing-places for steamers, and midway between the bridges there are landing-places of some description, which will have to be maintained.

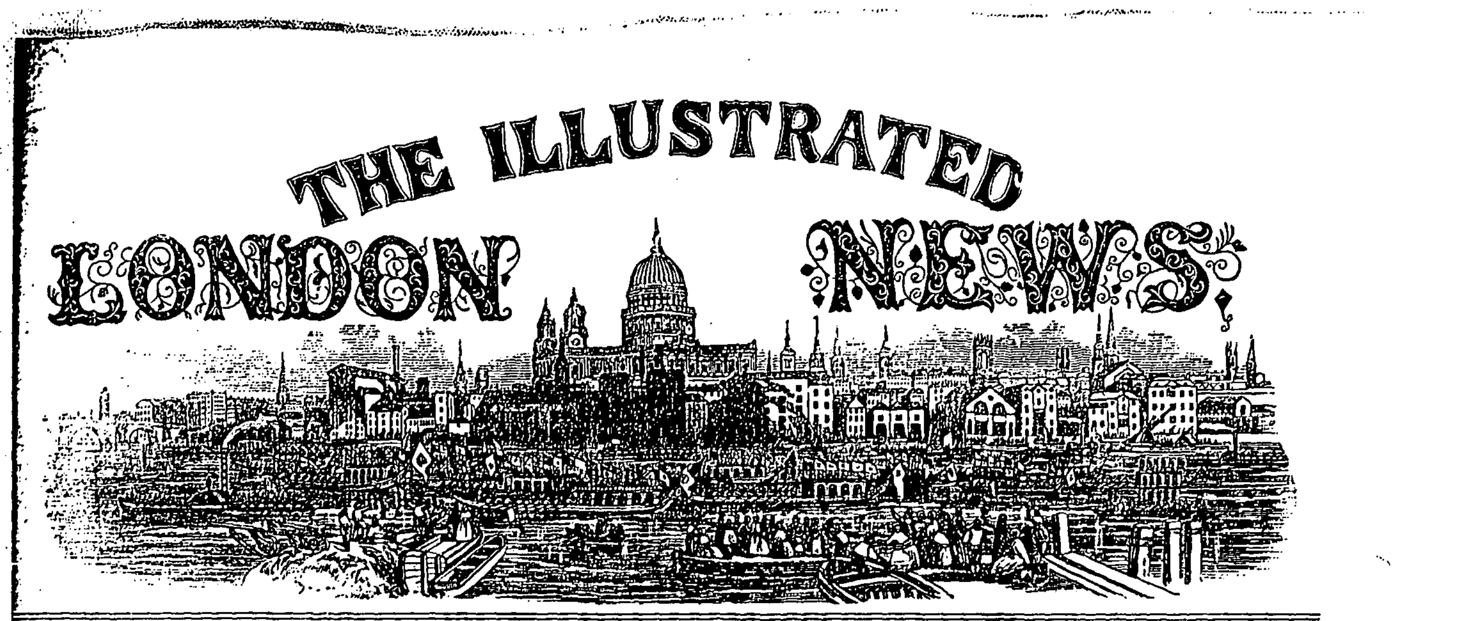
"To meet these requirements it is proposed to treat each length of embankment from bridge to bridge as a complete design, and to make the steam-boat piers and landing-places prominent and effective as well as useful and necessary features.

"At Westminster Bridge the roadway, which rises at an inclination of 1 in 80 to the level of the bridge, is set back some 30 ft. or 40 ft. from the face of the embankment wall; and the intervening space would be reserved as a promenade and steam-boat pier, having access from the bridge by a wide and imposing flight of steps opposite the Houses of Parliament. This will terminate without abruptness the varying styles of architecture at this point. Between Westminster and Hungerford Bridges would be landing-stairs for smaller craft; and here it is proposed to introduce the beautiful water-gate now situated at the end of Buckingham-street, and erected after a design by Inigo Jones. On each side of Hungerford and Waterloo Bridges would be steam-boat landing-places, the dumbies for which would be partly concealed within recesses formed by projecting into the river, in front of the general line of embankment, massive granite piers with moulded pedestals rising about 30 ft. above the roadway, and hereafter to be enriched with bas reliefs and surmounted by groups of statuary.

"Half way between Hungerford and Waterloo Bridges it is proposed to construct a flight of landing-steps 60 ft. wide, projecting into the river and flanked at each end with massive piers, rising to the level of a few feet above the roadway, and hereafter to be surmounted with colossal figures of river deities or other appropriate groups. It is proposed to form an approach for foot passengers from the high-level roadway to the river by a second flight of steps, descending to the level of the lower or embankment roadway, which would add much to the effect of this central feature as viewed from the river. On each side of this approach a line of shops could be erected on the land side of the embankment roadway, the backs of which would form a retaining wall to the ornamental crescent and promenade above them.

"Between Waterloo and Blackfriars Bridges, and in front of Arundel-street, a steam-boat pier would be constructed, in lieu of the present Essex-street pier, designed upon the same principle as those adjoining the bridges.

"The embankment wall itself has been enriched with mouldings of a simple character down to the level of high-water mark, the continuous line of moulding being broken by the introduction, at intervals, of massive blocks of granite to carry ornamental lamps, and by occasional recesses for promenade seats.



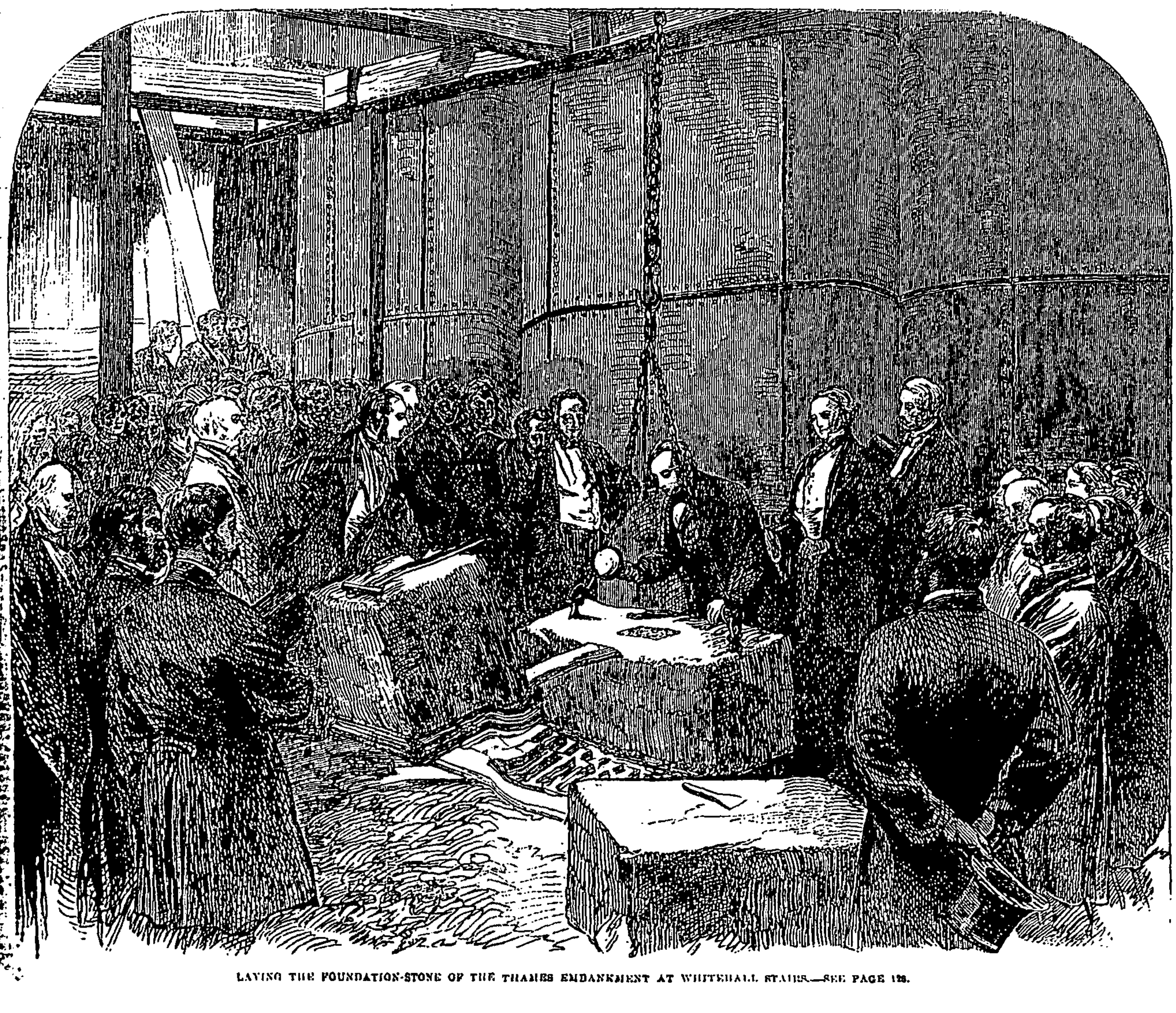
No. 1271.—VOL. XLV. SATURDAY, JULY 30, 1864. WITH A SUPPLEMENT, FIVEPENCE.

THE SESSION OF 1864.

A FAIR and complete review of a Parliamentary Session is not always feasible immediately upon its close. Party passions have not wholly subsided; legislative blunders or benefits have not had time for development; the mind is too much distracted by a multiplicity … proportions of g… can hardly be … hensive, and just … considerable dist… and treatment. On the other hand, however, public interest in the character and course of the Legislature is evaporated by the prorogation; and none but quarterly reviews can be got to put forth—none but studious politicians can be enticed to read—elaborate and exhaustive analyses of the proceedings of Parliament when once the members of the two Houses are dispersed and what is aptly called "the dead season" has commenced. Fully aware, therefore, that any review of the Session of 1864 made at the present … study which, besides being impossible just yet, would be out of place in these columns.

The Session of 1864 can hardly be called an eventful one in comparison especially with many of its predecessors, nor, in regard to actual legislation, a fruitful one; but it has been by no means an unimportant one. Parliament, during its continuance, has not added so largely nor so profitably to the statute book as on many former occasions, and such additions … al con… together … delling, … ne. It … sses to … hen the hands that sustained them have been stricken by death. It has evinced concern for the distressed, both in the manufacturing and metropolitan districts, and has extended over a larger area of juvenile labour its protecting shield. Without

Laying the foundation stone of the Victoria Embankment; note the caissons in the background: *Illustrated London News*, 30th July 1864



LAYING THE FOUNDATION-STONE OF THE THAMES EMBANKMENT AT WHITEHALL STAIRS.—SEE PAGE 128.

The Victoria Embankment in course of construction at Temple Gardens;
***Illustrated London News*, 4th February 1865**

PROGRESS OF THE THAMES EMBANKMENT AT THE TEMPLE GARDENS.—SEE PRECEDING PAGE.

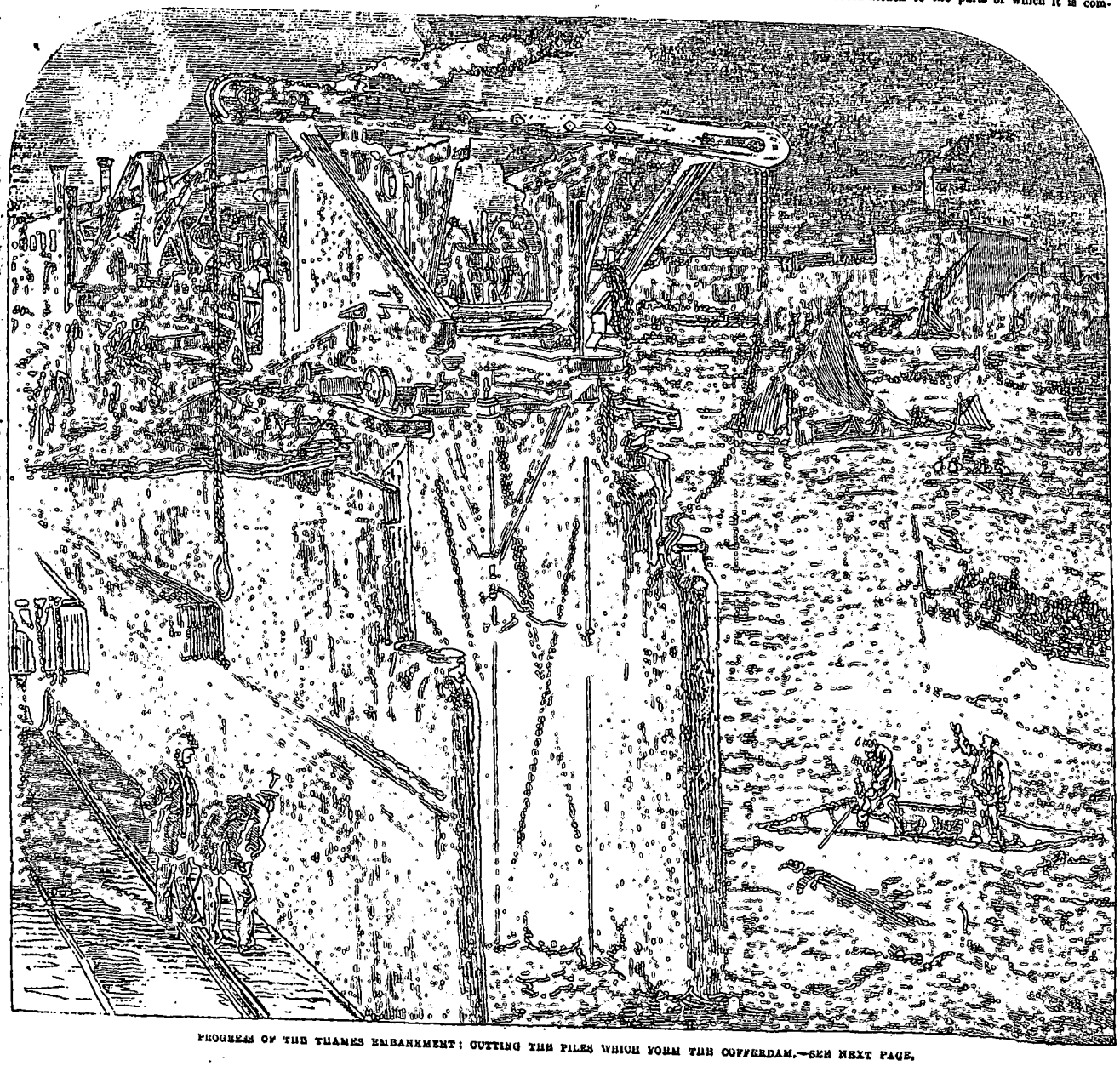
THE ILLUSTRATED LONDON NEWS.

Cofferdam being formed: *Illustrated London News*, 5th May, 1866

No. 1369.—VOL. XLVIII. SATURDAY, MAY 5, 1866. WITH A SUPPLEMENT, FIVEPENCE

METROPOLITAN MUNICIPALITIES.

A MEETING of gentlemen desirous of establishing municipal corporations within the metropolis, recently held at No. 6, Whitehall, under the presidency of Mr. T. H. Walter, suggests for consideration a question the importance of which it would be difficult to overrate. In truth, it is one which, for a long time past, has been asserting its claims to notice more and more impressively, until at length the period may be concluded to have arrived beyond which a fair settlement of it cannot be safely postponed. How is that populous district, that "province covered with houses," that aggregation of several cities, or rather of communities that, under any other circumstances, would be accounted cities, to which we give the general designation of London,—how is it to be organised with a view to its municipal government? Between two and three millions of people living within a circle the radius of which is scarcely more than half a dozen miles, and constituting a distinct entity in regard to the conditions which attach to the parts of which it is com-



PROGRESS OF THE THAMES EMBANKMENT: CUTTING THE PILES WHICH FORM THE COFFERDAM.—SEE NEXT PAGE.

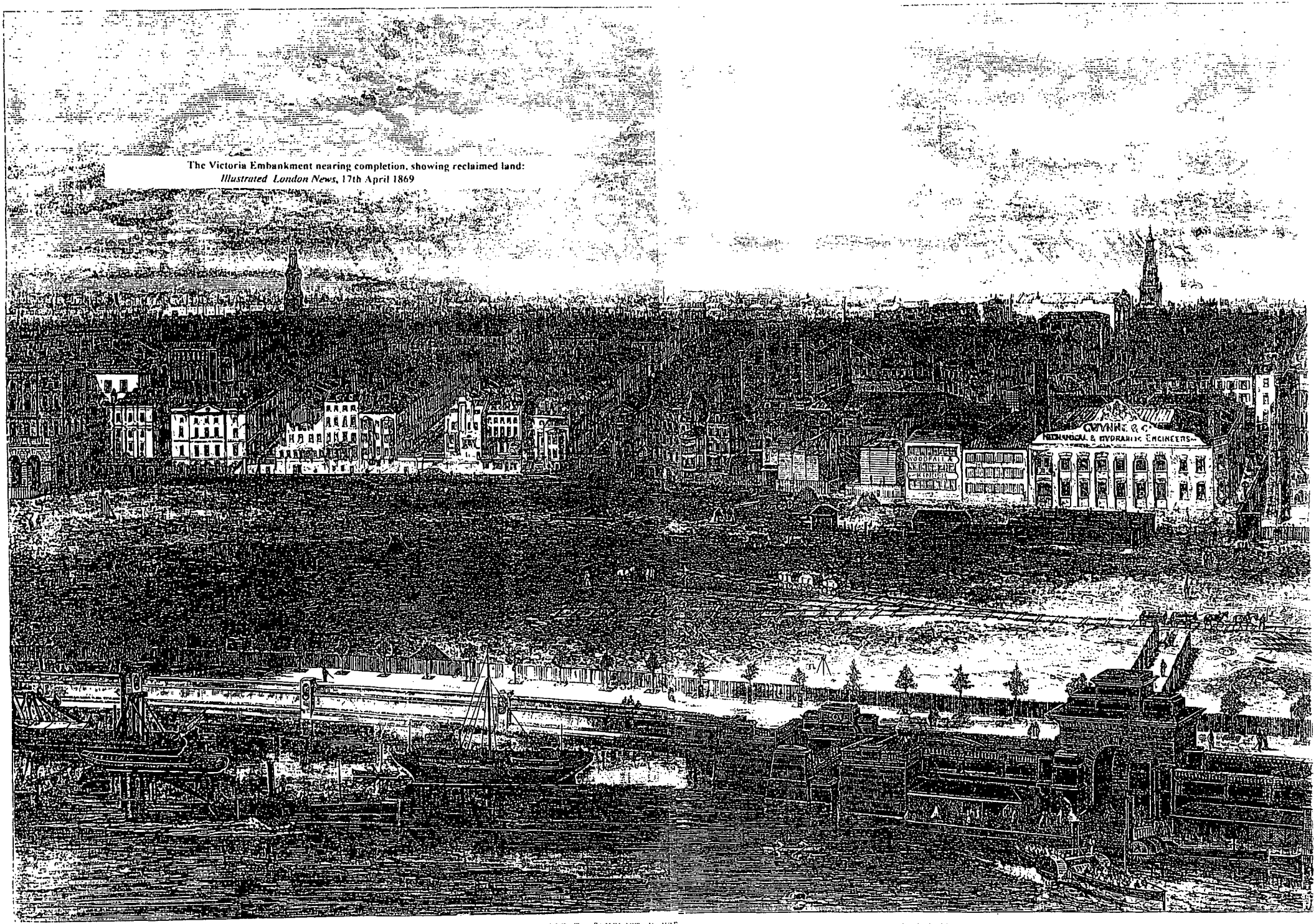
Section of the Victoria Embankment near Charing Cross railway bridge:
Illustrated London News, 22nd June 1867

