The purpose of this paper is to outline the development of Liverpool's drainage and sewerage systems from the seventeenth century to the present day, with emphasis on the work of the country's first Borough Engineer, James Newlands. The paper concludes with a brief summary of the sewerage elements of the Mersey Estuary Pollution Alleviation Scheme (MEPAS), for which the author had responsibility from the early planning stages, through to Engineer to Contract for the majority of the Liverpool work. Originally intended for a non-engineering audience, the paper seeks to demonstrate the major influence of civil engineering on one aspect of public health, at a time when many diseases were clearly associated with poor living conditions and a lack of sanitation, but the medical or scientific proof was lacking. Liverpool's insanitary conditions, created by explosive population growth, forced the city to produce pioneering legislation. However, it is suggested that long-term reliance upon that legislation has created at least one present-day anomaly. 1997 marks the completion of the Liverpool elements of MEPAS, exactly 150 years from Newlands' appointment.

Seventeenth century: The Portmoot Court
During the seventeenth century, Liverpool was governed through its Portmoot Court, presided over by the mayor. The court's officers, who were elected annually, came from a diversity of backgrounds and occupations.

2. Of those posts directly or indirectly related to drainage and sewerage, the Water 'Bailifie' had control of the port, the Moss 'Reaves' and Burleymer had duties including ensuring that no alterations were made to the watercourses. The Scavengers, of whom four were elected each year, swore on oath to keep the streets clean and to ensure that dung hills and middens were not placed in the streets.

3. At this time, the posts had the nature of empowering individuals to bring others before the court for offences, rather than being officers or employees who undertook work directly. However, those officers falling in their duties were frequently before the court themselves.

4. Of the offences considered by the court and orders of the Grand Jury between 1625 and 1649 a significant proportion relate to watercourses, ditches, the Pool, the River Mersey, and the cleansing of streets and related sanitary matters.

5. The map of 1650 (based on a nineteenth century reproduction in the Liverpool Records Office) (Fig. 1) shows a perch in the river, and the description

Limestone Perch below which the Fifth and sweepings are to be cast 1573. This perch continued to be placed about this situation 'till about the middle of the 18th century.

From the court records it is clear that individual frontagers had to keep ditches, watercourses and gutters clear, and were not to allow 'mucke' to accumulate before their houses (but frequently did, and were typically fined 3s 4d).

6. In 1648, the court records show that the scavengers were complaining of abuse and their inability to prevail upon the inhabitants to cleanse the streets. They were therefore empowered by the mayor and council to hire men for street cleansing, to restrain goods from the offending inhabitants, and to dispose of those goods to cover the expense, returning any surplus to the frontager. Resistance to the performance of this order was to result in punishment at the discretion of the mayor. Liverpool’s population at this time was no more than 1500.

Eighteenth and nineteenth century: Rennie and Foster
7. By the end of the eighteenth century, Liverpool's population had grown to 78,000 in an area little greater than that shown on the 1850 map. Inadequate sewerage was resulting in frequent flooding of properties.

8. In the early nineteenth century, the use of sewers for the conveyance of foul waste was not legal, and at this time sewers were regarded as man-made waterways with the primary purpose of intercepting overland flow and diverting it to where it would not cause a nuisance. Where sewers were underground, water was generally admitted via large pits and gullies, which served the purpose of settling out material picked up on the surface by storm flows.
Rennie

9. In 1816 Rennie reported to the town council on sewerage. In referring to what is now central Liverpool, he stated that 'No town in the British Dominions is better situated than the town of Liverpool for a complete system of sewers'. However, he continued to describe the inadequacies of the few existing sewers and resultting difficulty in keeping streets and houses free from soil. Rennie described the existing six primary sewers and tunnels and their secondary branches. He then described their deficiencies, for example the tunnel to the North Shore having no side sewers to lead sufficient water into it, and also being in a poor state of repair. With the exception of the North and South Shore sewers, all sewers discharged to the docks and basins. The basins were described as being so much loaded with soil that 'their use as dock entrances is greatly abridged and the expense of removing it is enormous'.

