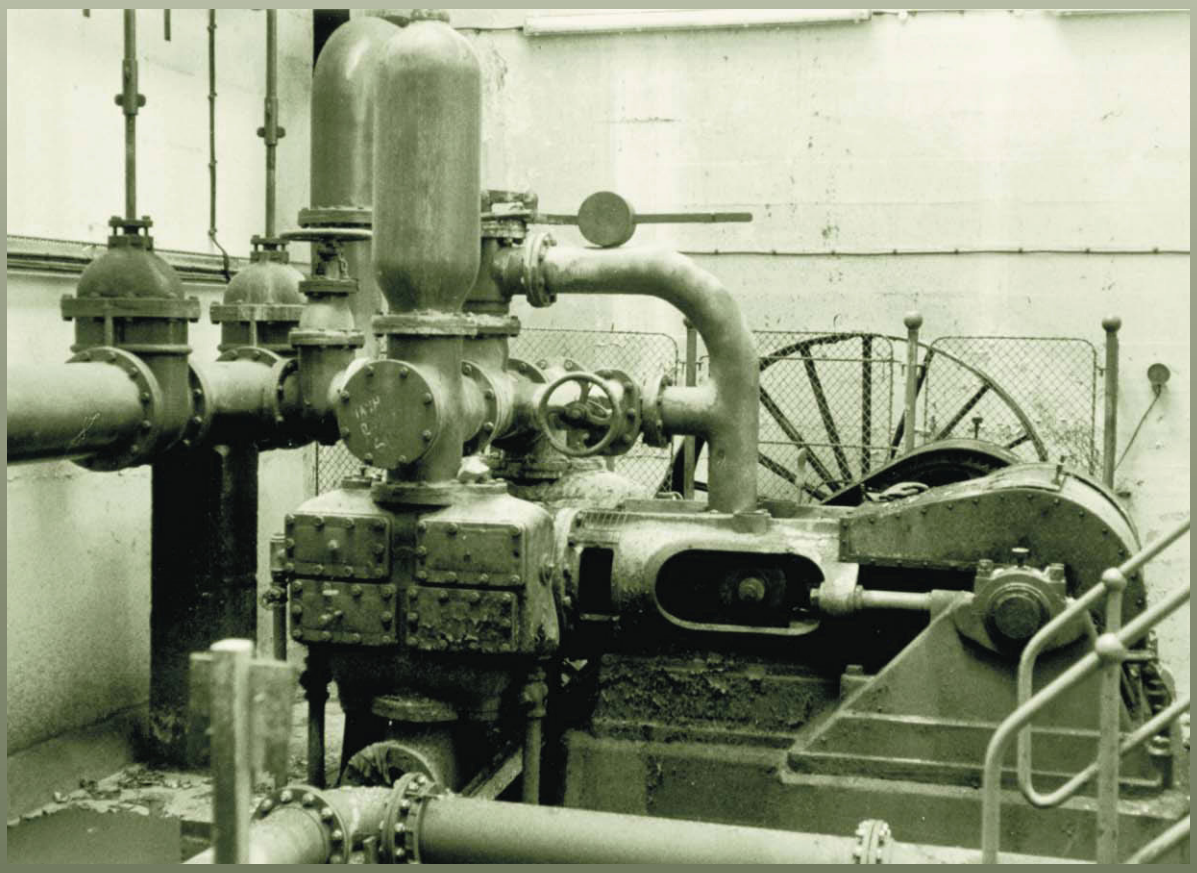
Landscape Evolution in the Middle Thames Valley
Heathrow Terminal 5 Excavations Volume 2

Perry Oaks Sludge Disposal Works
Archaeological Photographic Survey

(Section 24)



by Rob Kinchin-Smith
photographs by Elaine Wakefield

BAA
Thames Water Utilities Ltd.
Framework Archaeology

Perry Oaks Sludge Disposal Works
London Borough of Hillingdon

ARCHAEOLOGICAL PHOTOGRAPHIC SURVEY

NGR TQ 0550 7570

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SUMMARY

Framework Archaeology carried out an archaeological photographic survey at the Perry Oaks sludge disposal works on behalf of Thames Water Utilities Ltd. This recording was carried out at the client's request, in advance of the removal of a large number of sizeable sludge lagoons and drying beds made redundant by the installation of a centrifuge plant. Whilst some elements of the original plant and machinery were to remain in use in association with the new plant, the opportunity was taken to make a complete photographic record of the site.