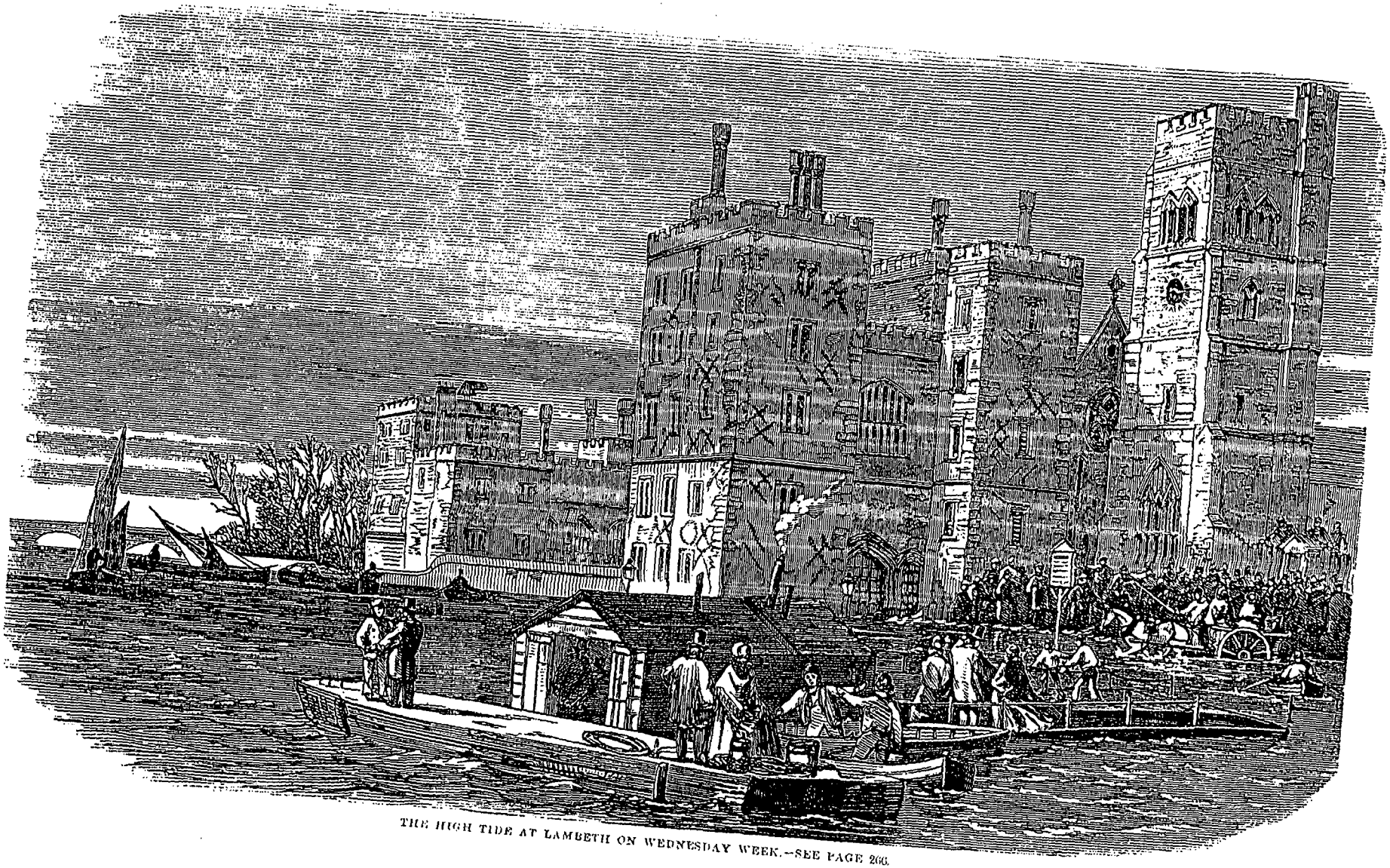
SECTION OF THE THAMES EMBANKMENT, SHOWING (1) THE SUBWAY, (2) THE LOW LEVEL SEWER, (3) THE METROPOLITAN RAILWAY, AND (4) THE PNEUMATIC RAILWAY.—SEE NEXT PAGE.

Southern (Albert) Embankment in course of construction:
***Illustrated London News*, 25th January 1868**

WORKS OF THE SOUTHERN EMBANKMENT OF THE THAMES AT LAMBETH.—SEE PAGE 84.

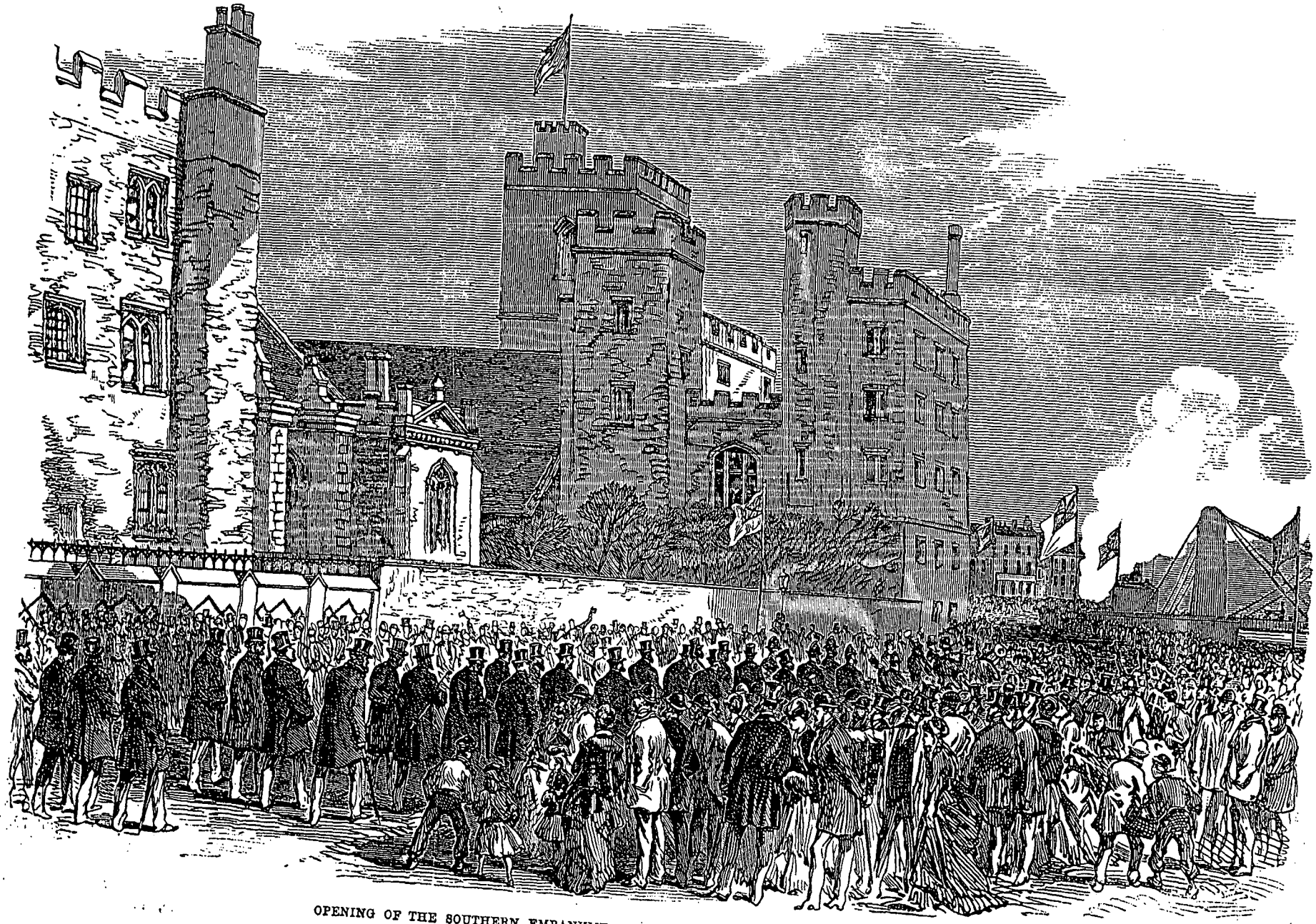
The Victoria Embankment nearing completion, showing reclaimed land:
Illustrated London News, 17th April 1869





THE HIGH TIDE AT LAMBETH ON WEDNESDAY WEEK.—SEE PAGE 266.

High Tide at Lambeth Palace before the construction of the Albert (Southern) Embankment, (*Illustrated London News*, 1860)



OPENING OF THE SOUTHERN EMBANKMENT OF THE THAMES, AT LAMBETH.—SEE PAGE 567

Opening the Southern Embankment,Lambeth Palace (*Illustrated London News*, 1869)

There was virtually no dissension from these views in the discussions that followed, which reflected the now widespread acceptance of this material, but the subject continued to engage the attention of the profession in the years not only in Britain but in Germany, where public testing procedures for the product were established while a lively correspondence between engineers and scientists in the two countries ensued.[67] Portland cement was the subject of five further papers given to the Institution in the following decade.[68] In one of these an engineer called Bernays who had been engaged in the construction of the dockyard at Chatham, (in the Medway valley, the home of the Portland cement industry) described the reluctance to specify its use in that project as late as 1867. This, despite the fact that its use for such purposes had been proposed by one of the earliest advocates of the material, Captain H.Y.D.Scott, R.E., in a paper read at Chatham in 1862.[69] However Bernays added that "For more than ten years past [he was writing in 1880] Portland cement has superseded every other description of mortar for brickwork and masonry, as well as for all varieties of concrete".[70] In the space of a few years, in the late 1860s, Portland cement had progressed from being a material which was regarded with considerable caution by engineers to one that was virtually the industry standard and it appears that the catalyst for the transition was the adoption of the material for the main drainage works and the associated testing procedures which both improved quality standards in the industry and instilled confidence in the product. Bazalgette's enterprise in adopting the new material conferred upon it an important seal of approval while his caution in establishing thorough testing procedures may be regarded as a significant contribution to concepts of quality control in this young industry.

Bazalgette as Consultant

Besides his work in London Bazalgette was active in other spheres of his profession and his reputation ensured that his services were frequently called upon by other communities in Britain and overseas. The *Proceedings* of the Institution of Civil Engineers record over one hundred contributions by Bazalgette either in the form of his own papers or in discussions of papers given by others.[71] The former include a paper printed in the first volume of the Institution's *Proceedings*[72] on the subject of

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[67]M.P.I.C.E., 62, 1880, p.98
[68]M.P.I.C.E.: 41, 1874-5, pp. 125-57; 54, 1878, pp. 264-75; 62, 1880, pp. 67-249
[69]Papers of Corps of Royal Engineers; Vol. XI, New Series, 1862, p.220
[70]M.P.I.C.E., 62, 1880, p.88
[71] See Institution of Civil Engineers *Name Index* for details.
[72]M.P.I.C.E. Vol. 1, 1840

land reclamation from the sea, based upon his early experience in Northern Ireland as well as his paper on London's intercepting system and his presidential address on the same subject.[73] His contributions to discussions on papers given by others range from familiar territory such as sewage treatment processes (fifteen contributions) to comments on the water supply to the fountains in Trafalgar Square, the adoption of novel mechanical devices for dredging and the geological problems of constructing a tunnel between Dover and Calais.[74] However an examination of the archives of the Institution of Civil Engineers suggests that he was most frequently engaged either as an expert witness in a dispute involving proposed construction work or as a consultant in the preparation of drainage plans for towns and cities outside the metropolis. Sometimes Bazalgette himself prepared the plans and sometimes he was called in for a second opinion on plans devised by others.

Bazalgette's Plans for Cambridge, Norwich, Budapest and Mauritius[75]

On 6th February 1866 the town surveyor for Cambridge invited Bazalgette to visit the town and advise on a scheme to divert sewage from the river Cam.[76] This followed a resolution by the town council's *Cam Purification Committee* that "to discharge sewage matter into the Cam between Mill Lane and Jesus Green is to convert the River into an elongated cesspool", words which echoed the ordeals of London in the previous decade. Bazalgette visited Cambridge on 16th March, charging the substantial fee of one hundred guineas and prepared a scheme which involved intercepting the sewage before it reached the river and conducting it to a point two miles downstream where it would be stored, pumped and used to irrigate an eight hundred acre field at Chesterton. He estimated the cost as £27,059. The council was evidently reluctant to spend this sum since, twelve years later, Bazalgette's advice was again sought, the explanation being given that the Public Health Act, 1875, now gave the council greater power to implement a scheme than they had possessed at the earlier date.[77] Bazalgette, together with a firm of engineers called Law and Chatterton, devised a modified scheme which extended the drainage area to Newnham. He devised a similar scheme for Norwich in 1865, also involving sewage irrigation downstream of the city.

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[73]M.P.I.C.E., Vol. 24, 1864-5
[74]See for example M.P.I.C.E. Vol. 19, page 42; vol. 37, p.152; and vol. 54, page 32
[75]Appendix 5 lists Bazalgette's reports on the drainage of towns other than London
[76]I.C.E. Archives; Ref. 1865 BAZ RDT manuscript volume pp. 489 et seq.
[77]I.C.E. Archives; Octavo tract; vol. 307

More surprisingly, in the midst of all his other responsibilities, Bazalgette found time in 1869 to visit Budapest[78] in response to a request from the Burgomeister and Sir Morton Peto whose civil engineering firm had been advising the City Council on how they could clean up the Danube.[79] Bazalgette recommended a system of three intercepting sewers and one outfall to the river downstream of the city and estimated the cost as £204,646 if executed by Morton Peto.He emphasised the beneficial effects of the scheme on the health of the inhabitants of the city, then numbering two hundred thousand:

> "Having carefully examined the city and studied the levels and other data connected with the drainage of Pest which have been placed in my hands, I have now the honour to submit for your consideration a plan, section and estimate of a scheme which I have prepared for its improved drainage...No -one can calculate how great the saving of life may be in case the City should be visited by Cholera and Fever".[80]

The City Council of Pest appears to have been no more willing than English counterparts to spend the money required since, five years later, they consulted Bazalgette again who replied, on 18th May 1874 that, before offering further advice, he would like them to pay him the £1,208 fee due "in payment for my time and thought in preparing the plans...after the use that has been made of my ideas by the City authorities, and their recognition of the soundness of the principles laid down by me".

His advice was sought even further afield when the Crown Agents asked him to devise a plan for the drainage of Port Louis, Mauritius, in 1869 but on this occasion he sent his son, Edward, to carry out the field work. The town was at that time dependent upon the removal of night soil by carts but Bazalgette dismissed this as a long-term solution by citing the experience of Paris where "The Paris system of removing all night soil by carts...is organised with all the precision and discipline of a military nation", despite which the Seine was frequently polluted. Bazalgette again devised a system of intercepting pipe sewers, to be made in England, shipped to Mauritius and assembled there at an estimated cost of £204,616

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[78]Perhaps this was unwise; in October 1869 Bazalgette was absent from work for a week owing to ill health; see page 201, note 18

[79]I.C.E. Archives; B867 BAZ RDT pages 454-511

[80]Ibid. pages 454 and 459

Bazalgette as Expert Witness

Besides his work in designing drainage schemes for communities outside the Metropolis Bazalgette was frequently called in as an expert witness to testify to the suitability or otherwise of projects designed by others. This work continued after his retirement from the post of Chief Engineer to the Board. Drainage schemes devised by Charles Austen for St Petersburg and for Berlin by an engineer called Frederick Barry were sent to Bazalgette for his opinion. The plans for Berlin had been criticised by Baldwin Latham as "the most contemptible thing as a proposition for the drainage of a town which I have ever witnessed" and Barry, understandably aggrieved by this judgement wrote to Bazalgette "I ask you candidly for your opinion on my project for the drainage of Berlin" and invited Bazalgette to condemn Latham's insult.[81]

In more conventional circumstances he was called upon by parties to legal disputes. In 1874 he was asked by J.F.Bateman, a resident of Moor Park near Farnham, Surrey, to give his opinion on the causes of pollution of the river Wey. Bazalgette wrote to him reporting that "I examined the River Wey from Moor Park to the neighbourhood of the Gostrey Meadow, Farnham" and giving his opinion that the pollution was caused by Farnham's pipe sewers.[82] Bazalgette's intervention did not resolve the dispute since, as observed in Chapter Two, the matter had to be taken to Aldershot County Court as *Bateman vs Farnham Local Board,* in January 1883.[83] A similar case arose in Birmingham in the years 1872 and 1874 when a group of citizens proceeded against the Borough Council over the pollution of the river Tame. Bazalgette swore an affidavit for the plaintiffs to the effect that the storm waters which were the cause of the pollution could be purified to a degree which would solve the problem.

He was also called as an expert witness to oppose schemes proposed by developers of railways, tramways and other facilities which met with the disapproval of local authorities. In May 1889, shortly after his retirement, he appeared as a witness for the London County Council (L.C.C.), successors to the Metropolitan Board, the Council being concerned that the proposed Central underground railway (the Central Line) would damage the Middle Level Intercepting Sewer. Having expressed his scepticism about the need for the railway Bazalgette testified to the Committee considering the London Central (Subway) Bill that its construction would damage the sewer in the

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[81]I.C.E. Archives B872 BAZ RDT pages 28-9; Bazalgette's reply is not recorded
[82]I.C.E. Archives: B872 BAZ RDT, p.260
[83]See above, page 77

vicinity of Shoe Lane and proposed that the railway company be required to deposit a bond of £25,000 as surety for the cost of repairs to the sewer should the need arise.[84] In the same month he appeared again as a witness for the L.C.C. in hearings on the Shortlands and Nunhead Railway Bill, in opposition to the company's plans to build its line across a recreation ground which Bazalgette had been involved in designing when he was Chief Engineer. Bazalgette's evidence on this occasion resonates with later concerns:

> "there is always a tendency in all parts of London for railway companies to take open spaces, because they can be more economically acquired, and, if there was not a public body to watch those open spaces, they would be very soon all absorbed and destroyed".[85]

The Odessa Contract

An embarrassing episode for Bazalgette concerned the "Odessa Contract". On 11th November 1863 the *Clerkenwell News* published a letter from "A.Ratepayer" who was very well informed on the tenders for the Northern outfall reservoir and the main contract for the Northern Embankment, both of which had been awarded to a contractor whom the Board often employed called George Furness. The writer claimed, correctly, that a company called Hickersley and Baylis had tendered £131,000 for the Northern outfall reservoir against Furness's price of £164,000. Moreover a contractor called Ridley, one of thirteen who had tendered for the contract,[86] had bid £495,000 for the Embankment against Furness's winning tender of £520,000. The writer questioned "how far Mr Bazalgette is fitted to be retained in his present office of Chief Engineer to the Board of Works" since it seemed that "acceptance goes by favour and not by merit"[87] The following week J.A.Nicholay, Board member for Marylebone, and an earlier rival to Thwaites for the chairman's role, replied to "A.Ratepayer" in terms which were very critical of Bazalgette. Nicholay stated that Ridley would have won the tender

> "but for the circumstances of our engineer emphatically stating he should place more reliance on Mr Furness whose knowledge, experience and capabilities were far superior. I have every reason to believe that such result would not have been obtained had the members known at the time that our engineer was about to receive from twelve thousand pounds and upwards

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[84]I.C.E. Archives, B890 BAZ CLR, page 462, *Proof of Sir Joseph Bazalgette*
[85]Ibid., page 153; *Sir Joseph Bazalgette's evidence*
[86]M.B.W. *Minutes*, 27th November 1863, p. 1070
[87]*Clerkenwell News*, 11th November 1863, p.2

as commission from Mr Furness for work to be carried out by him at Odessa".[88]

In the previous year Sir John Rennie had consulted Bazalgette on the suitability of Furness to execute a contract for draining and paving the city of Odessa, in the Ukraine. Bazalgette had recommended Furness, who agreed to pay 5% of the contract price to Rennie, of which one and three quarter per cent was to be paid to Bazalgette. In fact Bazalgette had made extensive enquiries into Ridley's background and had established that, although he had considerable experience as a sub-contractor on railway works in Canada,[89]he had no experience of tidal or harbour works and none of executing works on the scale of the Embankment contract, the second largest that the Board ever awarded. In Bazalgette's words:

> "I believe him to be an active and industrious man, capable of successfully completing a straightforward job; but I do not think he is competent, either from past experience, or from his judgement and engineering knowledge, to cope with...the great risks which must arise in the execution of that very important work".