10. The 'soil' referred to was material washing off land and highways via gullies and pits as there were no foul connections. Waste was supposedly removed by contractors for use on farmland, but in practice, contractors had little incentive to clear middens in the inner densely populated court areas and tended to concentrate on the outer parts of the built-up area. Middens were left overflowing; storms probably had the greatest effect of cleansing the streets, but to the detriment of those living in the courts and cellars in the low-lying central area near the pool.

11. Rennie's proposals were for further sewers to intercept overland flow at the town boundaries, provision of several new sewers and outfalls independent of the basins so as not to interfere with shipping, and in general, to intercept flows at such levels that discharge was practicable at all states of the tide. He was unable to provide this solution for the low-lying areas including the Whitechapel and Paradise street areas, where he proposed reservoir sewers to empty on a falling tide.

12. The new sewers and their dimensions are tabulated, but the method of calculation is not given, nor the estimate of cost. Rennie concluded that it would not be practicable to execute the works without an Act of Parliament, Commissioners, and fund-raising powers.

13. Rennie's principal existing and proposed sewer routes have been reconstructed from his descriptions and are shown in Fig. 2.

Foster

14. To what extent Rennie's recommendations were put into effect is unclear, for in 1829 John Foster was reporting on sewerage proposals with reference to Rennie,
whose report he had modified to take account of the 'increase in the town' and 'presuming upon a more intimate knowledge of its locality and present exigencies'. Foster, like Rennie, referred to the interception of water flowing from the adjacent hills and preventing it from entering the town, and referred again to the particular problem of the low-lying Whitechapel area. (Foster's changes are of detailed local interest and have not been included with this paper).

15. Foster concluded with reference to the need to lose no time in obtaining the necessary powers. Those powers were to come in the form of the Borough of Liverpool Act for Paving and Sewering and Settling the Borough Boundaries, 1830, which Act was also to place a duty upon the Dock Trustees to convey the discharge of any sewer made by the 1830 Commissioners into or through the docks and basins to the river, a duty which survives to the present day.

1846 'Sanatory' Act

16. During the early 1840s, Dr William Duncan, a Liverpool practitioner, campaigned for improvements in the living conditions of the poor and a reduction in the incidence of disease and mortality, and gave evidence to several inquiries. He had given evidence to Liverpool Corporation in 1833 following the first cholera epidemic, and on the state of the Irish poor in Liverpool in 1835. In 1840 he met Chadwick and gave evidence to a Parliamentary enquiry.

17. Following Chadwick's Poor Law Commission, Duncan contributed to reports in 1844 and 1845 on the State of Large Towns and Populous Districts. The reports of the Poor Law Commission in those same years on the need to remove decomposing matter from cities aroused a movement for removal and led to the 'filth' theory of disease, for this was a time when the association of poor living conditions and disease was clearly observable, but the actual causes could not be medically or scientifically proved.

18. In 1842 Liverpool's Health Committee was formed, and was faced with what might be considered to be insurmountable problems. There were two competing water companies providing limited supplies to householders and tenants (30 minutes per day typical). This water could only be used for cooking or domestic purposes, and not for washing external areas such as courts. Commissioners controlled paving and sewerage. The Health Committee itself supervised the drainage of courts. The Highways Board was responsible for watering the streets, and controlled its own borehole supplies. The Corporation Watch Committee was responsible for street cleansing. The council ran the fire service, but the Highway Commissioners had control of the associated water supply.

19. The provisions of the 1846 'Sanatory' Act, together with the Liverpool Corporation Waterworks Act 1847 by which the two private water companies were bought out, resulted in Liverpool having full control of the means by which water supply and drainage could be improved hand in hand.

1846 Conditions: Thomas Fresh

20. The 1846 Act and subsequent developments were being made against a background
which was to be well described by Thomas Fresh’s 1851 report. Fresh was the Inspector of Nuisances, and his 1851 report starts with a description of the pre-1846 situation.

Prior to the introduction of guano as manure, middens were emptied free of expense or even with a payment being given in return. [The importation of guano drastically reduced the demand from farmers and Fresh reported that by the end of 1846] ... the nightmen were refusing to discharge middens unless they received payment, and as a consequence, where parties refused to submit to the extortion, excrement and refuse remained in accumulated quantities to the material injury of the health and comfort of the inhabitants.