The site made a classic industrial-archaeological case study. The plant was constructed in 1934 as an adjunct to the sewerage plant at Mogden, then under construction as the major component of the huge West Middlesex Main Drainage scheme. The Mogden/Perry Oaks plant was then as advanced as any plant in use in Germany or the USA.

At the time of the Framework Archaeology survey, the Perry Oaks site was in the first stages of the removal of the redundant facilities. At that time, the site perfectly illustrated a large industrial plant, which had evolved to meet new demands and technologies. Whilst the site still retained substantial elements of each of its original key components (many of them still in use), it also displayed considerable features and remains from each of its later phases. Between them, these features reflected three distinct phases in treatment, handling and transportation technology. In each case, the change has represented a transition from a manual, land hungry and intermittent process to one that is fully automated, compact and continuous.

Acknowledgements

Framework Archaeology wishes to thank Thames Water Utilities Ltd (TWUL). for their cooperation in the site survey and BAA plc (BAA) for generously offering to meet the costs of the survey, the report and suitable archiving. Special thanks to John Goodman and Steve Bennett (TWUL engineers at Mogden and Perry Oaks works) for their help and assistance in preparing this report. The fieldwork team consisted of Rob Kinchin-Smith (Industrial Archaeologist) accompanied by Elaine Wakefield (photographer), both of Framework Archaeology. The text was prepared by Rob Kinchin-Smith and the photographs by Elaine Wakefield.

1 INTRODUCTION

1.1 Location and scope of work

1.1.1 In September 1998 Framework Archaeology carried out an archaeological photographic survey at the Perry Oaks Sludge Treatment Works on behalf of Thames Water Utilities Ltd (TWUL). This recording, which was funded by BAA plc (BAA), was carried out in advance of the demolition of a large number of sizeable sludge lagoons and drying beds made redundant by the installation of a centrifuge plant. The sludge treatment works lies to the west of Heathrow Airport and at the time of survey occupied an area of some 1.2 km^2 (Fig. 1).

1.2 Geology, topography and landuse

1.2.1 The site lies at the western extremity of Greater London on the Taplow gravels overlying London Clay. It is situated on an almost perfectly flat site drained by the natural river Colne and the artificial Longford and Duke of Northumberland's rivers (Figs.1 and 2). Most of the eastern part of the site is laid out on a flat gravel terrace which slopes gently from north to south from c.23.5m OD to c.22.5m OD and the maximum variation is between c.20 and 25m OD. At the time of survey, almost the entire site was occupied by sludge lagoons and drying beds (Fig.2). Historically, the site was used for orchards and meadows and the site was originally selected for sludge disposal on account of its marginal usage and the sparse population in the vicinity.

1.3 Archaeological and historical background

1.3.1 The archaeological and historical background to the site has been the subject of a separate desk study (Framework Archaeology, 1998) and is of little immediate relevance to this survey. Perry Oaks sludge disposal works was built as one element of the West Middlesex Main Drainage Scheme. This scheme was conceived following the First World War, at a time when West Middlesex was developing rapidly in both industry and population. The Scheme, devised in 1928 by John D. Watson, Past President of the Institution of Civil Engineers, was designed to replace 27 sewerage works operated by 22 Local Authorities. These lay within what became known as the "West Middlesex Drainage District", an area of some 160 square miles bounded by the Finchley and Barnet ridge and the rivers Colne and Thames. The pace of development in the area at that time was such that the Local Authorities were unable to keep pace with the provision of sewers and sewerage. Watson's study revealed that all of the area's rivers were overburdened with sewerage and that six of the rivers were discharging sewage effluent into drinking water sources (Watson 1937, p363-4).

1.3.2 Under the Local Government Act 1929, County Councils were empowered to assume the duties of a main drainage authority and in 1930 Middlesex C.C. deposited their Parliamentary Bill for powers to proceed with the works at an estimated cost of £4,290,000. The Bill proceeded through Parliament with the backing of the Government and the Ministry of Labour who contributed a 75% grant on the basis