In addition, Bazalgette had received confidential information from Waring Brothers, former employers of Ridley, to the effect that Ridley had appropriated one hundred pounds which should have been used to pay his workmen.[90] The Board set up a Committee of Enquiry into the affair and in his final evidence to it Bazalgette stated:

> "it is most important that the contractor should be a person of skill and experience and *possessed of great resources* (my italics). I was bound to advise the Board to this effect and Mr Ridley's tender was rejected".[91]

Bazalgette reminded the committee that he had originally recommended that the contract be awarded to a firm called Baker and Son but that this firm had wanted to impose an arbitration clause that the Board found unacceptable. Bazalgette had then recommended that the contract be re-advertised but this advice had been rejected and it was awarded to Furness. The committee declared that:

> "there has been nothing reflecting in any way on Mr Bazalgette's personal or

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[88]Ibid., 18th November 1863, p.2

[89]M.B.W. *Miscellaneous Reports*, no. 13, p.5, G.L.R.O.

[90]An account of Bazalgette's enquiries, with relevant correspondence, is included in M.B.W. *Minutes*, 30th December 1864, pp. 1291-1302

[91]M.B.W. *Miscellaneous Reports* no.11, 24th November 1863

professional honour and that he has throughout discharged his duties, both to the Board and their contractors, with ability, impartiality and integrity".[92]

The Committee nevertheless indicated their disapproval of the arrangement into which Bazalgette had entered and noted that he had agreed to forgo his commission.[93]

Public Interest: a "most extensive and wonderful work"

The construction of the system was closely followed in the press and in Parliament, receiving a degree of attention and comment which reflected both its significance in the life of the Metropolis and the importance attached by the Board to gaining and keeping support for the project amongst opinion formers. The attention was not always complimentary but became more so as the work progressed. Thus in September 1858 *The Observer*, referring to the Board's acquisition of a lease on its future headquarters in Spring Gardens, at the top of Whitehall, criticised it for having secured "a palace for itself before it has earned a high rank in the public esteem".[94] However once the works became visible the interest of the press was quickly aroused. The first comment appeared in the *Illustrated London News* on 19th February 1859 with an illustration of the commencement of the works on the high level sewer in Victoria Park, Hackney, together with an expression of gratitude to:

> "Old Father Thames [for] having last summer so loudly remonstrated against our tardiness in cleansing his bosom, and having threatened us with some sore disease if we continued to pollute him, for the fact of the spade, the shovel and the pick having at last taken the place of pens, ink and debate".[95]

Within two years a note of wonder replaced criticism in the pages of *The Observer*. In April 1861, shortly before the first part of the system came into operation, the newspaper commented:

> "It is two years since the most extensive and wonderful work of modern times was commenced, and yet the inhabitants of this metropolis, who are so deeply interested, seem to take little interest in the undertaking...It is hardly possible

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[92]M.B.W. *Miscellaneous Reports*, no. 13, p. 7

[93]M.B.W. *Minutes*, 27th November 1863, p.1070. Firth, J.F.B.: *Municipal London, or London Government as it is*, pp. 284-93, gives an account of this and of certain allegations concerning filling materials for the Victoria Embankment and the depth of foundations specified for the outfalls; neither was substantiated. This publication is in the G.L.R.O.

[94]*The Observer*, 26th September 1858, p.3

[95]*Illustrated London News*, 19th February 1859, p.173

> that such an undertaking could be finished in three years, or at a cost of only three millions of money".[96]

Both the three years and the three millions were significantly exceeded but such unqualified appreciation of works executed at the public expense are an interesting and unfamiliar reflection of the importance that was attributed to the project. Similar views were reflected in the *City Press* five months later. In a leading article entitled "The Main Drainage" the writer commented:

> "Looking at the results attained so far, we must do the Board the justice of uttering our opinion that it has accomplished wonders and if we were to contemplate the transference of its powers to the hands of government we should at the same time entertain grave doubts if the future progress of these immense undertakings would be prosecuted with one tenth the speed or with anything like the same efficiency. As to the cost, vast as it is, no-one can charge the Board with waste; in the proper mission for which it was created it has practised rigid economy and stern prudence, and let it have the praise it as well deserves."[97]

This is not to say that the Board was without its critics at this time. In February 1861 *The Marylebone Mercury* criticised the Board for increasing the salary of its architect from £800 to £1,200 and a month later an article entitled "The Uselessness of the Board of Works" took the members to task for wasting their time in naming streets and dealing with vestry grievances, but even this astringent publication was generous with its praise for the engineer and his works, stating that "To Mr Bazalgette no tribute of praise can be undeserved" and wondering at the fact that, in tunnelling beneath Woolwich, "So accurate were the designs that, when the different bodies of men met, there was not a deviation of a quarter inch in their projection"[98] These flattering comments followed a visit of inspection on which the newspaper's editor had been a guest the previous week which appears to have created the favourable impression the Board desired.

Such visits became a regular feature of the Board's public relations and were evidently effective in maintaining support for the enterprise. On 6th July 1862 *The Observer* contained a flattering account of a visit by one hundred and fifty members

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[96]*The Observer*, 14th April 1861, p.5
[97]*City Press*, 14th September 1861, p.4
[98]*Marylebone Mercury*, 2nd February 1861, p.2; 9th March 1861, p.2; 12th October 1861, p.2

of the Lords and Commons to inspect the Northern and Southern Outfall works and declared that "every penny spent is sunk in a good cause"[99] while two years later the *Marylebone Mercury* carried a long, humorous and good-natured account of a visit to the outfalls by members of Vestry and District Boards, five steamers being chartered by the Metropolitan Board for the visit which took place on 27th July 1864. The account was headed "The Main Drainage Works" and the opening sentence stated "That has at last been accomplished, which not long ago would have been regarded as an engineering castle in the air". Having described the works and the visit of inspection the *Mercury* described the lively lunch that followed and the toasts and cheers that accompanied the attempts of Thwaites, Bazalgette and others to address the gathering. However the writer then lamented "A most indecorous scene [that] marred what had hitherto been a merry gathering":

> "Mr Marley, a gentleman well-known and respected as a member of the Saint Pancras Vestry, rose at the conclusion of the regular programme of addresses, and endeavoured to say a few words, but he had hardly risen, before he was assailed from several quarters by large pieces of bread that remained from the luncheon".[100]

Mr Marley abandoned his attempts at speechmaking and the company, evidently fortified by their luncheon, proceeded to exercise themselves on the shoreline by walking and, in some cases, by organising barefoot races amongst themselves. The last group may have been amongst those who missed the returning steamers and had to be conveyed home via the temporary railway that had been laid to convey workmen and materials to the site. The indulgent tone of the account suggests that this was a particularly successful piece of news management by the Board.

The City, some of whose privileges had been weakened by the authority of the Board, remained a critical onlooker, particularly with regard to the Board's finances, and the *City Press* reflected some of these anxieties. In April 1863 the newspaper reported criticism by Dr Abraham,[101] at the City Court of Sewers, of Thwaites's request to extend the borrowing powers of the Board by £1,200,000, commenting that these things were handled better in the City and adding that the latter body had appointed a special committee to oversee any attempts by the Board to promote Bills which would infringe its privileges.[102] In May 1865 the Court of Common Council became

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99*The Observer*, 6th July 1862, p.3
100*Marylebone Mercury*, 30th July 1864, p.2
101Abraham, 1807-64, was a member of the Court of Sewers from 1847 until he died
102*City Press*, 4th April 1863, p.2

similarly exercised by a reported plan to reward Bazalgette and his team of engineers with a special bounty. This proposal had originated with a member of the Board called Miller, a Member of Parliament who, on 28th April 1865 had proposed to the Board that:

> "in consequence of the near completion of the Main Drainage works, it be referred to the Main Drainage Committee to consider the propriety of granting a special remuneration to the Engineer and Assistant Engineers".[103]

A fortnight later the Committee supported the proposal:

> "It appears to your Committee that a very general feeling exists that there should be some recognition of the valuable and eminent services of the Engineer and his Assistants, in the successful carrying out of the scheme of the Main Drainage of the Metropolis, which is universally pronounced to be one of the greatest works of this or any other age".

The committee proposed a payment of six thousand pounds to Bazalgette (three times his annual salary) with a further four thousand to be divided between the three assistant engineers. Counsel's opinion was sought as to whether such a payment would be within the Board's powers but in the meantime the Board received numerous protests from the vestries of St Martin in the Fields, St Marylebone, Southwark, Hackney, Paddington, Bow and Kensington and decided to defer the matter.[104] It was never considered again though the City, despite its critical comments on the Board's management of its finances, "was not prepared to say that Mr Bazalgette was not entitled to some recognition of the great talent he had displayed in carrying out the main drainage work".[105] The Board may have shown some skill in news management by inviting appropriate figures to inspect the works in progress and attend opening ceremonies but the fact that it was prepared to contemplate paying such a large bounty to Bazalgette and his assistants is a firm indication of the depth of public interest and approval that appears to have characterised the work.

The official opening occurred on 4th April 1865 and the importance attributed to the occasion may be judged by the fact that the Prince of Wales was accompanied by other royalty, Members of Parliament, the Archbishops of Canterbury and York, the Lord Mayors of London and Dublin and numerous other dignitaries, including Edwin

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103M.B.W. *Minutes*, 28th April 1865, p.512
104M.B.W. *Minutes*, 12th, 19th and 26th May, 1865; pp. 561-4, 583-7, 629-30
105*City Press*, 20th May 1865 p.2

Chadwick. After inspecting the works in progress at Abbey Mills, the party crossed to the Southern Bank where Bazalgette explained the workings to His Royal Highness who switched on the four great beam engines, named Victoria, Prince Consort, Albert Edward and Alexandra, thus marking the official inauguration of the system.[106] Construction work continued for many years. Crossness was not completed until 1867 and Abbey Mills was opened in 1868.Eighteen months later, on 21st December 1869, the pumps at Abbey Mills were damaged by an explosion in the air chambers, probably caused by the accumulation of floating debris such as corks. This temporarily disabled the mechanism which was subsequently modified to prevent a recurrence, at a cost of £12,912.[107] The Western area was not connected to the system until 1875, the pumping station opening on 5th August. Nevertheless, the official opening on 4th April 1865 was a significant date in the project and was recognised as such, being extensively reported in influential Metropolitan publications such as *The Times, Marylebone Mercury* and *The Builder*, which was particularly generous in its praise:

> "That the Board has been admirably served by Mr. Bazalgette and all the engineering staff, we need not say; that fact is shown by structural work that is the admiration of all who have seen it".[108]

The Board appears to have planned an opening for Abbey Mills almost as grand as that for Crossness but these plans were scaled down when the Duke of Edinburgh was unable to perform the ceremony and the Board learned that the Parliamentary recess would mean that prominent politicians would also be unavailable.[109] Instead, the Board issued three tickets for the ceremony to each member and also invited members of Vestry and District Boards as well as representatives of the press.[110] The opening took place on 30th July 1868 but once again the Board took advantage of the occasion to draw attention to its continuing activity. In the second week of August, 1868, VIPs visited the new pumping station from Monday to Thursday and on the Friday the workmen who had built it, with their wives and families inspected the

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106M.B.W. *Minutes*, 7th April 1865, p.434; the beams, each weighing 47 tons, remained in use until 1953

107Institution of Junior Engineers: *Record of Transactions*, Vol. vii, 1896-7, p. 125; M.B.W. *Annual Report* 1869-70, p.12 and appendix 1, p.95; M.B.W. *Minutes* 23rd December 1869, p.1321, Bazalgette's Report to the Board

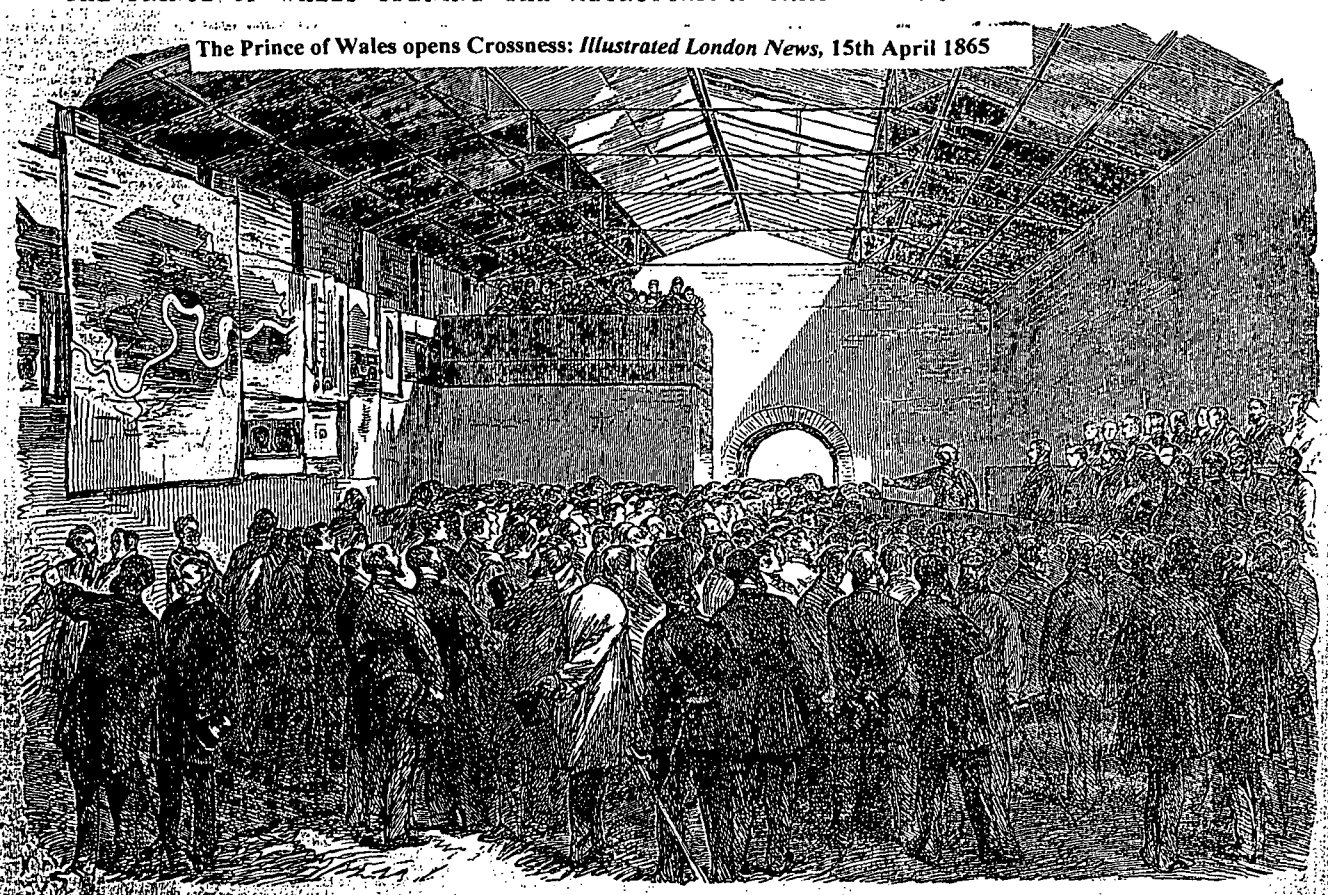
108*The Builder*, 8th April 1865, pp.238-9 contains a detailed account of the event

109M.B.W. *Minutes*, 3rd April,1868, p.879

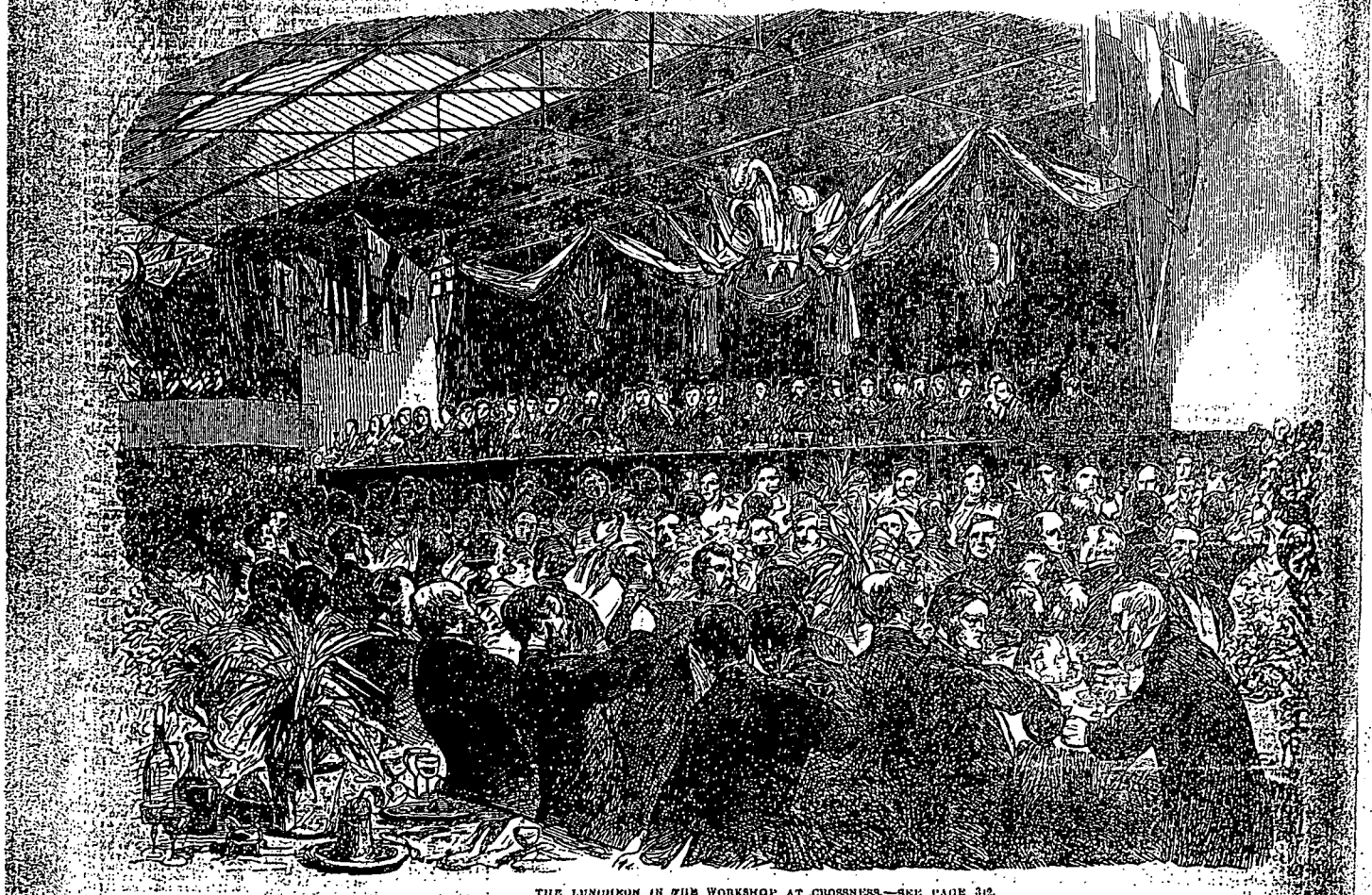
110M.B.W. *Minutes*, 1868, pp. 879, 956, 1026 et seq..