21. Following the 1846 Act, Fresh was able to report in 1851 on the implementation of new procedures whereby middens were emptied following written notice being given to an appropriate contractor. Each application was given a contractor division number, a police section number and a parish number, and the police were issued with details each night so that they could report on compliance or otherwise by the contractor.

22. Whilst this may all have been an immediate improvement on the pre-1846 situation, the reality was that the systems of regulation and removal of waste had hardly changed at all from those of the mayor and his bailiffs and scavengers in the seventeenth century, despite a massive increase in Liverpool’s population from 1500 to 231,000 occupying virtually the same area.

Appointment of first Borough Engineer: James Newlands

23. Under the provisions of the ‘Sanitary’ Act, Liverpool was to appoint William Duncan as the country’s first Medical Officer of Health.

24. The same Act made provision for the appointment of a Local Surveyor of drainage and other works authorized by the Act, ‘A person duly qualified as a civil engineer’. (The amendment Act of 1854 required him to be called and known as the Borough Engineer – a name used in practice from the outset.)

25. Newlands was one of five candidates, and was appointed on the extraordinarily high salary of £700 per annum (Fig. 3). Born in 1813, Newlands had been educated in Edinburgh, and is recorded as having studied mathematics and philosophy at that university. Before coming to Liverpool, he had been articled to the Edinburgh Corporation Architect, and had assisted Professor Low, who held the chair in Agriculture, including the production of models and woodcuts of farm buildings and equipment. Whilst continuing to extend his education, he gained work as an architect and wrote sections for Encyclopaedia Britannica. Immediately before coming to Liverpool he had added railway land valuation and damage claims to his business. Newlands was appointed on 26 January 1847. With limited staff he set about surveying the town in great detail, reviewed the previous drainage proposals, and reported to the Corporation in April 1848 at extraordinary length and detail on a range of health and sanitation issues, including his own proposals for an elaborate drainage system.

27. Newlands’ 1848 report listed three essentials to a proper system of sewerage.

(a) Removal in covered conduits of all refuse capable of suspension or solution in water.

(b) Perfect underground drainage of the whole strata to such a depth as will keep the lowest parts of buildings free from damp.

(c) Disposal of refuse (effluent) so that it may not pollute ... streams ... but may be applied (as fertilizer) to the surrounding country.

28. These essentials are further elaborated upon as follows.

(a) Removal: Every street and court to have a closed conduit for the connection, via branch conduits into which water closets and sinks will discharge their contents.

(b) Underground drainage of strata: Conduits (for sewage) to be at such a depth as to be below the foundations of buildings, and have branches connected with proper percolating drains led into them.

(c) Disposal of refuse (effluent): If sewers must discharge to rivers ... outlets to be at a distance downstream of town ... The perfect solution ... application to land in such a manner as not to be injurious to health.

29. On this latter point, Newlands costed options for direct land irrigation including
pumping from the low-lying areas, and examined existing land irrigation systems at Edinburgh and Mansfield. He concluded that

(a) the promoters of irrigation schemes seriously underestimated costs
(b) land for disposal would be quickly overtaken by the expansion of Liverpool.

30. Consequently, Newlands concluded that plans should proceed for river disposal pending identification of economic means of land disposal, health being more important than other considerations.

31. Liverpool was on the banks of a major estuary, so Newlands' 'pro tem' decision for river disposal was more easily made than it could have been for inland towns which in some cases were to continue with midden and pail systems into the twentieth century.

32. The difference of location and topography also helps to explain the lack of combined sewer overflows in Liverpool to the present day. Inland towns, although on midden systems, had the same problems as Liverpool (albeit on a lesser scale) of sewers and minor watercourses being polluted illegally or unintentionally through contaminated surface run-off, and then contaminating the larger watercourses at the points of outfall. The inland solution eventually adopted, was to build storm sewers to discharge to the watercourses, and to pass forward the dry weather flow to a pipe running parallel to the watercourse which would convey this flow for irrigation or some other form of land disposal or treatment.

Rainwater and surface drainage

33. Newlands saw the necessity for the adjustment of street levels to cater for surface drainage, and the need to keep the rainwater conduits separate from those taking the percolating drains for strata and foundation drainage (but made no reference to the need to separate the latter from foul drainage).