that the work would be completed by 1st October 1935; that 90% of the labour should be recruited from local labour exchanges, and that of that number, no less than 70% should be men from the "Distressed Areas" (Watson 1937, 465). The scheme was designed to cope with a population of two million using up to 240 gallons/day each (Watson 1937, p468-9) and involved the construction of 146,535 yards of new sewers (Watson 1937, p566). The principal purification works was built at Mogden, near Isleworth. This contained all of the facilities for dealing with disintegrating and screening the sewerage as well as tanks for the primary digestion and sedimentation of the sludge. It was considered that there was inadequate space for sludge-drying at the Mogden Works and that a more thinly-populated area would be preferable for the air-drying of sludge. Therefore, the decision was taken to separate the sewerage treatment and sludge disposal elements of the process. Thus primary treatment and digestion was (and still is) located at Mogden, with the resulting sludge being pumped the 7 miles to Perry Oaks in a liquid state, where 10 secondary digestion tanks and 50 acres of drying beds (increased to 72 acres in 1939 (Townend 1947, p384)) were laid out. At Perry Oaks the liquid portion was/is separated off and pumped back for final treatment at Mogden. Initially, it was proposed to tip the resultant "cake" at Perry Oaks but in 1940 the decision was taken to sell the "cake" to farmers as fertiliser (Townend 1947, p384), a practice which continues to this day.

2 AIMS

2.1.1 The aim of the survey was to provide rapid and representative photographic coverage of the Perry Oaks works at the time of its decommissioning. The purpose of the record was to create a lasting visual and descriptive record, which could be used either on its own or in conjunction with the Thames Water engineering archive.

3 METHODOLOGY

3.1.1 The photographic survey was carried out in a single day. Photographs were taken in both medium and 35mm formats using black and white print film. Additional 35mm images were taken using colour slide film. Films were processed to archaeological archive standards.

4 SCOPE OF FIELDWORK

4.1.1 The survey area was the whole of the Perry Oaks Sludge Works and was to consist of representative and selected detail views of repetitive or generic structures as well as selected internal and external views of all buildings.

5 DESCRIPTION

5.1 Introduction

5.1.1 The site description will be dealt with in two sections. The first part consists of Watson's 1937 description of the site (Watson 1937, p549-554) which is repeated verbatim, with appropriate cross-references to the photographs reproduced at the back of this report. This section describes the site as built. Comments and observations made during the survey will be found in the captions to the reproduced photographs.

5.1.2 The second part of the site description comprises a brief description of the principal subsequent developments, again cross-referenced to the reproduced photographs. This second section has been prepared principally from observations made on site and from a rapid analysis of the limited collection of engineering plans and drawings supplied by BAA. The plans and drawings referred to are listed in Appendix 1 at the end of this report.

5.1.3 The photographs selected to illustrate this report have been reproduced with extended captions. These captions are intended to allow the reader to understand the use and evolution of the site without reference to the text. Readers are referred to the phased site plan (Fig.2).

5.2 Watson's 1937 Description

PERRY OAKS SLUDGE TREATMENT WORKS

Isolation from existing dwelling-houses and unlikelihood of building development taking place in the immediate vicinity recommended the Perry Oaks site for sludge-disposal, although the low cost of the land (about one-sixth the price per acre of the Mogden land) was an important factor. Although only 7 miles from Mogden, it is no less than 3 miles from the nearest railway-station. The nearest habitable dwelling is an isolated farm 700 yards from the drying beds; the nearest building-development lies on the Bath road, more than ½ mile to the north of the site.

The total area of land acquired was 250 acres, including 19 acres on the west side of the Longford river and 21 acres between the Longford river and the Duke of Northumberland's river, which, although not of much value as sites for sludge-tips, were of value to the County Council in giving them control over development in that area. The area made available for sludge-treatment and drying is approximately 175 acres, allowing generous margins between it and the public roads.

Since the strata of the site are ballast and light soils overlying the London clay (sic.)*, objection to the Proposals was taken by the Metropolitan Water Board on the grounds that sub-soil water finding its way into the Thames, from which the Board draws a supply, would be affected agreement was reached that a clay-puddle trench should be constructed surrounding the available site, and taken through the ballast to key well into the London Clay. This puddle wall encloses the area of 175 acres referred to above. A branch sewer is provided to convey all rain-water falling inside the area, together with drainage from the drying-areas, to the main sewer in the Bath Road, and thence to Mogden for full treatment as sewage.*

The first contract let was for the construction of the puddle wall; the minimum width specified was 2 feet, but the actual width as executed was 2 feet 3 inches. The puddle used was clay from tunnel excavation on one of the sewer-contracts, the clay being specially tipped on the Perry Oaks site for this purpose under the conditions of contract. The maximum depth of ballast encountered was 25 feet, the minimum 12 feet and the total length of puddle trench executed under the contract was 3,864 yards. Most of the land had been an old orchard, and about 56 acres had to be cleared of trees and roots, under this contract, before work was started on the site.