THE PRINCE OF WALES OPENING THE METROPOLITAN MAIN-DRAINAGE WORKS AT CROSSNESS.

The Prince of Wales opens Crossness: *Illustrated London News*, 15th April 1865

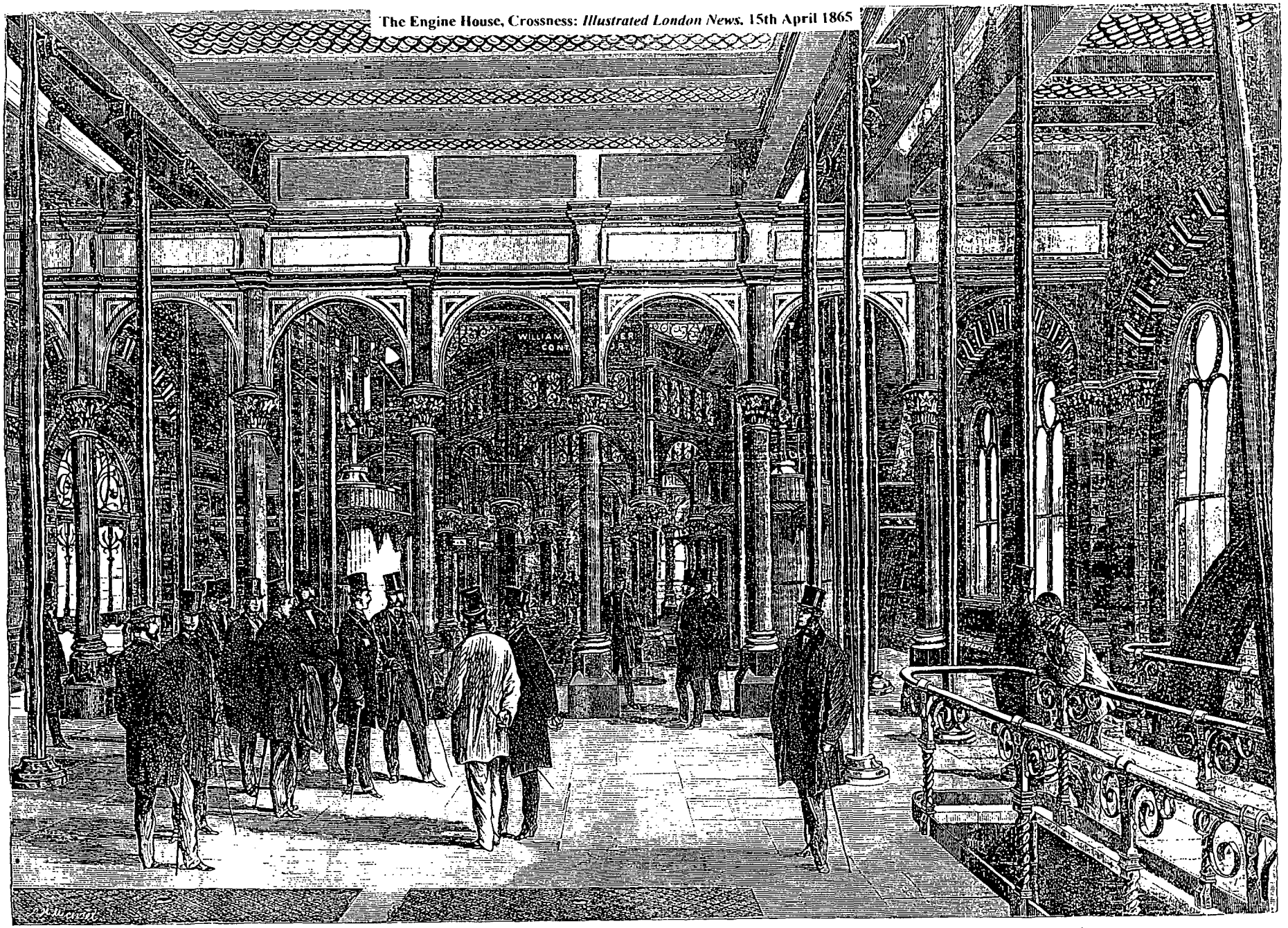


MR. BAZALGETTE EXPLAINING THE MAIN-DRAINAGE PLANS.



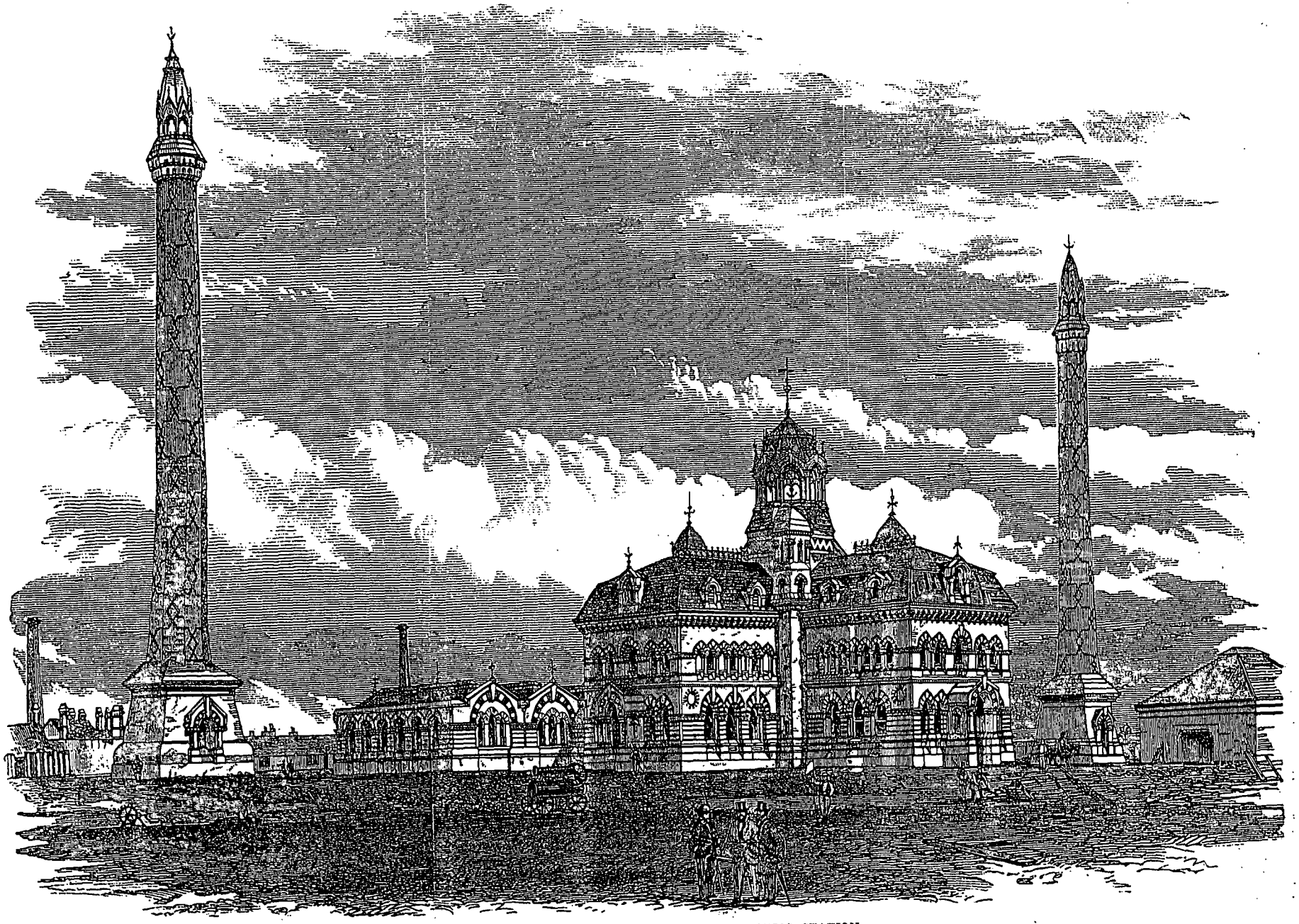
THE LUNCHEON IN THE WORKSHOP AT CROSSNESS.—SEE PAGE 342.

The Engine House, Crossness: *Illustrated London News*, 15th April 1865



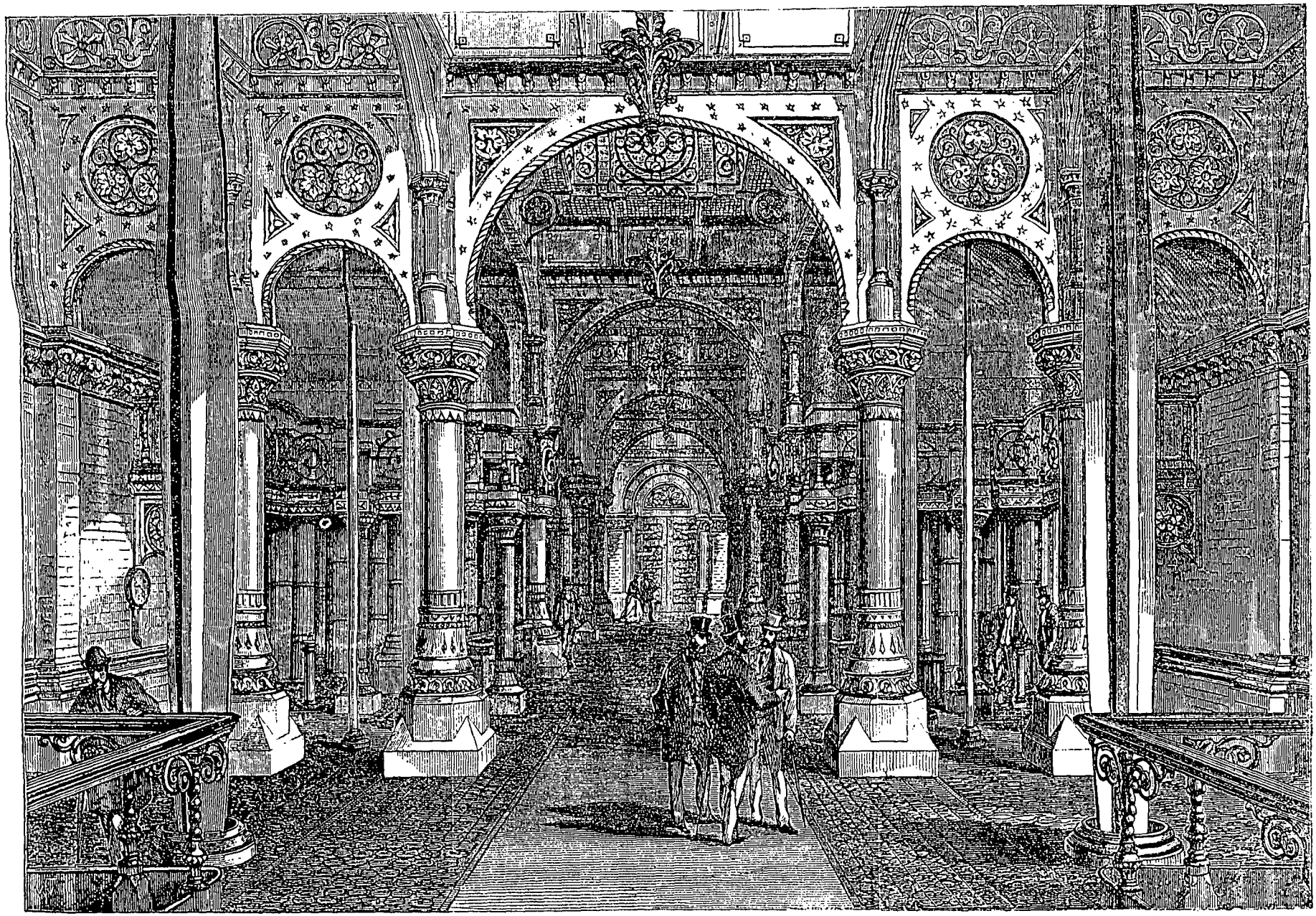
THE PRINCE OF WALES OPENING THE METROPOLITAN MAIN-DRAINAGE WORKS AT CROSSNESS.—INTERIOR OF THE ENGINE-HOUSE.—SEE PAGE 345

THE METROPOLITAN MAIN DRAINAGE.



GENERAL VIEW OF THE ABBEY MILLS PUMPING STATION.

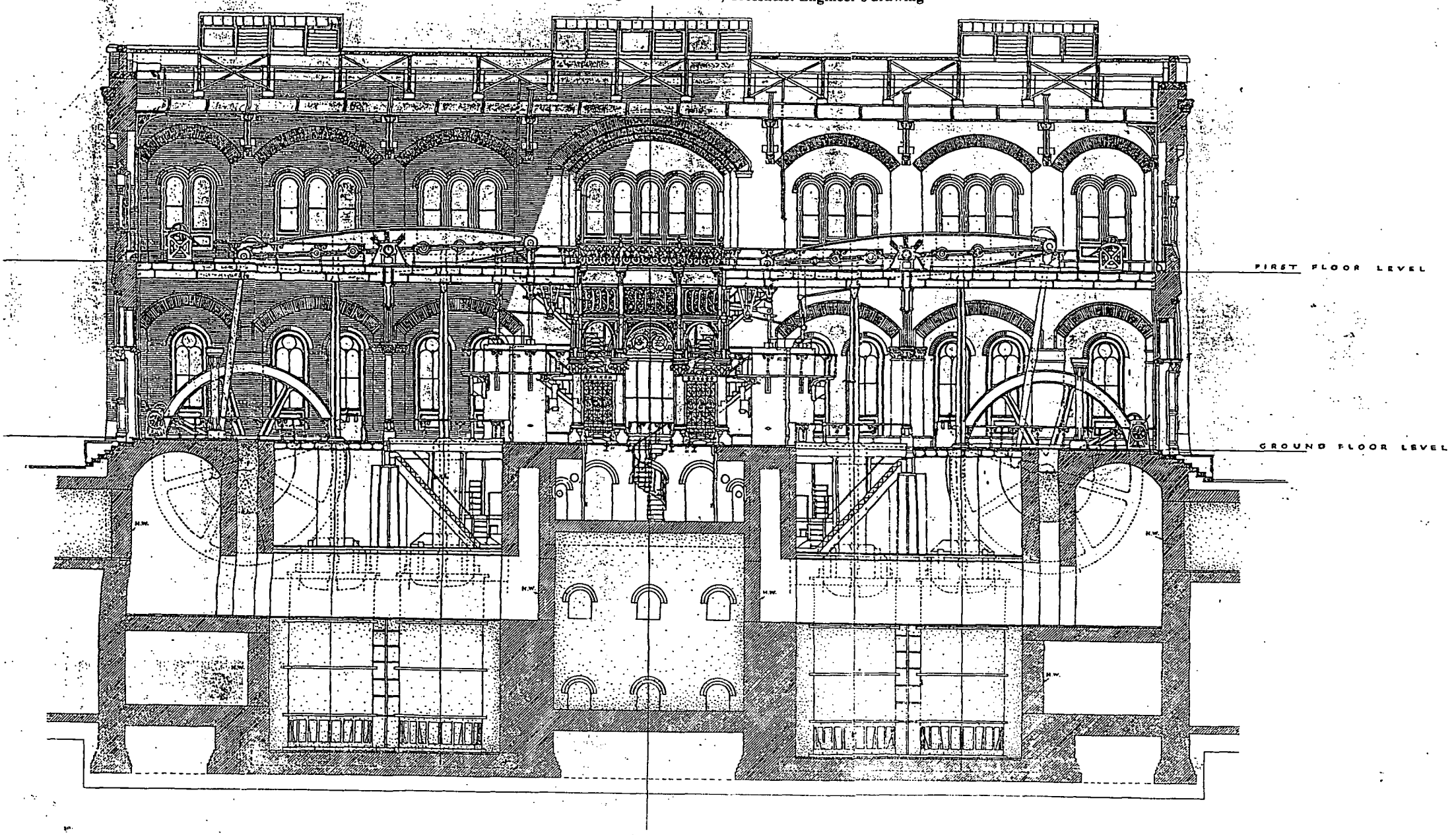
Abbey Mills Pumping Station, (*Illustrated London News,* 1868)



INTERIOR OF THE ABBEY MILLS PUMPING STATION.—SEE NEXT PAGE.

Interior of Abbey Mills Pumping Station, (*Illustrated London News*, 1868)

Longitudinal Section, Crossness: Engineer's drawing



LONGITUDINAL SECTION
LOOKING TOWARDS THE RIVER

installation as the guests of the Board and sat down to a meal.[111]. Not everyone was impressed. The Greenwich District Board censured Abbey Mills as "an elegant structure in a swamp [which] might be taken for a mosque or Chinese temple...for embellishments, no music hall in London could compare with it."[112]

As indicated above, parts of the system did not come into operation until many years after the official opening and the project continued to attract interest and comment throughout this longer period. In 1869 *The Builder* featured the Northern outfall sewer, now in full operation following the completion of the Northern low level system and the commissioning of Abbey Mills. It described the engineering problems the outfall had had to overcome, the bridges, rivers and railways it had traversed and commented:

> "We have before expressed a high opinion of the completeness of the preparations by the engineering staff of the Board...a completeness which has contributed to that efficiency of superintendence which we have also acknowledged".[113]

As the Western sewers neared completion *The Metropolitan* continued the sequence of favourable verdicts that had characterised comments on the scheme:

> "Our great elective body appears to have proceeded with far more energy, and to have made a far larger amount of real and satisfactory progress, than an executive department of the government would have accomplished in the same space of time".[114]

Besides building the intercepting sewers the Board was also responsible for maintaining the network of main sewers previously constructed by the Commissioners of Sewers and their predecessors. Thus in its annual report for the year 1863-4 the Board reported that, with most of the contracts for the main drainage under way, it had been turning its attention to repairing and enlarging the older sewers, on which it had spent £800,000 during that year.[115] The Board eventually re-constructed 165 miles of old main sewers (twice the length of the intercepting system

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111*The Builder,* 22nd August 1868, p.627, contains an account of the visits
112*The Builder*, 26th September, 1868, p.719
113*The Builder*, 6th October 1869, p.633. leading article
114*The Metropolitan*, 5th April 1873, p.216
115M.B.W. *Annual Report*, 1863-4, p. 13

itself) together with storm relief sewers, while 1,100 miles of new local sewers were constructed by Vestries under the supervision of the Board .[116]

Testing the System - Rain

In preparing his plans Bazalgette had to make assumptions about the likely future population of the area over which his responsibilities extended and the quantities of sewage that each would generate. He allowed for a population of 3,450,000, of which two thirds would be North of the River and one third South. This was about twenty-five per cent more than the population at the time he designed the system.[117] Bazalgette also estimated that the water supply to the population would increase from the figure then prevailing, of twenty to twenty-five gallons per day, to a more generous thirty gallons per day. Subsequently, both estimates were greatly exceeded. By the time of Bazalgette's death, in 1891, the population had already reached 4,225,000, more than twenty per cent above Bazalgette's estimate[118] and greater increases followed in the twentieth century, while per capita consumption of water grew to ninety gallons per day. In Bazalgette's lifetime the system proved adequate to cope with the greater volumes of sewage and, when further growth of the metropolis began to put strains upon the capacity of the system, further sewers were added.