34. The low-lying central area, as in the case of the Rennie and Foster reports, was identified as requiring special attention, being mainly occupied by the poorer classes and being inundated by both tide and overland flow. Newlands considered that the Rennie and Foster proposals had not solved the problem as the new relieving sewers were too high and too far apart, thus leaving the area still vulnerable to overland flow.

35. He considered relief by using: a tank sewer to operate at high water; a pumping station to operate at high water; or a double system of sewers, one for house drainage and one near the surface directing water direct to the dock basin. This latter proposal was to be adopted, the first being discounted on size and cost, and the pumping station proposal being held in reserve as part of a future system for diverting the sewage to land.

36. Following the detailed description of the proposed sewers, Newlands declared that he had satisfied the conditions for house and rainwater drainage, 'but that the whole of the sewage is still thrown into the river . . . as to act prejudicially on the health of the town'.

37. This last statement is repeatedly used to this day in other texts (such as the 1995 NRA report on the Mersey) as a description of the pre-1846 situation, but read in context it is clear that Newlands is in fact referring to the future effects that his proposals were going to have (without a land disposal system), with the situation worsening as WC's were introduced.

Summary of Newlands' first report

38. Newlands' first report, produced only 18 months after his appointment, covers at great length and in detail every practical aspect of drainage, sewage disposal, sewer ventilation, gully design, and types of road surface conducive to cleansing by flushing from hydrants. Slaughterhouses, road and house design and layout, wash and bathhouses are considered among many other issues, including the justification for a detailed survey beyond that available from Ordnance Survey. These issues are beyond the scope of this present paper, but show that Newlands' engineering role embraced every aspect of civil engineering, municipal architecture and town planning, long before the latter was to be recognized as a specialization and profession in its own right. Sewer details from the report are reproduced as Fig. 4.

39. As with Rennie and Foster, the plans accompanying Newlands' report are lost. However, the very detailed descriptions provided by Newlands show the extent of progress achieved by the 1830 Commissioners, with most of the central area being sewered as far south as the boundary at Parliament Street. Newlands listed sewers to be repaired or replaced, and classified sewers by size. Unfortunately, the use of vertical and horizontal dimensions for both rectangular and ovoid sewers makes it difficult to estimate the proportions of each type, although there are occasional clear references to inadequate 'square' sewers in the lists. (Daymond, in his discussion of Hill's paper, assumed that the Rennie-designed sewers were of the rectangular form. Newlands' 1855 publication listed details of the old and new sewers, and described new construction as being, for example 4% in or 9 in rings, but the anomaly of using vertical and horizontal dimensions remains; the new sewers are ovoid but we cannot be certain about some older types.) Fig. 5 illustrates the pre-1847 construction.
40. There are also occasional references to existing sewers being at inadequate levels for draining houses, or only being suitable for surface water. These references have been taken by this author to mean that particular sewers were too shallow for future connection of WC’s etc. and sub-soil drainage.

41. Observations are also made on current design practice, with Newlands clearly favouring an approach based on observation of existing outfalls after rainfall (resulting in size reduction).

42. Newlands’ survey of Liverpool was published in January 1840, showing contours at 4 ft intervals. The original, with its fine red line engraving, is difficult to reproduce, but a part of the map, with alternate contour shading added, is reproduced as Fig. 6, and clearly shows the problematic situation of central Liverpool, (exacerbated by the earlier filling of the Pool).11

Newlands’ 1851 progress report

Sewers

43. Newlands’ 1851 progress report indicated that 17 miles of sewer had been constructed since June 1847 at costs generally less than the original estimates. The new Dingle Lane sewer on the southern boundary of the town was described as being the most important and expensive. (Newlands was prioritising his sewer construction in consultation with Duncan, the Medical Officer of Health. The priority given to this sewer passing through mainly new, low density, expensive private housing areas in contrast with the areas served by the other six main outfall sewers may appear odd. However, it can be interpreted as an attempt to intercept and divert overland flow from the area at the south-east boundary of Toxteth, which flow would otherwise find its way overland to the new densely developed areas around Warwick Street. Thus, the previously established strategy of intercepting overland flow had

Pre 1847 type ‘A’ Sewer
As illustrated by Hill in 1938 (See text)
simply been transferred to the new southernmost boundary, and the fact that the tunnel passed through new low density housing was incidental to its primary purpose.)