On the completion of this preliminary work the way was clear for the letting of a contract for the main constructional programme on the site, and, unlike the Mogden work, it was practicable to advertise it in-toto as one contract. The work comprised secondary sludge-digestion plant, sludge-drying beds, and sludge pumping station, together with roads, tracks, and buildings.

Secondary Sludge-Digestion Tanks (Plates 1-2).
The tank-capacity provided is 21 million cubic feet, making with the capacity of 1.66 million cubic feet at Mogden an aggregate total of 4.16 million cubic feet, or nearly 3.3 cubic feet per person for a population of 1,250,000.

Ten circular tanks (Plate 1*), each 100 feet in diameter, with a side-water depth of 30 feet 5 inches and conical floors laid at 1 in 12 were adopted, the floors being laid on a 3-inch sealing coat of concrete as at Mogden, because here too the foundations are in London clay (sic.).*

Delivery-pipes enter the tanks at one point only, where a vertical leg is erected against the wall with outlets at several levels to obviate splashing when the tank is nearly empty. Suction-pipes are laid on the floors of the tanks, and dip at the centres to small sumps (Plate 2). *Supernatant-water draw-off pipes 9 inches in diameter are provided at three levels, 3 feet, 6 feet, and 9 feet respectively below top sludge-level. They are concentrated and controlled by valves at central control-chambers, each of which serves four tanks. All pipes passing through tank-walls are accommodated in cast-iron sleeves, double-socketed, and provided with puddle-flanges as in the ease of the primary sludge-tanks at Mogden.*

The depth of excavation for these tanks was about 26 feet, and it was preferable to remove the 12-foot depth of ballast over the whole area rather than to leave small dumplings between tanks. To control the water in the ballast, steel sheet-piling was driven to enclose the whole site of the tanks, being located sufficiently far from the tanks to enable ballast left inside to support the piling, and to obviate the use of shoring. On completion of the work, the piling was withdrawn. The ballast excavated was conveyed to the gravel-washing and screening plant, and thence for use as medium in the drying beds. In the construction of the tanks, a circular rail-track was laid on the floor-sealing coat, carrying a specially-made steel framework mounted on wheels, from which sections of steel shuttering were hung, so that the moving and setting of the shuttering for each lift was simplified. Each lift of the walls was limited to 4 feet in height, being poured in alternate bays not exceeding 60 feet in length, and the floors were-completed after the walls were finished. Concrete was mixed by batcher at the central mixing plant, and was delivered to the place of deposit by pumping.

Sludge-Drying Beds (Plates 3-4 and 7-10) .
The area of beds provided is 50½acres, divided into sixty-two plots each 300 feet long by 120 feet wide (except in five cases where site-limitations have

slightly modified the dimensions). They are arranged in one large block, containing two lines of sixteen beds and two lines of fifteen beds, with the length of the beds at right-angles to the long axis of the block. Two lanes, accommodating a light-railway track, divide the lines of beds (Plate 4), so that each track gives access to beds on left and right. The block is also divided by one roadway running at right angles to the light-railway track, while another road runs completely round the site.

The light-railway track is looped at each end of the block and a triangle is provided to facilitate shunting, a locomotive-shed being built on a siding off the main line. The track is continued across the Duke of Northumberland's river, on a steel-girder timber-decked bridge, to give access to tip-sites. Roadways and lanes are formed in concrete. The division and external walls of the beds are also formed in concrete, and are carried 2 feet above medium level (Plates 7-8*). All walls are 6 inches thick with footings 2 feet or 2 feet 6 inches wide, there being four types of wall, three differing only in the footings owing to slight differences of formation-level of groups of beds. The long division-walls between beds are required as gangways, and are therefore widened out to 18 inches at the top* (Plate 7*). The approximate length of wall is 6¼ miles. This mileage justified the use of steel formwork, and the amount of repetition no doubt reduced the price considerably. Ordinary earth banks would have wasted 9 per cent. of the area, whereas the loss in effective area with concrete walls is less than 1 per cent, and the cost of keeping down weeds on over 6 miles of earth bank is entirely avoided. Concrete walls are tidier, cleaner, and of better appearance.*

The fall across the original ground-surface over the whole area was less than 4 feet in 600 yards. Since a difference of 1 inch in level made a difference in excavation of about 8,000 cubic yards, care had to be taken in fixing the bed-levels, and the excavation was reduced to a minimum by grouping the beds at four different levels, the highest being 18 inches above the lowest. Turf and topsoil were stripped off 6 inches deep, even where filling was required. Excavation was computed at 68,000 cubic yards, and refilling at 3,500 cubic yard, exclusive of excavation for drainage-pipes and wall-footings. General excavation was carried out by scrapers drawn by tractors, and spoil was used to make embankments around the site.