However Bazalgette also had to accommodate rainfall whose volume over short periods was far less predictable. He estimated, from studies he had undertaken with Thomas Hawksley and George Parker Bidder in 1858, that about half the rain which fell would find its way into the sewers, the remainder being lost through evaporation or absorption into the soil.[119] He designed the system to cope with a quarter of an inch of rain falling during the six daytime hours of maximum sewage flow, a larger volume being accommodated when there was less sewage flowing (for example at night). However, as Bazalgette also observed in his 1865 paper to the Institution of Civil Engineers, violent rainstorms can occur in which as much as two inches of rain can fall in an hour. It would have been impractical to build sewers which had the capacity to handle these exceptional flows which, he estimated, would occur on a maximum of twelve days a year. He therefore constructed:

116M.B.W. *Annual Report*, 1888, pp. 16-19 gives an account of these works

117M.B.W. *Printed Papers*, vol.1 no.10, G.L.R.O.

118Hollis, J. and Seddon, A,: *The Changing Population of the London Boroughs*; statistical series no. 5, O.P.C.S. library

119M.P.I.C.E. vol.24, 1864-5, p. 292

> "overflow weirs, to act as safety valves in times of storms, have been constructed at the junctions of the intercepting sewers, with the main valley lines; on such occasions the surplus waters will be largely diluted, and, after the intercepting sewers are filled, will flow over the weirs, and through their original channels into the Thames".[120]

The system was subjected to its first severe test in the early hours of 26th July 1867. Between midnight and 9 a.m. three and a quarter inches of rain fell, more than had ever previously been recorded in such an interval, amounting to about one eighth of the average annual rainfall. *The Builder*[121] reported that the intercepting system had coped. Bazalgette, in his report to the Board on *The Extraordinary Rainfall on Friday, 26th July 1867*,[122] observed that:

> "the pumps were that day lifting a volume of water equal to nearly half an inch of rain over the whole of the low level area, nearly double the quantity they were intended to lift".

He commented that serious flooding had been confined to an area in Battersea in which houses had been built since the Main Drainage plans had been published; yet they had been built with basements in some cases twelve feet below high water mark - a level at which they could not be effectively drained by the intercepting system.

Eleven years later, in July 1878, heavy rains again tested the system, this time with less satisfactory results. The *City Press*[123], in a leading article, summarised the problem:

> "We have no wish to detract from the merits of the Main Drainage system, it is certainly a marvellous piece of scientific engineering. But it is confessedly inadequate to meet the whole of the wants of the metropolis. When the scheme was projected, some twenty years ago, there were only about three hundred thousand houses in London; now there are nearly five hundred thousand. Ten thousand miles of streets have grown to fifteen thousand. But beside this - and here we shall at once see how in one way the storm floods are to be accounted for - thousands of acres of land, which a few years ago were in use as pasturage or were under cultivation, and which naturally absorbed the rainfall, have been transformed into streets of houses, the result being to increase in a double sense the pressure put upon the sewers...In plain words, the Main Drainage system was designed for London as it was,

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120Ibid., p. 292-3
121*The Builder*, 17th August 1867, p.614
122M.B.W. *Miscellaneous Reports*, no.23
123*City Press*, 24th July 1878 p. 2

not for London as it is".

The Echo[124] supported the *City Press* asserting that "The defect has been produced by the extraordinary growth of London during the last twenty years - a growth which no man foresaw, and which even now, in all its aspects, is hardly realised".

Once again, the serious flooding had occurred South of the River, in the Wandsworth and Battersea area. Following the construction of the Victoria, Albert and Chelsea Embankments North and South of the river, the old wharves which remained in use to the East of the Southern (Albert) Embankment were inadequate to protect this low-lying area from flooding when high tides coincided with heavy rain. The Board failed to persuade the wharfingers to upgrade their river frontages. Bazalgette, in evidence to a Select Committee, observed that some of the firms had spent more on lawyers' fees opposing the requests of the Board than it would have cost them to comply with those requests.[125] The Board therefore promoted a Thames River (Prevention of Floods) Bill in response to the Wandsworth floods which received its second reading and was then lost through pressure of work but, following the Select Committee report, the Board succeeded in securing the passage of the Metropolis Management (Thames River Prevention of Floods) Amendment Act, 1879 (42 and 43 Vict. c.198)[126] which empowered it to require wharf owners to carry out flood prevention works and, where necessary, to execute the works itself and charge the cost to the owners.

Testing the System: Problems at the Outfalls

In its annual reports the Board made careful note of the favourable effects of the Main Drainage on the condition of the river. One of the consequences of the pollution of the river in the 1840s had been the disappearance of fish from the Thames (see Chapter One pages 22-3) so in its Report for 1865-66, following the official opening at Crossness, the Board referred to "the return of fish in large quantities to those parts of the river, which, previous to the execution of the works, were in the most polluted condition, namely, between Vauxhall bridge and the Pool"[127] and in the following years such comments became a regular feature of the Board's reports. Nevertheless,

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124*The Echo*, 27th August 1878, p. 3

125P.P.1878-9, vol.13, *Select Committee on Prevention of Floods*, Mins of evidence Q.679,

126M.B.W. *Annual Report*, 1878-9, pp. 22-3 describes this process

127M.B.W. *Annual Report*, 1865-6, p.17

even before Abbey Mills was opened in July 1868, doubts were being expressed about whether the problems of pollution had been solved or simply moved downstream. In 1867 there was a lengthy "Correspondence between Thames Conservancy Board and the Metropolitan Board of Works relative to deposits"[128] and in May 1868 the vicar and one hundred and twenty-three other inhabitants of Barking presented a petition to the Home Secretary concerning the condition of the river near the outfalls, claiming that the local water supply was being polluted.[129] Robert Rawlinson conducted an enquiry into the matter and concluded that pollution was caused by poor sewers in Barking itself and by chemical pollution of the River Roding which entered the Thames close to the outfalls.[130]

Rawlinson effectively exonerated the Board on this occasion but, following the publication of his report, the Thames Conservators proposed a Parliamentary Bill which would have forbidden the Metropolitan Board to discharge sewage into the Thames without de-odorising it. The Board opposed this measure in Committee and the resulting compromise was the Thames Navigation Act, 1870, which permitted the discharge of raw sewage but included a clause (20) which stated:

> "The Metropolitan Board of Works shall, at their own expense, keep the Thames free from such banks or other obstructions to the navigation thereof as may have arisen or may arise from the flow of sewage from their outfalls for the time being into the river".

Clause 21 provided for an arbitration process to be invoked in case of disagreement between the Board and the Conservators.

On 29th July 1874 the Thames Conservators informed the Board of the existence of banks of deposits in Halfway Reach, a little way downstream from the outfalls, implying that the outfalls were responsible and invoking the provisions of Clause 20. On Bazalgette's advice the Board responded to the Conservators' complaint by asserting that it had been taking soundings in the vicinity of the outfalls since 1867 and that, far from creating banks, the outfalls produced a "positive scour and improvement in the depth of the river referred to, to the extent of three hundred thousand cubic yards, or in other words that part of the river is actually ten inches deeper than in 1867."[131] In June 1877 the Conservators raised the matter again,

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128P.P. 1867-8, vol. 55
129P.P. 1868-9, vol. 50, p.475
130P.P. 1870 vol. 11
131M.B.W. *Annual Report*, 1875, pp.20-21

suggesting that the Board was responsible for the banks and that it should remove them by dredging at its expense. To support their case they appointed Captain Calver, R.N., who produced a report on 15th October 1877 which asserted that:

> "offensive accretions had recently formed within the channel of the Thames; that a material portion of these were within the neighbourhood of the sewage outfalls...that the constituents of these accretions were the same as those of the sewage, and that the latter was discharged in sufficient quality to account for them, the tidal streams in the neighbourhood of the outfalls being the effective cause ".[132]

In arguing against the discharge of crude sewage into the river Calver referred to a report that Bazalgette and another engineer had produced on the drainage of Glasgow, in which they had written: "We consider it quite out of the question to propose any scheme by which the sewage shall be discharged into the Clyde at any point, unless it has previously undergone purification". This was quoted in *The Times*[133] and brought a swift reply from Bazalgette who argued that "were Captain Calver's theory correct, the Thames and all other tidal rivers of the universe would long ago have ceased to exist". He questioned Calver's calculations and quoted other authorities in support of his argument that estuarial action generated far more silt from river banks than could be produced by human waste. Bazalgette explained that his recommendations that Glasgow's sewage be purified before discharge into the Clyde had been influenced by the fact that the banks of the Clyde were suitable for residential development "whereas the neighbourhood of the Metropolitan Outfalls is surrounded by bone boilers and glue and artificial manure works and they can bear no comparison". Bazalgette added that, in 1858, the Thames had become so offensive that "It was suggested that Parliament would have to abandon its sittings at Westminster whereas now I have the evidence before me of flounders being frequently caught in the neighbourhood of Westminster".[134]

On 7th December the Board considered Calver's Report and referred it to Bazalgette and on 15th April 1878 appeared the Board's formal rebuttal of Calver's conclusions, in the form of an elaborate report[135] from Bazalgette, Henry Law and George Chatterton.[136] They refuted Calver's allegations point by point and concluded that

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132P.P. 1884, vol.41, p.xxxiv

133*The Times*, 12th December 1877, p.8, col.1

134*The Times*, 18th December 1877, p.7, col.6

135P.P. 1884, vol. 52, pp. 15-37

136Henry Law was a civil engineer and meteorologist who had worked with Brunel on the Thames Tunnel; Chatterton was engineer to the West Kent Sewerage

"The present muddy condition of the river is caused principally by the unprotected state of its banks, which in many parts are being rapidly washed away and which are the result of a neglect of the duty which legislation has cast upon the Thames conservators"[137]. They reiterated the Board's claim that the outfalls had made the channel deeper.

The Builder took an unsympathetic view of the Board's stance and reported in critical terms the Board meeting at which Calver's report was considered:

> "As matters now stand, the metropolitan sewage discharge has reproduced, in mid-Thames, in an aggravated form, a nuisance which was felt to be unbearable in the upper portion of the river. The only difference now is that the nuisance, which was formerly brought down to London by the ebb, is now carried up to London by the flood".[138]

On 3rd September 1878 occurred an accident which sharpened the dispute but did little to resolve it. A pleasure steamer called the *Princess Alice* collided with a freighter called the *Bywell Castle* causing the *Princess Alice* to sink, with the loss of many lives.[139] The collision occurred a short distance upstream from the outfalls and it was suggested in some quarters that many fatalities had resulted from poisoning rather than drowning.[140] Woolwich Board of Health commissioned a chemist called Wigner to produce a "Report on the State of the Thames with special reference to the question as to whether the water was so contaminated by sewage discharge on 3rd September 1878 as to cause the death of any of the passengers on the *Princess Alice*." He reported that such deaths could have been caused by "uncontrolled vomiting" and his conclusions were reported in *The Times*.[141]

The Builder, drawing attention to the fact that the outfalls had on this occasion cast their discharge upstream, attacked Bazalgette and the Board for taking advantage of the Board's supposed exemption from those provisions of the Thames Conservancy Act which prohibited the discharge of pollutants and cited a number of judicial decisions which appeared to support the Conservators in their wish to rid the river of

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Board. Two chemists called Keates and Dupre contributed to the report

137M.B.W. *Annual Report*, 1878, p.18

138*The Builder*, 4th May 1878, p.467

139*See The Times*, 4th September 1878, p.7 col.4 for the earliest account, with extensive coverage on the days that followed

140*Saturday Review* 5th October 1878, pp. 423-4

141P.P. 1884, vol. 62 *Papers Relating to the Pollution of the River Thames*, contains Wigner's report; *The Times* commented on 24th October 1878, p.7, col. 6

untreated sewage.[142] It again gave strong support to the Conservators in a long leading article on 26th October 1878.[143] This represented a significant departure from the mood with which the journal had greeted the opening of Crossness thirteen years earlier.

In the autumn of 1878 Bazalgette and Sir James Hogg, Chairman of the Board, undertook four voyages of inspection around the outfalls in which they collected samples of water for testing.[144] Following Calver's rejection of the conclusions of Bazalgette and his fellow engineers[145] there followed, during the early months of 1879, an exchange of correspondence between the Board and the Conservators which failed to resolve the issue. On 4th November, 1879, therefore, arbitrators were appointed. The Conservators nominated Captain Douglas Galton (veteran of the earlier 1858 dispute over the outfalls, see page 99 et seq. above); the Board nominated F.J.Bramwell; and Sir Charles Hartley was appointed as umpire by the Board of Trade.[146] Twenty-five sittings were held between 4th November 1879 and 24th March 1880 and the findings of the arbitrators were unanimous. They concluded that river navigation had actually improved since the outfalls were constructed; that the banks complained of resulted from the Conservators' own dredging operations, which had altered the flow of water; and that "we are therefore of opinion that the Metropolitan Board of Works should not be called on to remove or contribute any portion of the expense of removing the three banks or any of them".[147]Bazalgette added his own riposte in his evidence to the Commissioners, repeated in his annual report, declaring that "Captain Calver's imaginary sewage zone in the lower reaches of the river can have no existence".[148]

The Board was thereby again exonerated from responsibility but the problem remained of the lower reaches of the river being polluted. On 4th October 1878 J.B.Monckton, clerk to the City of London, had written to the Board complaining

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142*The Builder,* 3rd August 1878, pp. 796-8

143*The Builder*, 26th October 1878, pp.1107-9

144M.B.W. *Annual Report*, 1878, p.20; reported in *The Builder*, 7th December 1878, pp. 1275-6

145M.B.W. *Minutes* , 11th October 1878, p.436

146F.J.Bramwell, 1818-1903; Civil Engineer; President of I.C.E. 1884-5; Sir Douglas Hartley, Civil Engineer specialising in river and harbour works: Odessa, the Nile, Danube, Mississippi and Scheldt

147M.B.W. *Annual Report,* 1880, p.21

148M.B.W. *Annual Report* 1878-9, Bazalgette's Report, p.135

about the condition of the river at the outfalls[149] but nothing was done pending the report of the Commissioners. On 14th December 1881 fourteen members of the Port of London Sanitary Committee wrote to the Lord Mayor and Common Council recommending that they apply to the Home Secretary to enquire into the condition of the river at the outfalls, under the provisions of the Metropolis Local Management Amendment Act, 1858, clause 104.[150] The Port of London's Medical Officer, William Collingridge, had prepared a report which estimated that, in the vicinity of the outfalls, sewage could constitute as much as one fifth of the volume of fluid. Three months later, on 7th March 1882, a group of merchants, traders, shipowners and the representatives of dock and shipping interests on the Thames held a meeting and drafted a memorial to Gladstone asking that a Commission be appointed to enquire into the condition of the river. Sixteen Members of Parliament from the Metropolitan area were included in the hundred and fifty-nine signatories who announced that they had formed themselves into the "General Committee for the Protection of the Lower Thames from Sewage". The memorial was supported by the secretary to the Local Government Board in a letter dated 15th May. On 22nd June a Royal Commission was appointed, chaired by Baron Bramwell, a retired judge, and including two civil engineers, a professor of chemistry from University College, a doctor and an army surgeon. The Metropolitan Board argued unsuccessfully that the Commission should be postponed until October "and not made in the hot summer months when de-composition is more rapid". It is hard to resist the conclusion that this was a further defensive move by the Board to protect its own narrow interests.

The deliberations of the Commission were attended by a continuing flow of correspondence between the Board and the Conservators. On 4th 1884 the Secretary to the Conservators, Captain Burstal, wrote to the Board "relative to the foul state of the river" and this was followed by similar correspondence from representatives of communities situated close to the outfalls which, despite Bazalgette's recent assertion that the areas were fit only for "bone boilers and glue and artificial manure works" (see above page 230) had acquired a substantial resident population.[151] On 18th July the clerk to the Woolwich Local Board of Health reported that "numerous

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149M.B.W. *Minutes*, 11th October 1878, p. 434

150This correspondence is recorded in P.P. 1884, Vol. 62, *Papers Relating to the Pollution of the River Thames* pp.1-85 and some of it is recorded in M.B.W. *Minutes*, 1884, pp. 39,98,150,193-6

151For example the population of Plumstead grew almost fourfold from 1851 to 1881 compared with a growth of 69% for London as a whole; see *Statistical Abstract for London*; L.C.C., Vol. 1, 1897,p.3; G.L.R.O.

complaints have been made to them of the very foul state of the River Thames in this district" . The Plumstead and Erith Boards lodged similar complaints and the Home Secretary, Harcourt, also joined the correspondence, drawing attention to letters from the Metropolitan Police and from Lord Bramwell, chairman of the Royal Commission, who had journeyed down the river and concluded that "The River was in such a state as to be a disgrace and a scandal to the Metropolis and civilisation". Harcourt supported Bramwell and wrote to the Board implying that he might institute proceedings against them if they did not respond positively to the criticisms. Hogg replied that the problem was a temporary one, caused by high summer temperatures, low volumes of land water and a temporary shortage of de-odorising chemicals, the latter problem having been remedied immediately after Bramwell's voyage of inspection.

The Commissioners produced two reports. The first, published on 31st January 1884, stated that "the discharge of the sewage, in its crude state, during the whole year, without any attempt to render it less offensive, is at variance with the original intentions and with the understanding in Parliament when the 1858 Act was passed"[152] this being a reference to Derby's speech on the Act when he had stated:

> "It is generally understood, although there is no express provision in the Bill to that effect, that the modus operandi is to be by intercepting sewers, whereby the sewage of the Metropolis will not be allowed to be poured into the river until it shall have undergone, at such place or places as shall be determined on, the process of de-odorisation"[153]

The Home Secretary, Harcourt, supported the Commissioners and wrote to the Board on 29th July 1884 to the effect that "The Secretary of State thinks it greatly to be regretted that, instead of disputing the existence of the evil when it was first urged upon their attention in the early part of the year 1882 by the Secretary of State, on the representation of the Corporation of London and other persons, the Metropolitan Board did not at once take measures to remedy so serious a mischief".[154] In its reply the Board continued to maintain, as it had done two years earlier, that the problem was a temporary one caused by high summer temperature, low water flow and shortage of de-odorising agents but added that the Board was enlarging the reservoirs at Barking and Crossness in order to eliminate the need to discharge before the ebb

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152P.P. 1884, vl.41, p. lxvii, conclusion 4
153*Hansard*: vol. 151, 28th June 1858 col. 2157; see also Chapter 2 page 109
154P.P. 1884, vol .62, *Papers Relating to the Pollution of the River Thames*, p.70

tide[155]. The Board had in fact resolved to increase the reservoir capacity by fifty per cent three years earlier in order to be able to hold all the sewage pending the arrival of the ebb tide but had later resolved to postpone the work pending the outcome of the Royal Commission.[156]

The Second and Final Report of the Commission was unequivocal and, having considered the possibility of sewage utilisation as a full and permanent solution, its fourteen recommendations included the following:[157]

> "2. It is neither necessary nor justifiable to discharge the sewage of the Metropolis in its crude state into any part of the Thames
>
> 3. Some process of deposition or precipitation should be used to separate the solid from the liquid portions of the sewage
>
> 5. The solid matter deposited as sludge can be applied to the raising of low lying lands, or burnt, or dug into land, or carried away to sea."
>
> 10 to 13: suggested that the remaining liquid, being too impure to return to the river, should be filtered through land or conveyed to Hole Haven, near Canvey Island, before being discharged. This applied also to the waste from the Southern drainage, which would be piped across the river to the Northern shore

The Board was alarmed at the expense of these last proposals. The cost of acquiring sufficient land for filtration in the vicinity of the outfalls would be high, as would the alternative of conveying Northern and Southern liquid to Hole Haven. For these reasons Bazalgette, together with the Board's chemist, W.J.Dibdin, carried out a series of experiments first at the Pimlico pumping station and later at Crossness as a result of which they reported that the sewage could be disposed of by precipitating the solid elements through the addition of lime and proto-sulphate of iron. The resultant small quantity of solid material could then be burnt, given to farmers or dumped at sea while the much larger volume of liquid, rendered harmless by the process, could be discharged to the river.[158] As an additional precaution the Board retained, as consultants, four chemists to report on the recommendations, one of the four having

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155Ibid. pp. 73-4; the Board's secretary, J.E.Wakefield, replied on 2nd August 1884
156M.B.W. *Annual Reports*, 1881, p. 20 and 1882, p.6
157P.P.1884-5, Vol.31; *Royal Commission on Metropolitan Sewage Discharge,* p.lxvi
158M.B.W. *Annual Report*, 1888, p.26

been a member of Bramwell's Royal Commission.[159] These advised that, in addition to the recommendations of Bazalgette and Dibdin, further chemicals should be added to the liquid before it was released to the river:

> "The Board might safely conclude that the adoption of the process of precipitation, with the further resort to permaganic acid in hot weather would effectually render the discharge of the sewage into the river innoxious and inoffensive all through the year".[160]

Following the publication of the Commissioners' findings the Board deliberated for longer than some thought necessary over what measures should be taken. The *Financial News* ran a campaign which suggested that the Board, and particularly Bazalgette, were resolutely opposed to the more worthy proposals of entrepreneurs who wished to promote sewage utilisation schemes and came close to suggesting that the Board's four consultant chemists had been bribed to give their support:

> "with a handsome retaining fee of £500 in their pockets, they would, of course, feel kindly towards the process of the Board's own officers, supported by an active clique in the Board's Committee of Works".