44. The typical sewer was 3 ft × 1 ft 10 in ovoid with either 4 1/2 in or 9 in brickwork; several sewers were 6 ft × 4 ft or 6 ft × 4 ft 6 in.

45. Much work was undertaken by contract, and the report covers contractor selection, bonds, and contract retentions for reinstatement. Contractors were required to undertake final reinstatement within six months, but Newlands considered immediate reinstatement by the council to be preferable.

Gullies

46. Trapped gullies with gratings were introduced, and old gullies reconstructed, reducing the availability of old large gullies and cesspool traps for use as receptacles for building waste, oyster shells and ashes.

Ventilation

47. The trapping of gullies had commenced near the outlet end of sewers, and its effectiveness, presumably combined with tidal effects, had resulted in an increasing problem of gases being forced out of connections at the upper end of catchments. Newlands proposed, as in his first report, consuming gases within furnaces and chimneys at high points on the system, and was evidently in negotiation in 1851 with the London and North Western Railway Company directors over the use of a redundant chimney at Crown Street, where several drainage areas had a high point and could be easily connected. (The Health Committee was to deny him the £20 required, and also was to deny him authority to make connections to furnaces elsewhere.12)

Flushing

48. Newlands recommended the design and installation of valves for direct flushing from the mains at the extremities of certain sewers, and considered self-acting valves for the tidal flushing of the outfalls, where, particularly in the case of the Dingle sewer, despatch of manual labour for desilting the outfall at low water was proving expensive.

House drainage

49. The manner in which house drains were laid out was contrasted by Newlands with a system recommended for London. The London system involved a private drain passing from yard to yard at the rear of premises, sometimes being built over, whereas the Liverpool system was to promote the use of rear passageways giving access to both the drain laid therein, and permitting the collection of refuse from the rear of each property. (This layout was to become familiar as the typical 'Section 24' sewer in Liverpool.) The 'tubular drain' would connect to the main brick ovoid sewer at the end of the row of houses, with front rainwater connections made direct to the sewer. Newlands' layout is reproduced as Fig 7.
50. Tubular drains are referred to rather than the small two-part ovoid pipes suggested in the 1848 report. (Daymond (see Hill 19) believed the ovoid sewer to have been the invention of Phillips in 1847. Hill recorded that only one stoneware ovoid sewer had been encountered in Liverpool.) Newlands' report also included a proposal for the provision of separate sewer services to each side of a street, ideally in combination with water and gas services, all passing through or adjacent to coal cellars. This was in contrast to the actual provisions of the previous 1830 Act, where there was a specific requirement to lay gas pipes as far away as practicable from water pipes for fear of contaminating the latter.

51. Newlands was proposing and constructing a purpose-designed system of small diameter drains feeding into ovoid brick principal and outfall sewers. It has been noted by Hamlin13 that Newlands was independently working from a viewpoint similar to that of the barrister Chadwick. However, Newlands was in a position to put his drainage and town planning proposals into practice rather than arguing the point, and eventually Chadwick (who had supported Rawlinson for the Borough Engineer's post) moved from a pro-engineer to an anti-engineer position, disenchanted with private practice engineers, and seeing Newlands as a squanderer of public funds.

52. In 1854 Newlands was requested by the Health Committee to prepare a complete list of streets, adopted and unadopted, together with details of the new and old sewers. This list was published in 1855.14

Newlands' 1858 paper

53. In 1858 Newlands presented a paper on Liverpool's sanitary operations to the National Association for the Promotion of Social Science.15 This paper is notable for its summary of the growth of Liverpool, and the descriptions of a population housed in multi-occupancy courts and cellars, with true back-to-back houses, poor ventilation, and poor water supply. With foul drainage previously forbidden, courts had middens or ashpits for excrement, with liquids overflowing into so-called dry wells drilled into the sandstone from which the water supply was obtained.

54. The groundwork of Duncan, Chadwick and the Commission on the Health of Towns was highlighted, together with the founding of the Health of Towns Association in Liverpool in 1845, the publications of which, under the editorship of Dr Sutherland were to contribute materially to the success of the sanitary movement.