The beds are underdrained with 3-inch porous concrete pipes, laid in herring-bone pattern at about 12-foot 6-inch centres, connecting to a main open-jointed stoneware pipe. This pipe runs parallel to a division-wall, and picks up the porous pipes from two beds. Supernatant-water draw-offs are built in the division-walls, each serving two beds, and directly connected to a stoneware drain (Plate 7). *A main intercepting drain is laid down the lane between lines of beds to intercept the stoneware drains, and finally all the drainage is discharged to the branch sewer. The controlling factor in design was the amount of rainfall expected, rather than the amount of sludge-drainage.*

Medium for the beds consists of a 1-foot 6-inch depth of gravel in three layers, 2½-inch to 1½-inch gauge, l½-inch to ¾-inch gauge, ¾-inch to ¼-inch gauge, and a top dressing of sand of ¼-inch gauge downwards.

Sludge is delivered to the beds through a 12-inch pumping-main, with 9-inch branches running down the centre of each bed; each branch is controlled by a sluice-valve adjacent to the lane, and the sludge is discharged from three vertical stand-pipes equally spaced down the centre-line of the bed. Special removable bellmouth tops to these upstands are fitted, for convenience in sluing the light-railway track during the operation of emptying a bed, and the height of the bellmouths can be regulated to secure equalisation of discharges. Although the maximum distance which sludge has to flow in a bed is 78 feet, there is a slight tendency for the sludge to form cones with each inlet as an apex, and as these cones intersect, the wettest sludge reaches the walls half-way between outlets. The supernatant-water draw-off chambers have therefore been located at these points, there being four on each side of each bed.

An opening is formed in the concrete wall of each bed next the lane, at the corner of the bed, to give access for sludge-lifting. This opening is normally closed by two sets of 3-inch stop planks, dropped into grooves at the sides of the opening (Plates 9-10).

Light-railway track is composed of 25-lb. rails, embedded in the concrete of the lane, except opposite each opening, where the concrete is sunk so that two standard lengths of rail are exposed (Plate 9). *One of these lengths is removable and a standard turnout, either left- or right-hand, can be dropped into its place and fished-up, to give access to the appropriate bed. Jubilee wagons are provided, together with two 27/32-HP. diesel-engined locomotives.*

On the west aide of the site a sectional timber building has been erected on a concrete floor, as a men's shelter. Water is laid on to lavatory basins, and a central fireplace provided for warming food and drying clothes.

The Pumping Station (Plates 11-14)
The pumping-station building (Plates 11-12) *also houses the manager's office and men's canteen, with lavatory accommodation and spray-baths. It is a single-storey building, with two galleries in the pump-room to accommodate the fuel-oil storage tank, batteries, and cold-water cistern. The dry pump-well is 33 feet by 21 feet by 15 feet deep, and is founded on clay, whereas the building itself is founded on gravel, and the two structures are therefore quite independent, a sliding joint being formed by cork and bitumen. A hand-operated 3-ton travelling crane commands the pump-bay, in which the two identical horizontal duplex pumps* (Plates 13-14*) belt-driven by diesel-engines. The pumps are capable of discharging 500 gallons per minute against a pressure of 100 lbs. per square inch, and the ratio of the drive can be altered if required, so that the output can be made 1,000 gallons per minute against a head of 50 lbs. per square inch.. The engines can develop 92 B.H.P. on oil fuel, and are capable of conversion to run on sludge-gas if desired.*

Although it is not proposed at present to collect gas from the secondary digestion-tanks, two tanks have been constructed with a resting-corbel to carry a gasholder-cover, should operating experience show the collection of

gas to be justified (Plate 2*). In this event these two tanks can be treated as reception-tanks, and after a few days the sludge can be pumped to the other tanks for storage and complete digestion. Laying of the rising main as a closed circuit and the provision of a double suction pipe enable this to be done, as well as permitting the mixing of sludge by pumping from one tank to another should this be desirable. The rising mains from Mogden are also cross-connected to the rising main from the above pumps, so that the tanks can be bypassed if necessary and sludge delivered direct from Mogden on to the drying-beds. The delivery and suction mains are all 12-inch cast-iron pipes.*

Gravel-Pit.
As over 22,000 cubic yards of concrete were placed, and over 122,000 cubic yards of various grades of sand and gravel were required for medium for the drying-beds, tenderers were given the option of opening and working a gravel-pit on the site, instead of buying sand and gravel for concrete-aggregate and drying-bed media, and five out of the six lowest tenderers based their tenders on working their own gravel-pit. Alternative prices inserted in the bill for gravel from outside sources suggest that a saving of £17,500 was thus effected, and in addition the gravel-pit was made available as a tip for dried sludge. The pit was worked as a wet pit, with floating barges carrying a suction-dredger. Ballast was screened and washed on vibrating screens near the pit, and the power and lighting required for all temporary plant was produced by diesel-engines driving generators.