The paper further accused an "Inner Ring of officers and members" of conspiring "to keep these impertinent intruders in check".[161] By the autumn of 1885 *The Times* was publishing material which was alarmingly similar to that which had appeared in its pages during "The Great Stink" twenty-seven years earlier (see above Chapter Two, page 100 et seq.), writing:

> "Anybody who has frequented the Thames would, though he has been years away and returned blind, recognise its stream by the dull brooding atmosphere of odours the Metropolitan Board of Works brews from its London sewage".[162]

In January 1886 the *Pall Mall Gazette* took the Board to task, asserting that "The Royal Commission on the Sewage Discharge returned a verdict of guilty on the Board

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159Sir Frederick Abel; Dr William Odling; Dr Dupre; Dr Williamson (R.C. member); see M.P.I.C.E. vol. 88, 1887, pp. 155-298 and vol. 129, 1897, p. 55 for an account of the experiments

160M.B.W. *Minutes*, 26th March 1886, p.615

161*Financial News*: "Metropolitan Board of Works"; Argus Printing Co., p.80 and p.8, G.L.R.O.

162*The Times*, 30th November 1885, p. 9 col. 4

on January 31st 1884" [the date of the first report of the Commissioners] and asking why the Board did not order Bazalgette to take the necessary steps. The writer added:

> "There are not wanting those who say that Sir Joseph is master of the Board and will not give them definite advice on the difficulty. They argue that it is his own scheme that he is called upon to correct, and that the natural man in him puts off the evil day of having to admit failure. Canvey Island may claim whatever credit belongs to the fact that it is as clearly designed for the treatment of London sewage as the belt of chalk under the English channel was created by Providence for the construction of the channel tunnel - which latter fact the world has on the unquestioned authority of a railway chairman".[163]

The reference to Canvey Island concerned a proposal made by two promoters called Colonel A.S.Jones and J.Bailey Denton who, anticipating that the Board would convey the sewage to Hole Haven, proposed that the Board should pay them £110,000 per annum to dispose of the sewage. Denton and Jones, who had purchased an interest in Canvey Island, had proposed the scheme to Gladstone and continued to lobby the Board and its advisers for the next two years, long after other proposals had been adopted.[164]

The Works and General Purposes Committee of the Board reported on this and other proposals on 26th March 1886. Bazalgette had calculated that the cost of conveying the sewage to Hole Haven, including cost of capital, would amount to £215,000 whereas the precipitation and disposal process developed by himself and Dibdin would cost £118,000. This would generate 850 tons of pressed sludge a day. Tests had shown that burning it produced offensive smells and limited results had been achieved by giving it to farmers, so it would be dumped at sea.[165] Unsurprisingly, the Committee recommended the adoption of this process. In January 1887 the Board engaged a contractor to construct thirteen precipitating channels at Barking, at a cost of £406,000 and this was followed in May 1888 by a similar contract for channels at Crossness at a cost of £259,816.[166] Six sludge vessels were ordered, the first *The Bazalgette*, arriving from the Naval Construction and Armaments Company, Barrow, in June 1887 at a cost of £16,353.[167] The Board also engaged the services of the

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163 *Pall Mall Gazette*, 7th January 1886, p.11

164 M.B.W. *Minutes*, 14th January 1887, p.66 and 24th July 1888 p.727

165 M.B.W. *Minutes*, 26th March 1886, pp. 613-17

166 For an account of these works see M.B.W. *Annual Report*, 1888, pp. 26-7

167 The remaining 5 vessels, *Barking, Binnie, Barrow, Burns* and *Belvedere* arrived between 1887 and 1895; see L.C.C. *Annual Report*, 1913

eminent chemist Sir Henry Roscoe, F.R.S., Vice-chancellor of London University and Liberal M.P. for South Manchester, as its adviser, possibly in the hope that he would be able to exert political influence with the government should the Board come under pressure to adopt proposals advocated by others.[168]

The Board had slowly, with great reluctance and with a strong rearguard action, come to accept that it could no longer discharge raw sewage into the Thames at Barking. A solution which had been greeted with enthusiasm in the 1860s was no longer acceptable in the 1880s, in which period London had grown in population by almost fifty per cent and the previously sparsely inhabited communities of Barking and Plumstead had become substantial Metropolitan suburbs. David Owen agreed with the contemporary judgement, quoted above, of the *Pall Mall Gazette.* Bazalgette,"an old and tired man...had been with the Board for so long that he had, perhaps, gained an excessive influence over its decisions" consequently showing reluctance to make significant changes to the system which he had devised thirty years earlier and for which he had been widely praised.[169] His system was nevertheless easily adapted to the process of precipitation and disposal at sea, the and this practice has continued successfully until 1997.[170]

In the early summer of 1997 Thames Water began to commission an incineration plant at its Beckton treatment works which will be fully operational by 1998, thereby enabling the company to conform with European directives which require that marine disposal of waste cease by the end of 1998.[171] The new plant will compress the sludge recovered from the settlement tanks at the treatment works to a condition in which it is reduced to 32% solid matter and 68% water and will then incinerate it through a sand bed at a temperature of 850 degrees centigrade. The heat generated will be recovered and used to drive a steam turbine which will provide electricity to run the Beckton treatment works and leave some surplus for "export" to the National Grid. The remaining liquid, "settled sewage", is treated by an aerobic process which promotes bacterial activity to remove remaining impurities before the treated liquid is released to the Thames. Similar facilities are being installed at Crossness. In the

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168M.B.W. *Minutes*, 23rd March 1888, p.513

169D.Owen: *The Government of Victorian London*, Belknap, 1982, p.73

170See *Water Pollution Research, Technical Paper No. 11, "Effects of Polluting Discharges on the Thames Estuary"*, H.M.S.O., 1964, pp. 96 et seq. for a later assessment of the problem.

171For the details that follow I am indebted to Graham Pilkington, Operations Manager, Beckton catchment, Thames Water Utilities and his staff

meantime, Thames Water is generating electricity from methane gas and in 1995 "exported" 4.3 megawatts of electricity for supply to the National Grid from their CoGas (Combined Gas and Steam) power plant at Beckton.

Conclusion

This work opened with a quotation which compared the celebrity of I.K.Brunel with the anonymity of Joseph Bazalgette, while recognising the achievements of each. The purpose of this examination of Bazalgette's work has been to assess his claim to a place in the ranks of nineteenth century engineers alongside celebrities like Brunel who, not long before his death in 1859, supported Bazalgette in his application for the post of Chief Engineer to the Metropolitan Board which he occupied for the thirty-three years of its existence.[1] It would not be appropriate to labour the comparison with Brunel but a few points of reference will help to put Bazalgette's achievements in perspective. In the pages that follow I will attempt to form a judgement of Bazalgette's work by reference to four criteria: the scale and complexity of the works he executed; the enterprise and innovation he employed in carrying them out; the consequences for his fellow-citizens; and the personal qualities he needed to display.

Scale and Complexity

During the time that he held office, Bazalgette was responsible for executing about £14,000,000 worth of works on behalf of the Metropolitan Board. These sums mean little in 1997 but, for purposes of comparison, it may be observed that Brunel's Great Western railway cost about £8,000,000 and his S.S. *Great Britain* about £176,000,[2] so by contemporary standards Bazalgette's works were of the highest order of magnitude. About half of the money spent on Bazalgette's works was devoted to street improvements and associated clearance of slum properties.[3] Twenty-two dwelling improvement schemes were carried out, covering fifty-nine acres of property, re-housing 38,231 people and creating a number of notable London thoroughfares.[4] All the bridges crossing the Thames were freed from tolls and Bazalgette was responsible for re-building three to cope with the needs of Victorian traffic (Putney, Battersea and Hammersmith) and for strengthening others (Waterloo and Albert Bridges). The cost of the work on the bridges was £613,000. At Bazalgette's suggestion, the Woolwich Free Ferry was introduced to afford a means of

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[1]See above page 91

[2]For details of Brunel's works see Burton, A., *The Railway Builders*, John Murray, 1992 and Vaughan, A., *Isambard Kingdom Brunel, Engineering Knight-Errant,* John Murray, 1991

[3]M.B.W. *Annual Report*, 1888, p. 30 et seq. gives the financial information referred to in the following paragraphs

[4]See page 2 (above): they included Charing Cross Road, Northumberland Avenue, Queen Victoria Street and Shaftesbury Avenue

crossing the Thames to the one third of London's citizens who lived downstream of London Bridge.

Bazalgette's most conspicuous works were the Victoria, Albert and Chelsea Embankments, and it is not surprising that it was on the first of these that his monument was placed in 1901, ten years after his death. The embankments cost £2,400,000 and reclaimed fifty-two acres of land from the river which, besides provided footways and parks, also provided a much-needed thoroughfare between the City and Westminster to supplement the badly congested route from Ludgate Hill via Fleet Street and the Strand.[5] However, although he recognised the importance of the Embankments, Bazalgette himself recognised that the Main Drainage, which cost £4,100,000, was his greatest achievement. He put the work in context in his own words in his interview with *Cassell's Saturday Journal* less than a year before his death:[6]

> "I get most credit for the Thames Embankment, but it wasn't anything like such a job as the drainage...The fall in the river isn't above three inches a mile; for sewage we want a fall of a couple of feet and that kept taking us down below the river and when we got to a certain depth we had to pump up again. It was certainly a very troublesome job. We would sometimes spend weeks in drawing out plans and then suddenly come across some railway or canal that upset everything, and we had to begin all over again. It was tremendously hard work. I was living over at Morden then and often used to drive down there from my office at twelve or one o'clock in the morning".

Bazalgette's work was not confined to London. Between 1858 and 1875 he produced, as a consultant, thirty-two reports on drainage works for British communities beyond the Metropolis, and a further report on the drainage of Pest, Hungary.[7]

Municipal Management

In 1991, to mark the hundredth anniversary of Bazalgette's death, the Institution of Civil Engineers organised an exhibition called "Civil Engineering in the Victorian

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[5]In May 1860, during a debate in the House of Commons, Joseph Paxton commented that "It took a longer time to go from London Bridge to the Great Western Railway than from London Bridge to Brighton"; Hansard, 3rd Series, Vol. 158, col. 736, 4th May, 1860, reported in *The Builder,* 12th May 1860

[6]*Cassell's Saturday Journal*, 30th August 1890

[7]Records held in the Institution of Civil Engineers and summarised in Smith D.: Newcomen Society *Transactions*, vol. 58, 1986-7, Appendix C, pp. 104-5

City" which celebrated the contribution made by Bazalgette and other engineers to the development of effective municipal management through such activities as sanitary engineering, slum clearance and road building programmes. The Metropolitan Board of Works was London's first Metropolitan government and, as we have seen, its establishment did not occur without controversy and much opposition. The idea that London should have a Metropolitan government, with powers to raise money from all ratepayers and spend it on large projects was fiercely opposed by a multitude of interests, some of which were wedded to the idea that vestries and paving boards were the appropriate repositories of such authority while others feared that "there was a danger that the proposed local Parliament of forty-two members would discuss politics instead of sewerage questions, and threaten to overshadow the authority of the Speaker and that of the Imperial Parliament".[8] The original Metropolis Local Management Act had attempted to placate both these interest groups by giving Parliament, in the form of the Chief Commissioner of Works, the power to authorise or veto any significant expenditure; and by giving local ratepayers the right to appeal against the rates levied on them by the Board if they felt that the rates were excessive in relation to the local benefits.[9] The Amendment Act which Disraeli pushed through the house in the face of the "Great Stink" removed both of these restraints[10] and thereby created a more powerful body than had been intended. If the Board had been less than highly successful in executing its great engineering projects under Bazalgette's direction, its critics could easily have argued that it was the nature of its authority which was at fault and argued for a reversion to smaller units of local government. As it was, controversy over the corruption of some of its officials clouded the Board's final years[11] but the principal of Metropolitan government survived, to be inherited by the L.C.C. in 1889, although members of the latter were directly elected rather than nominated by vestries and districts. Bazalgette, as the Board's longest-serving and most prominent officer, thus made an important contribution to the establishment of the concept of representative Metropolitan government, as well as contributing to the "professionalisation" of municipal administration which has been detected by historians such as Lowell and Clifton.[12]

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[8]Hansard, 3rd series, vol. 137, col. 726, 16th March 1855; see chapter two for a summary of these debates, notably page 64 et seq..

[9]See clauses 136 and 177-9 of Metropolis Local management Act and pp. 82-3 above

[10]See above, page 106 et seq..

[11]See P.P.1889, vol. 29: *Royal Commission Appointed to Inquire into Certain Matters Connected with the Metropolitan Board of Works* for an account.

[12]See page 69 (above)

New Methods and new Materials

At the time that Bazalgette was executing the Main Drainage works the Civil Engineering profession was embryonic, as were many of the techniques used by its practitioners. The Institution of Civil Engineers had been founded in 1818, the year before Bazalgette's birth, with the elderly Thomas Telford as its first president. Telford instituted the practice of having papers read to weekly meetings of the Institution, discussed afterwards and recorded in its *Proceedings* and it was on such bases that the profession accumulated its knowledge and experience in these early stages. Nevertheless, at the time that Bazalgette was working many of his contemporaries had learned their trade in the most rudimentary manner. Thus John Phillips, Chief Surveyor to the Westminster Commissioners told the Metropolitan Sanitary Commission in 1847:

> "I went to work when I was eight years old, as a bricklayer; I never had the slightest education. The little I do know I have taught myself...Some few months ago the members of the Institution of Civil Engineers did me the honour to elect me an Associate of that Institution".[13]

Thomas Brassey, one of Bazalgette's principal contractors, had worked with Telford on the construction of turnpikes and later been apprenticed to a land surveyor. These modest credentials did not prevent him from being employed by Bazalgette to manufacture special "Staffordshire Blue" bricks for the invert of the Northern Outfall sewer because of the pressures to which they would be subjected in the rapid fall of the sewer.[14] Another contractor, Sir John Aird, had no formal training as an engineer and learned his trade by laying gas pipes for the Phoenix Gas company in Greenwich.[15] It was upon such experience that Bazalgette depended to execute his plans and he later played his full part in advancing the professionalism of civil engineering by presenting numerous papers on his work and by encouraging his officers, notably John Grant, to do likewise. In the circumstances it is not surprising

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[13]P.P. 1847-8, vol. 32A, p. 42

[14]*City Press*: 14th September 1861, p.4; the expression "Staffordshire Blues" is still used though the generic term "engineering bricks" is more common.

[15]See Buchanan, R.A.: *The Engineers: a History of the Engineering Profession in Britain, 1750-1914*, Jessica Kingsley, 1989 and Rolt, L.T.C.: *Victorian Engineering*, Penguin, 1988, for an account of the early years of the profession

that, in choosing contractors, he preferred to work with those who had done good work for him in the past even if their prices were a little higher, though as we have seen this caused him some embarrassment in his choice of Furness for the Northern Reservoir.[16]

Bazalgette's decision to use Portland cement in the construction of the intercepting sewers and the Albert Embankment mark him out as a pioneer in the use of this material and in the development of effective quality control techniques in this young industry. The importance which the Metropolitan Board felt about the choice of appropriate materials was reflected in their decision to obtain the advice of consultants[17]. Portland Cement had previously been regarded with some suspicion by engineers because of its sensitivity to variations in the manufacturing process and in the 1840s, twenty years after Aspdin had patented Portland Cement, Isambard Brunel, Robert Stephenson and James Walker all produced testimonials to the superior qualities of *Roman Cement.*[18] Bazalgette's decision to use it for the first time in a major civil engineering project may be regarded as bold. Yet by 1870 Bazalgette could claim in a discussion at the Institution of Civil Engineers on the experiments carried out my his assistant, John Grant, that "Portland cement concrete could now be used with advantage and safety where brickwork and stonework were previously used, thus effecting a large economy in engineering works"[19]; and a manufacturer, G.F.White, who had advocated the use of the material in a paper presented at the Institution in May 1852[20] observed in the discussion of Grant's first paper that the Board's engineers had been the first to use effective testing procedures on the product.[21] The material became a standard for the industry and, in the words of the industry's historian:

> "Probably no event did more to set the Portland Cement Industry on its feet and demonstrate the importance and capabilities of the new material than a series of tests commenced in 1860 by John Grant, assistant engineer to the Metropolitan Board of Works."[22]

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[16]See above, page 218, "The Odessa Contract".
[17]See above page 208
[18]Reproduced on pp. 73-5 of Davis, A.C.: *A Hundred Years of Portland Cement, 1824-1924*, Concrete Publications Ltd., 1924
[19]M.P.I.C.E., 32, 1870-1, p. 314
[20]M.P.I.C.E., vol. 11, 1851-2, pp. 478 et seq.
[21]M.P.I.C.E., 25, 1865-6, p.
[22]Francis, A.J.: *The Cement Industry, 1796-1914*: David & Charles, 1968, p.132

Bazalgette's decision to give Grant a central role in experimenting with the new material confirms that the earlier skirmish over pipe sewers had not blinded him to Grant's qualities as an engineer. Nor did it blind him to the merits of pipe sewers. Pipes were not adopted for the main intercepting sewers because no pipes could be made of the dimensions required but Bazalgette approved their extensive use in the smaller sewers constructed by the Vestry and District Board. Each of the Metropolitan Board's Annual Reports, from 1857 to 1888, includes an account of the sewers thus approved by Bazalgette, amounting to almost 1173 miles. Over seven hundred miles of the sewers Bazalgette approved in this way were constructed of pipes, amounting to sixty per cent of the total, with some of the remainder being constructed of concrete in the later periods of the Board's existence and the remainder of brick.