55. After summarizing the work described in his earlier reports, Newlands presented Duncan's estimates of reduced mortality (800 per year in 1850, rising to 3000 per year in 1857), but concluded with an argument to extend the borough for sanitary purposes so as to take control of the less populated and undrained swampy land surrounding the borough.

Summary of Newlands' work

56. The 1848 plan had largely been completed by 1869. Newlands, who had suffered from chronic bronchitis to the extent of regularly needing recuperation abroad, retired from active Borough Engineer duties following which his health deteriorated rapidly. He died on 15 July 1871 at the age of 58.16 His funeral was more like that of a Head of State than that of a public servant.17

57. Reference to the local satirical press of the period (i.e. Porcupine, edited by Hugh Shimmin)18 which had generally been supportive of Newlands and reported council sewerage and health issues on a regular basis, shows however that at least as far as the public were concerned, the sewer ventilation problem still existed. For some reason the Health Committee had failed to act on any of Newlands' recommendations since 1866; the water supply had never been sufficient for the intended flushing of the sewers from their highpoints, and ventilation was therefore critical. Lack of ventilation was contributing to accidents and deaths, (although the issue was clouded in one case by chemically contaminated ground). Individual rainwater pipes were now being left untrapped for ventilation. Newlands had developed Archimedean screw
ventilators which had so impressed Bazalgette that he was using them at Scarborough. The best methods of sewage treatment versus land irrigation were still being debated (locally and nationally), and the quality of some sewer construction materials was still in doubt. In 1862, Newlands' men working in James Street stumbled upon a tunnel from the long-dismantled Liverpool Castle (and subsequently turned it into a sewer), Fig. 8.

58. Contrary to the popular belief that Liverpool made no attempt to treat its sewage, Liverpool was in fact utilizing sewage (by hose and jet spreading) on land at Sandhills through a private Sewage Utilization Company. In 1869, the latter was reported as being in need of grants and injections of capital. Newlands saw the sandy coast from Waterloo to Ainsdale as being the ideal opportunity to implement a future scheme to combine sewage and refuse disposal with soil improvement.18

59. Newlands' lasting epitaph is perhaps best taken from a letter of appreciation sent by Florence Nightingale following Newlands' secondment from Liverpool to the Crimea as a Sanitary Commissioner: "Truly I may say that to us sanitary salvation came from Liverpool."19

The twentieth century

60. Liverpool absorbed further outer boroughs or districts in 1895 and 1913, and in doing so inherited sewerage systems outfalling to treatment works at Walton and Fazakerley draining to the River Alt, and at Woolton draining ultimately to the Ditton Brook.

61. Present-day Liverpool sits astride a ridge running SE–NW parallel to the Mersey, and one of the first tasks in 1913 was to create new capacity at Fazakerley by turning the Northern drainage area sewers into a new 8 ft diameter brick-lined tunnel driven back through the ridge to outfall direct to the Mersey at Canada Dock on the Liverpool–Bootle boundary.20 With this notable exception, all of Liverpool's sewer drainage areas follow the natural watersheds. (Ironically, the old West Derby Board had taken its sewers to the Walton boundary in 1869, but had been blocked in its own attempt to continue with a tunnel driven west through the ridge to the Mersey (and despite (or because of?) a declared intention to implement a utilization scheme at Waterloo).)

Sewers

62. Whilst pre-cast concrete pipes were to become standard for larger sewers, avoid brick sewer designs were to continue well into the latter half of this century, often with variations incorporating reinforced concrete.

Watercourses

63. Liverpool's original and surviving watercourses (Fig. 9) were comprehensively described by Hill in 1938.21 Hill does not mention, however, that within the city, watercourses were frequently maintained, culverted or improved for the most part under the comprehensive drainage powers of the 1846 Act (and successor Acts). This was equally true of the districts later incorporated, and may explain the lack of 'Main' rivers within the city, notwithstanding the fact that many watercourses were culverted and/or diverted with high quality materials and completely rebuilt in a similar form to the sewers.

64. This has left present-day Liverpool with something of a dilemma: it may be argued that

![Fig. 8. Report on castle tunnel discovery](image)

![Fig. 9. Liverpool watersheds and watercourses](image)
the former Corporation's use of its drainage powers has relieved riparian owners of future liability. The watercourses are not the responsibility of the Environment Agency or North West Water, notwithstanding the fact that improvements may have been previously charged (correctly) to the sewerage rate, and that ratepayers had also been contributing to a not insignificant regional land drainage precept.

**Water table**

65. In the latter part of the twentieth century, concern has been expressed at the effects of reduced industrial (and North West Water) abstraction from the aquifer beneath Liverpool, and the resultant rise in the water table. The author was interviewed by a research group during the late 1980s concerning the fact that the water table often appeared to rise but then stabilize at an approximate depth of 3 m within the inner built-up area. The explanation suggested at the time was that infiltration into the sewerage system was the cause. It is clear, however, from Newlands' work, that one primary purpose of his system was to provide sub-soil drainage below foundation level, and this may also be limiting present-day water table rises in the central areas.

**Separate system**

66. 1972 legislation gave Liverpool the power to require the use of separate system drainage for all new developments. This policy was to result, at least in the old central drainage areas, in new separate systems being built and temporarily connected into the existing combined sewers, pending the construction of new foul systems which would have permitted the original network to revert to storm use.

67. The provision of a new foul system network was going to be prohibitively expensive, and the requirement was eventually to be overridden by North West Water once the principles had been agreed for implementing the Mersey Estuary Pollution Alleviation Scheme.

**Mersey docks**

68. The Mersey Docks and Harbour Board not only had the duty to convey flows through its estate to the river, but also suspected that it had the burden of dredging much of the solid content of the sewage from the navigable channels. This resulted in a comprehensive study published in 1938.21 The study concluded that the volume of sewage suspended solids was actually comparatively small, and that the hardness of the river deposits was comparable with those of relatively unpolluted estuaries.

Mersey Estuary Pollution Alleviation Scheme

69. Consultant JD & DM Watson reported to a Steering Committee on Pollution of the Mersey Estuary in 1974.22 Whilst none of the detailed East Bank options was to be subsequently adopted by North West Water, the principles laid down for the Liverpool bank regarding interception were pursued.

70. In 1976, on the assumption that there would be both practical and planning difficulties in finding a suitable waterfront site for a treatment plant, consideration was given to a variety of options. These included short-term dry weather flow screening installations on individual outfalls (with the intention of conversion to storm overflows with interceptor sewers at a later date), and a combination of a high level interceptor taking flow inland to the Fazakerley works, with lower level waterfront sewers and major pumping installations.

Liverpool City Engineer's department participated in this work as agent for North West Water. (This work, together with the description of the proposals for treatment, was covered by Dixon in 1985). Fig. 10 shows the principal drainage areas and the route of the MEPAS tunnels. The drainage areas broadly correspond to the watersheds (Fig. 9) with the previously noted Northern Outfall diversion to the Mersey.

71. Storm overflows were modelled at Liverpool University with a view to capitalizing on depths available at certain locations, capturing first flushes, and generally bettering the efficiencies of previous designs.23
72. The eventual choice and approval of a waterfront site at Sandon Dock enabled the design of the interceptor sewers, storm overflows and outfall penstock chambers to begin in earnest in 1984. Elements of the scheme commissioned to date have demonstrated the major benefits of a reactive Real Time Control system, upgradable in the long term for further storm flow capture and predictive use with rain gauges or radar. A major incidental benefit of the project is that the low-lying central areas of Liverpool now have greater protection due to the exclusion of the tide, using controlled gates.

73. The central Liverpool network elements of the project are described in an associated paper, and may be seen as the completion of Newlands’ original intentions 150 years on. His temporary solution, Britain’s first purpose-designed complete sewerage system for conveying foul waste, designed by the first Borough/City Engineer, had all too successfully achieved its original public health objectives, but at an environmental price.

Acknowledgements

74. The author wishes to thank both North West Water and Bechtel for granting permission for this paper to be published. He would also thank Bechtel Water Technology Graphics staff for their assistance, and the librarians at Liverpool City Libraries and the Institution of Civil Engineers for help in locating original reports.

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