The End of Cholera Epidemics

The most startling phrase from the quotation which heads the Introduction (page one, above) is the claim that Bazalgette probably "saved more lives than any single Victorian public official". A comparison of Bazalgette's work with that of other Victorian figures such as Edwin Chadwick and Florence Nightingale is unlikely to generate any satisfactory quantitative assessment of such a claim. However, a century after his death there is no longer any serious doubt that the elimination of cholera and other epidemics from the Metropolis was caused by the fact that the Main Drainage, when completed, played a major part in protecting the water supply from cholera, typhoid and other water-borne infections: a fact of which his successors, who now manage the system he created, are fully aware.[23]

Nevertheless, at the time of Bazalgette's death in 1891, many well-qualified authorities failed to recognise the clarity of the link between epidemics and infected water, persisting in the belief that a "miasma" of foul air was the cause, despite mounting evidence to the contrary. The convictions of Edwin Chadwick and the early scepticism of figures like John Simon and William Farr have already been noted but there could be no better illustration of the reluctance to abandon the miasmatic explanation of infection than the experience of Hamburg, whose severe cholera epidemic in 1892 caused some anxiety in London, as observed in chapter five, despite the fact that twenty-five years had passed since London's final epidemic. In the 1860s

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[23]When I asked the young engineer who manages the Beckton incineration plant how she describes her job to others she replied "I prevent cholera epidemics". Visit to Thames Water at Beckton, 12th May 1997

and 1870s Hamburg's drainage system had been re-built on the advice of an Englishman, William Lindley who based his design on that of London. In the face of opposition from Hamburg's propertied classes, who were no more enthusiastic about the cost than were London vestrymen, Lindley obtained testimonials from Chadwick in support of his scheme.

However the system suffered from two serious defects. As late as the 1890s about twenty thousand inhabitants were left unconnected to the system, their waste being stored in leaking cesspools similar to those which had caused such problems in London in the 1840s[24]. The second defect concerned the means of sewage disposal. It was emptied, in its raw state, into the Elbe where tidal conditions ensured that it flowed up and down the city's shoreline, much of it entering the city's canals whence it could make its way into other watercourses. In 1885 a zoologist published an article entitled *The Fauna of the Hamburg Water Main* in which he identified sixty species of organisms, while several contemporaries reported finding eels and fish in the water mains[25]. The situation invites comparison with the London of the "Great Stink" and with the condition of the East London company's water supply in the 1866 outbreak.[26]

A further comparison with London of the 1860s is to be found in the scepticism with which the Hamburg city authorities greeted the idea that infected water was the cause of cholera epidemics. In January 1884 the Prussian scientist Robert Koch had visited Calcutta and succeeded in isolating and identifying the Cholera bacillus. He returned to Prussia to be feted and honoured by the Emperor and, when cholera broke out in Hamburg in 1892 the Prussian government gave him what amounted to dictatorial powers in the face of an outbreak in which recorded mortality rates reached 13.4 per thousand inhabitants - twice the figure recorded in London's worst outbreak of 1849. Nevertheless Koch encountered the same scepticism that had greeted Snow's hypothesis.[27] The newspaper *Hamburger Fremdenblatt*[28] scorned the idea that the

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[24]See above, pages 33 et seq.

[25]Evans, R.J.: *Death in Hamburg*, Clarendon Press, 1987, p.149 gives details and references

[26]See above pages 103 et seq. and 149 et seq.

[27]Howard-Jones, N.: *Gelsenkirchen Typhoid Epidemic of 1901, Robert Koch and the Dead Hand of Max von Pettenkofer*, British Medical Journal, 13th January 1973 gives an account of the scepticism that Koch faced many years after his discovery. This phenomenon of scepticism in the face of evidence which challenged the "miasmic orthodoxy", and subsequent resolution in the face of crisis, may be taken as an example of Thomas Kuhn's thesis that paradigms

bacillus caused the disease. At the same time the Burgomeister complained that during the 1892 outbreak "it was the Imperial Health Office and Professor Koch who ran things here.[29] In Evans's words "Local doctors remained convinced of the impossibility of the disease being conveyed in the water supply".[30]

The anxiety felt in London at the proximity of the 1892 outbreak was justified by precedent. The previous epidemics, including that of 1866, were all believed to have entered through major ports and, as recorded in Chapter Three (page 161) the authorities were sufficiently alarmed to commission a report on the subject.[31] There was no epidemic and, at the very least, it may be argued that Bazalgette's now complete Main Drainage system saved the Metropolis from the epidemic that devastated Hamburg, killing 8,605 people in a city one seventh the size of London. If the epidemic had struck London to the same degree that it struck Hamburg, the deaths in the Metropolis would have exceeded those of the four previous epidemics combined.

Personal Qualities

Bazalgette's laconic description[32] of the difficulties that he overcame in designing and constructing the main drainage draws attention to an aspect of his character which is frequently glimpsed in his public statements and writings: a dogged patience which carried him through many controversies. He was not an entrepreneur in the heroic mould like Brunel. Unlike Brunel he did not have to raise the money for his great works, this being left to the Metropolitan Board. His brief period as an independent consultant during the Railway mania led to a breakdown in his health and a year's recuperation was required before he became a public servant as assistant surveyor to the Metropolitan Sewers Commission.[33] Bazalgette had the considerable advantage

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shift in the face of crisis rather than the steady accumulation of evidence. See Kuhn, T.S.: *The Structure of Scientific Revolutions,* Chicago U.P., 1970, notably chapter 8, *The Response to Crisis*

[28]16th January 1893, cited in Evans, R.J.: *Death in Hamburg,* Clarendon Press, 1987, p.491

[29]City archives, cited in Evans, R.J.: *Death in Hamburg*: Clarendon Press, 1987, p.491. The complaint invites comparison with Chadwick "England's Prussian Minister" see above page 69

[30]Evans, R.J.: *Death in Hamburg*: Clarendon Press, 1987, p.279

[31]P.P. 1894, vol. 40

[32]In *Cassell's Saturday Journal*, 30th August 1890 see page 240 (above)

[33]See page 53, above

of working within the framework of an organisation, the Metropolitan Board of Works, whose authority over the governance of the Metropolis had been won after many battles waged by others.

On the other hand, Bazalgette often had to demonstrate heroic patience when dealing with or placating politicians, vestrymen and Board members like the acerbic John Leslie. These qualities of detachment were evident during the battles over the position of the outfalls which preceded the "Great Stink" of 1858 and, particularly, during the later disputes with Captain Calver over the shoals which had supposedly been formed in the vicinity of the outfalls as the result of sewage deposits. During the dispute Bazalgette had been subjected to some hostile criticism of a personal nature[34] but when an independent enquiry upheld the Board's view against those of Captain Calver Bazalgette contented himself with observing that "Captain Calver's imaginary sewage zone in the lower reaches of the river can have no existence". It is hard to imagine Brunel showing such restraint.

Only once did Bazalgette allow his objectivity to be seriously compromised, during the "Pipe Sewer" controversy which occurred during the time that he was working as Engineer to the Sewers Commission and in which he showed himself rather too anxious to be loyal to the organisation which employed him. Following the controversy over Bazalgette's thoroughly biassed report, of which John Thwaites was highly critical in his account of the episode[35] the Metropolitan Commissioners asked their five district engineers, Grant, Lovick, Cooper, Donaldson and Roe to report on their pipe sewers, including those that Bazalgette had criticised in his report. None of the five supported Bazalgette directly though some were muted in their criticism of the report of their superior. John Grant, however, was less inhibited, commenting that:

> "Had the former examination been as full, and accompanied by similar explanations, the diffusion of a considerable amount of error would have been prevented, and the benefits of good drainage immensely extended."[36]

This was harsh criticism from a subordinate and there followed an exchange of correspondence in which Bazalgette tried to excuse any errors on the grounds that he had had to prepare his reports in great haste, while Grant continued to press his

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[34]See above, page 230

[35]J.Thwaites: *A Sketch of the History and Prospects of the Metropolitan Drainage Question*, Ash and Flint, 1855, pp. 15-17 (G.L.R.O.)

[36]P.P. 1854-5, Vol. 53, p.33

criticism. The exchanges ended with Bazalgette implying that he was considering suing Grant.[37] It says much for both men that Bazalgette later appointed Grant as one of his principal assistants at the Metropolitan Board, gave him responsibility for the critical experiments with Portland cement and gave Grant full credit for the work and for the "large economy in engineering works"[38] which it helped to achieve. Bazalgette also enjoyed a harmonious relationship with Thwaites, despite the earlier disagreement and the predictions of *The Observer*.[39] As observed above. Bazalgette's earlier opposition to pipe sewers did not affect his later judgement either of the material or of Grant. It is hard to imagine the more flamboyant Brunel making such a ready acknowledgement of an error of judgement .

Bazalgette's obituary in the *Proceedings* of the Institution of Civil Engineers summarises the personal qualities that enabled him to carry out his great work in the face of difficulties that others had found insurmountable:

> "Although of small stature and somewhat delicate health, he possessed great energy and strength of will, which enabled him to combat and surmount the difficulties, often considerable, of his responsible public post. He had in later years often suffered seriously from asthma".[40]

Although in his public work Bazalgette appears to have been notably calm and objective in the face of errors and difficulties, these qualities were not so evident in his private life, his great-grandson having recorded that "he was small, very asthmatic, and probably rather irascible".[41]

Bazalgette will probably never be as celebrated as Brunel but his achievements were certainly comparable in their scale, their complexity, their use of new materials and their effects on his fellow citizens. If he had lived a year longer Bazalgette could have observed the Hamburg epidemic confident in the knowledge that his intercepting system would protect London, despite the anxiety that it occasioned amongst the politicians. He worked within the framework of an emerging concept of local administration to which his great works helped to give authority, dealing calmly and effectively with problems which had driven his predecessor at the Sewers Commission, Frank Forster, to an early grave, his life "shortened by the labours,

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[37]Ibid..

[38]M.P.I.C.E., 32, 1870-1, p.314

[39]See above page 90 for an account of this episode

[40]M.P.I.C.E., vol. 105, 1891, page 308

[41]Newcomen Society *Transactions* vol. 58, 1986-7, p. 111; Rear-Admiral Derek Bazalgette in discussion of paper by Denis Smith, Ph.D.

thwartings and anxieties of a thankless public office".[42] Bazalgette may not be in the heroic tradition of Brunel as "Engineering Knight Errant"[43] but his patience and persistence in the face of difficulties which had defeated others were heroic and certainly earn him "a niche in the temple of fame" proposed for him by Sir Harry Haward, comptroller and historian of the L.C.C..[44] The writer in *Cassell's Saturday Journal*[45] who described Bazalgette as the "deadliest foe" of the "malignant spirits whom we moderns call cholera, typhus and smallpox" may, like many of his contemporaries, have exhibited an imperfect understanding of epidemiology, but he was correct in placing Bazalgette at the head of those who ended the scourge of water-borne diseases in urban society.

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[42]M.P.I.C.E., vol. 12, 1852-3, p. 158 and page 50 (above).

[43]Vaughan, A.: *Isambard Kingdom Brunel: Engineering Knight-Errant*, John Murray, 1991

[44]Haward, Sir Harry: *The L.C.C. From Within*, Chapman & hall, 1932, p. 5; see also the reference of p. 56 above.

[45]*Cassell's Saturday Journal,* 30th August, 1890 and p. 3 (above)

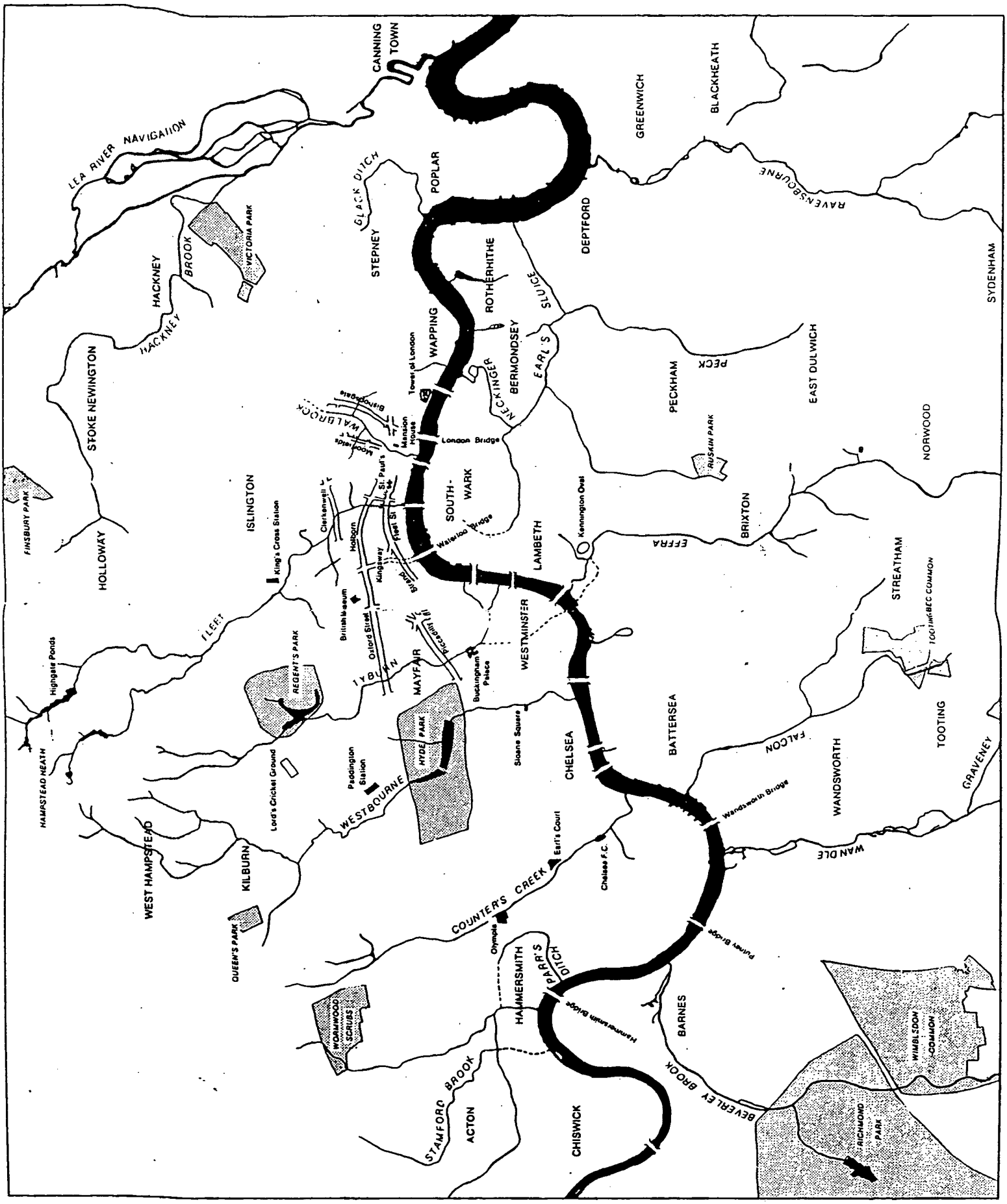
Maps

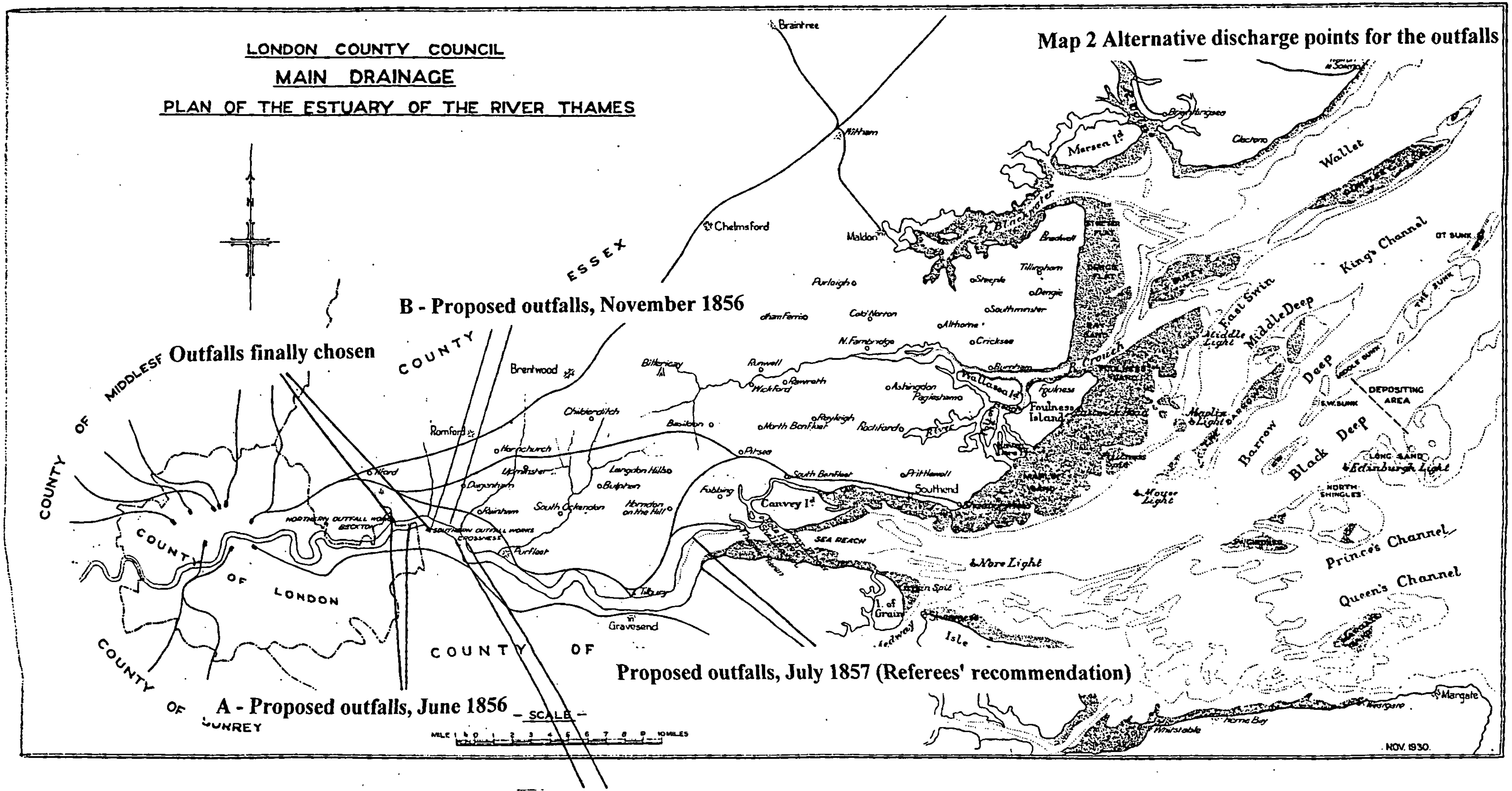
Map 1 London's Natural Watercourses

Map 2 Alternative discharge points for the outfalls, 1858

Map 3 The intercepting system

Map 1: London's natural water courses





Map 2 Alternative discharge points for the outfalls

B*- Proposed outfalls, December 1856
(Burstall's recommendation)

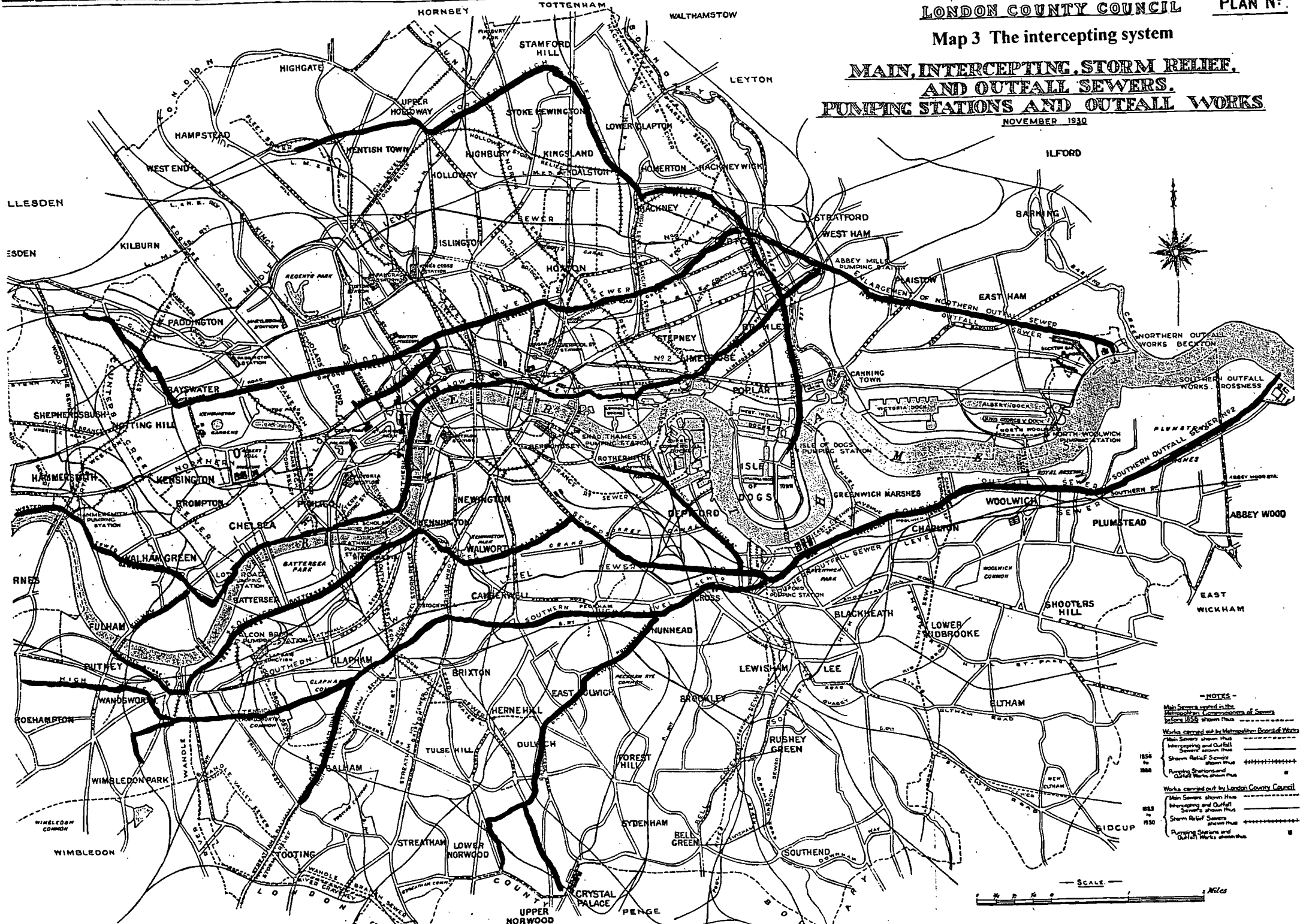
LONDON COUNTY COUNCIL

PLAN Nº.

Map 3 The intercepting system

MAIN, INTERCEPTING, STORM RELIEF, AND OUTFALL SEWERS. PUMPING STATIONS AND OUTFALL WORKS

NOVEMBER 1930



Appendices

Appendix 1 The First Metropolitan Board of Works: backgrounds of members

Appendix 2 Bazalgette's Plan

Appendix 3 Main drainage contracts

Appendix 4 Bazalgette's Plans for other communities

Appendix 1

The First Metropolitan Board of Works: backgrounds of members

The following is an account of the experience of the members of the first M.B.W. which took office on 1st January 1856. It briefly describes the professional and administrative experience of each of the twenty-nine members for whom details are available, taken from accounts in two London newspapers, *The Elector* and *The South London News* in 1857. Blank entries indicate that no details were given.

M.B.W. member's name	Professional experience	Administrative experience
John Thwaites (chairman)	draper	Member of Met. Sewers Comm.
William Cubitt	builder	Lord Mayor, M.P.
William Dennis	builder of sewers	
Benjamin Dixon		
John Leslie		
George Wallis		Board of Guardians
Henry Lowman Taylor	"man of rank & connection" not intimidated by Benjamin Hall[1]	
Frances Chalmers	non-practising barrister	Magistrate
Alfred Bristow	solicitor	
J.Humphrey	wharfinger	Lord Mayor, M.P...
John Ware	solicitor	
John Savage	merchant & freemason	
Frederick Doulton	lecturer at Mechanics' Institute (also mfr. of earthenware pipes)	
Ambrose Boyson	merchant	Magistrate & Guardian
Alexander Irvine		Guardian, associate of Birkbeck
Thomas D'Iffanger	lecturer at Mechanics' Institute	
William Hows	pawnbroker	
Henry Burslem	Kensington aristocrat	M.P..
Deputy Harrison		City Deputy
Josiah Wilkinson	barrister	
Charles Few	solicitor	
Joseph Morland*	captain in the army	
Philip Crellin		
James Pascall		
Charles Harris	tea trader	
Valentine Stevens	accountant	
Edward Collinson		
William Hawkes	shopkeeper	
Alexander Wright	gas engineer - own business	

*Morland was one of two members of the M.B.W. described as not being a member of a vestry or district board. The other is not named.

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[1] *The Metropolitan*, 20th March 1880, in a profile of Lowman Taylor, stated that he was a wholesale ironmonger in Cheapside, member of the Court of Common Council and J.P.

Appendix 2: Bazalgette's Plan

Name of Sewer	Start	Finish	Length	Dimensions
Northern High Level	Gospel Oak Fields	Old Ford	7.25 m.	4 feet diameter to 12' x 9'6"
Northern Middle Level	Kensal Green (with branches from Coppice Row and Piccadilly)	Old Ford	9.5 m.	4'6" x 3' to 12' x 9'6"
Northern Low Level	Chelsea (branches from Hackney, Isle of Dogs, Chiswick, Fulham, Acton)	Abbey Mills	8.25 m.	6'9" to 10'3" diam.
Northern Outfall	Abbey Mills	Barking	4.5 m.	3 outfalls, each 9' diameter
Southern High Level	Clapham Common (connecting with the Effra branch at Deptford)	Deptford	9.5m	4' 6" x 3' to 10' 6" diameter
Southern Low Level	Putney High St.	Deptford	10 m.	4' diameter to 7'
Southern Outfall	Deptford Creek	Plumstead marshes	7.75 m.	11' 6" diameter

Appendix 3

Summary of Main Drainage Contracts

In the summaries that follow the *contract price* is the price agreed at the time the contract was awarded; the *cost* is the amount paid; the difference between the two being accounted for by variations in quantities and material prices from those prevailing at the time the contract was awarded. The details are extracted from Bazalgette's annual reports, in which he gave a detailed analysis of progress on each contract. The reports are held in the Greater London Record Office.

Northern System

Northern High Level Sewer
Contractor: William Moxon
Description: 8m 4295' of brick sewer from 12' x 9'6" to 4' x 2'8" with overflow chambers, penstocks; River Lea to Hampstead
Contract Price; £152,430; dated 14.1.59; Cost: £181,773
Completed year ending 3/62; begun y/e 3/59

Northern Middle Level
Contractor: Rowe
Description: 12m 1280' brick sewers
Contract Price: £264,533; 4,319' executed for £12,451
Begun y/e 3/61; failed same year
Contract date 24.2.60

Northern Middle Level (replaced Rowe)
Contractor: Brassey & Co.
Description: 12m 1280' brick sewers; 33,862' in tunnels; from point between Northern High Level. Sewer, E. of Sir George Duckett's canal, and Western arm of Counter's Creek Main Sewer, nr. Kensal Green.
Contract Price: £329,800; dated 20.2.61; Cost: £349,869
Completed year ending 3/65 begun y/e 3/62

Northern Low Level Sewer
Contractor: William Webster
Description: 4m. 4855' of brick sewers; Abbey Mills to Tower Hill; branch from St. Leonard Street to Old Ford.
Contract Price: £229,000; dated 15.7.64; Cost: £292,398
Completed year ending 3/68; begun y/e 3/65

Northern Low Level
Contractor: Hiscox & Williams
Description: Westminster Steamboat pier to Grosvenor Canal basin; 1m. 4430' of brick sewers
Contract Price: £72,700; dated 3.6.69; Cost: £71,156
Completed year ending 12/74; begun after 3.6.69

Northern Low Level
Contractor: William Webster
Description: Tower Hill via Cannon St. to New Earl St.; 4400' brick sewer.
Contract Price: £67,500; dated 3.6.69; Cost: £56,824
Completed year ending 12/71; begun after 3/6/69

Northern Low Level
Contractor: Kelk, Waring & Lucas
Description: 1605' brick sewer; 1830' x 12" pipe; St. Andrews Hill - New Earl St.
Contract Price: £22,000; dated 20.10.69; Cost: £24,246
Completed year ending 12/74; begun after 20.10.69

Northern Low Level
Contractor: Webster
Description: 475' x 8'6" diameter; Chatham Place & St. Andrew Hill, Blackfriars.
Schedule of prices: Board resolution 7 & 8/70; Cost: £14,647
Completed year ending 12/71; begun after 8/7/70

Isle of Dogs Branch
Contractor: William Webster
Description: 1m. 4398' of brick sewers; from Northern Low Level to Manchester Road, Isle of Dogs
Contract Price: £79,700; dated 18.1.63; Cost: £120,299
Completed year ending 3/70; begun y/e 3/66

Abbey Mills Foundations
Contractor: William Webster
Description: Foundations to Ground Level (buildings added later)
Schedule of prices: dated 7.7.65; Cost: £227.000
Completed year ending 3/70; begun y/e 3/66

Abbey Mills Pumping Engines
Contractor: Rothwell & Co.
Description: 8 beam engines = 1136 hp; 16 Lancashire boilers
Contract Price: £54,570; dated 6.10.64; Cost: £59,510
Completed year ending 3/69; begun y/e 3/65

Temporary Pumping Station, Abbey Mills
Contractor: William Webster
Description: temporary arrangement to deal with 1866 cholera outbreak
Contract Price: £11,850 date 3.8.66; Cost: £14,551
Completed year ending 3/70; begun y/e 3/67

Northern Outfall Iron Fencing
Contractor: J. Horton
Description: 21,120 yds. iron fencing
Contract Price: £2,422; dated 20.12.59; Cost: £2,422
Completed year ending 3/61; begun y/e 3/60

Northern Outfall Sewer
Contractor: George Furness
Description: Embankments and 5m. 1400' of sewers therein and iron bridge etc. Old Ford to Barking Creek.
Contract Price: £625,000; dated 9.11.60; Cost: £669,762
Completed year ending 3/65; begun y/e 3/61

Northern Outfall Reservoir
Contractor: George Furness
Description: Reservoir with Penstocks and machinery
Contract Price: £164,000; dated 27.2.63; Cost: £172,222
Completed year ending 5/64; begun y/e 3/63

Plaistow Embankments and Roadways
Contractor: William Webster
Description: Roadways, footpaths over Outfall and embankment
Contract Price: £3,330 date 16.8.67; Cost: £3818
Completed year ending 3/69 begun y/e 3/68

Underpinning Ranelagh Sewer
Contractor: William Dethick
Description: Underpin and deepen 1480' of Ranelagh Sewer; Motcombe St. to Albert Gate
Contract Price: £2,996; dated 17.8.60; Cost: £2,995
Began year ending 3/61, ended same year

Ranelagh Storm Overflow
Contractor: William Dethick
Description: 1m. 420' of brick sewer; from Ranelagh sewer, nr. Albert Gate, to Grand Junction Road, via Kensington Gardens.
Contract Price: £23,500; dated 5.6.61; Cost: £31,582
Completed year ending 3/63; begun y/e 3.61

Acton Branch, West
Contractor: Walker & Neave
Description: 7,359' of brick sewers and iron sewers along Uxbridge Road
Contract Price: £8,850; dated 11.8.59; Cost: £9,821
Completed year ending 3/61; begun y/e 3.60

Western Sewers, North
Contractor: Moxon & Co.
Description: 4m 1390' brick sewers; R. Thames - Chiswick Mall; King's Rd. near Sand's End Lane to Fulham Bridge
Contract Price: £56,740; dated 9.10.62; Cost: £65,587
Completed year ending 3/65; begun y/e 3/63

Western Sewers Extension
Contractor: Wm. Moxon
Description: Extend from Sand's End Lane to Cremorne
Contract Price: Schedule of Prices; dated 23.10.63; Cost: £18,741
Completed year ending 3/66; begun y/e 5/64

Western Pumping Station Buildings
Contractor: WilliamWebster
Description: Engine House
Contract Price: £126,950; dated 11.10.72; Cost: £123,700
Completed 1875; Begun 1873

Western Pumping Station Engines
Contractor: William Webster
Description: 4 beam engines = 360 hp
Contract Price: £56,789; dated 11.10.72; Cost: £56,789
Completed 1875; begun 1873

Southern System

Southern High Level
Contractor: Joseph Norris Helling (later became Lee & Bowles)
Description: 9m. 2940' of brick sewers, 810' being a double line Deptford Creek to High St. Clapham; branch from Deptford to Effra sewer, Dulwich.
Contract Price: £213,000; dated 3.8.59; Cost: £215,299
Completed year ending 5/64; begun y/e 3/60

Works in connection with Southern High Level Sewer
Contractor: Thomas Pearson
Description: 16,100' of brick sewers; Dulwich, Norwood, Gipsy Lane
Contract Price: £18,087; dated 12.12.61; Cost: £19,374
Completed year ending 5/64; begun 3/62

Deptford portion of Southern Low Level
Contractor: John Aird
Description: 132' of 7' x 7' brick sewer; through Gas Co. Works, Deptford
Contract Price: £9,150; dated 17.8.60; Cost: £9,242
Completed year ending 3/62; begun y/e 3/61

Southern Low Level
Contractor: William Webster
Description: 9m 2895' of brick sewers; High St. Putney to High St. Deptford
Contract Price: £234,000; dated 20.2.63; Cost: £237,800
Completed year ending 3/66; begun y/e 5/64

Southern Low Level, Bermondsey branch.
Contractor: Aird & Son
Description: 2m. 3142' brick sewers; Bermondsey, Rotherhithe & Deptford parishes
Contract Price: £107,000 date 18.8.62; Cost: £96,000
Completed year ending 3/64; begun y/e 3/63

Earl Sewer, St. George's Wharf, Deptford
Contractor: John Aird
Description: 700' of 10' brick; 180' of 3'8" iron pipe; London St., Grove St., and St. George's Stairs
Contract Price: £8,566; dated 28.3.60; Cost: £20,834
Completed year ending 3/63; begun y/e 3/61

Earl Outlet, St. George's Wharf, Deptford
Contractor: Thomas Middleton
Description: Erect a Murray's patent Pump
Contract Price: £535; dated: Board Order 21.12.60; Cost: £610
Began year ending 3/61, ended same year

Greenwich & Deptford Sewers
Contractor: Wm. Dethick
Description: 2m. 4,470' brick sewer; Deptford pumping station via Greenwich Hospital to Pelton Road; 2 branches.
Contract Price: £22,940; dated 7.6.64; Cost: £25,684
Completed year ending 3/66 begun y/e 3/45

Deptford Pumping Engines
Contractor: Slaughter, Gruning & Co.
Description: 4 beam engines total 500 h.p.,10 Cornish boilers
Contract Price: £22,300; dated 8.3.60; Cost: £28,990
Completed year ending 3/66; begun y/e 3/61

Deptford Pumping Station
Contractor: Aird & Son
Description: 2 engine houses, boiler house and ancillary works
Contract Price: £113,136; dated 2.5.61; Cost: £109,456
Completed year ending 3/65; begun y/e 3/62

Southern Outfall Sewer
Contractor: William Webster
Description: 7m. 2240' of brick sewer, 5000' of which in tunnel; from Erith Marshes, under Woolwich to Norman's Road, otherwise N.Pole Lane, Greenwich
Contract Price: £300,000; dated 6.3.60; Cost: £310,648
Completed year ending 3/63; begun y/e 3/61

Southern Outfall Works
Contractor: William Webster
Description: Engine & boiler houses, reservoir, sewers etc.
Contract Price: £300,000; dated 9.7.62; Cost: £397,000;
Completed year ending 3/67; begun y/e 3/63

Southern Outfall Engines
Contractor: James Watt & Co.
Description: 4 beam engines = 500 HP; 12 Cornish boilers
Contract Price: £44,900; dated 10.10.62; Cost: £54,177;
Completed year ending 3/67 begun 3/63

The Embankments

Northern (Victoria) Embankment: contract 1.
Contractor: George Furness
Description: 3,740' of river wall, sewers and embankments; Westminser Bridge to Waterloo Bridge
Contract Price: £520,000; dated 27.10.63; Cost: £500,977
Opened: 13th July 1870; begun y/e 3/64

Northern Embankment: contract 2
Contractor: A.W. Ritson & Co.
Description:1,970' of river walls, sewers, subway Westminster Bridge to Inner Temple Contract price: £229,000; dated 16.1.64; Cost: £247,094
Completed y/e 3/70; begun y/e 3/65

Northern Embankment: contract 3
Contractor: William Webster
Description: 925' of embankments and sewers, Temple to Blackfriars
Contract Price: £126,500 dated 23.7.68; Cost: £124,679
Completed y/e 3/70; begun y/e 3/69

Eight further contracts were let to Furness et al. for the provision of steamship piers, decorative lights and other features at a cost of approximately £42,000

Southern (Albert) Embankment
Contractor: William Webster
Description: 4,300' of river wall from Westminster Bridge to Gunhouse Alley
Contract price: £309,000; date: 28.7.65; Cost : £293,069
Completed November 1869; begun July 1866

Chelsea Embankment
Contractor: William Webster
Description: 4,130' of embankment and sewer, Chelsea Hospital to Battersea Bridge
Contract price £133,950; dated 12.5.71; cost £133,950
Opened 9th May 1874; begun July 1871

Appendix 4 : Bazalgette's plans for other communities

The following list of plans which were devised by Joseph Bazalgette or the subject of his reports is taken from his private collection of manuscript papers deposited in the archives of the Institution of Civil Engineers by his great-grandson, Rear-Admiral Derek Willoughby Bazalgette. The reference numbers are those of the I.C.E. catalogue.

B858 BAZ RDT:	Epsom College	Luton	Netley
	St Petersburg	Hove	Brighton
	Weston-Super-Mare	Feltham	Shrewsbury
	Cheltenham	Bristol	
B865 BAZ RDT	Norwich	Hastings	Don Valley
	Oxford	Cambridge	Folkestone
	Greenwich		
B867 BAZ RDT:	Hampton Court Palace	Glasgow	Herne Bay
	Windsor Castle	Belfast	Northampton
	Budapest	Lea Valley	Tunbridge Wells
	Skipton	Yeo Valley	
B872 BAZ RDT	Scarborough	Birmingham	Dorking
	Wandle Valley	Beckenham	Oxford
	Sevenoaks	Farnham	Margate
	Hampstead	Maidstone	Berlin
	Glasgow		

B870 BAZ DPL Port Louis, Mauritius

B878 BAZ RJW Cambridge

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Records of the Metropolitan Board of Works

Records of the Institution of Civil Engineers

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Newspapers, magazines and journal articles

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1850, vol. xxi, vol. xxii, vol. xxxiii
1851, vol. xv, vol. xxiii, vol. xlviii
1852, vol xix and (session 2) vol.xx
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1863, vol. l
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1876, vol.xxxviii
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1884-5, vol.xxxi
1889, vol. xxix
1892, vol. xxiv
1893-4, vol. xl
1894, vol. xl
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J.W.Bazalgette's Graduate Membership Certificate, I.C.E..

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Bazalgette's own papers, donated to the Institution by his great-grandson, Rear-Admiral Derek Bazalgette, are filed in the Institution's archives in bound quarto and octavo volumes under the reference BAZ, together with the year in which the work was undertaken: e.g. 1882 BAZ.

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