(Watson 1937, p549-554)

5.3 Post 1937 Developments

5.3.1 The first substantial change to occur at the Perry Oaks site was an enlargement in the area occupied by the drying beds carried out during 1939. The original area of 50 acres was increased to 72 acres in 1939 (Townend 1947, p384) by the building of a further two rows of beds (rows E2-E11 & F2-F11; see Fig.2 & Plate 3) between the original beds and the pumping-station. These were laid out and constructed in an identical manner to the originals and it appears that the original steel formwork was reused. The archaeological watching brief currently being carried out on the site has revealed that whilst the drains under the original beds were laid out with the under-drainage in a herringbone pattern, those in the later beds were laid out square.

5.3.2 The Perry Oaks site needed no further modification until c.1948. The first substantial change to occur in the operation of the facility would appear to have been the construction of earth-walled sludge lagoons. Discussion with staff on site indicates that these served a similar function to the original circular sludge-digestion tanks, the sludge being allowed to settle to the bottom, from whence it was pumped to the drying beds whilst the supernatant water was drawn-off through sluices round the perimeter for return to Mogden. The sluices were fitted with decanting boards. These could be fully closed or progressively opened, thus leaving small gaps between the boards through which the supernatant water can be run off whilst keeping the more solid material in the tank (Plate 20 shows similar sluices). The earth-walled sludge lagoons were identified by letters and the first to be built (lagoons A and B) were located to the south of the drying beds (see Fig.2 & Plate 15). These had an area

of c.0.75 hectares and they would appear to have been about eight feet (2.5 metres) deep (TWUL dwgs. P4.5 and P122, May 1952 and Feb 1965).

5.3.3 Under the initial scheme, dried sludge had been tipped on land lying between the Duke of Northumberland's river and the Longford river which then flowed in a north-west – south-east direction (see Fig.2). As part of the modifications of the late 1940s/early 1950s, the latter river was diverted to run parallel to the former, allowing more land to be annexed for further sludge tips and to allow the construction of additional sludge lagoons, C, D and E, which were built in 1948, 1949 and 1950 respectively (TWUL dwns. P4.1 and 4.5, Feb 1949 and May 1952). The realigned rivers traversed the site contained within concrete troughs, probably to keep the river water separate as the rivers crossed the area enclosed by the puddle wall (Plate 16). New bridges were also required. Whether for rail or road use, these were variations on a standard design with cast *in-situ* reinforced concrete abutments and deck with brick parapets. Lack of any evidence on site of the original steel girder light-railway bridge to the sludge tips indicates that this bridge was replaced by a new structure at this time. Map evidence indicates that the original bridge must have been contiguous with the skew-bridge extant at the southern end of the site (TWUL dwg. P2/1, May 1934). This was the only bridge not to have a concrete road surface. The northernmost bridge on the site still had 2-foot gauge light-railway track set into the concrete roadway (Plate 17). This bridge cannot have carried rail traffic for long as the route of this railway to the west of the bridge was overlain by D lagoon in 1949.

5.3.4 The next substantial change in the management of the Perry Oaks facility was the building in 1952 of two sets of concrete-lined dewatering tanks (sludge lagoons) (Nos.11-17) (Plate 19) adjacent to the circular sludge-digestion tanks and pumping-station at the extreme eastern end of the site (TWUL dwg. P57, October 1952). These tanks, which were each some 0.6 hectares in area and some 4.24 metres deep, were numbered in series from the original circular sludge-digestion tanks and appear to have served the same function, the sludge again being allowed to settle to the bottom before being pumped to the earth-walled lagoons or directly to the drying beds. Supernatant water returned to Mogden. Apart from the change in shape, the principal difference between the original digestion tanks and the sludge lagoons was that whilst the original tanks had four-level input legs and three-level supernatant water drainage outlets, the newer tanks (and the earth-walled lagoons) were fed at low level and the supernatant water was drawn off through sluices fitted with decanting boards (Plate 20).

5.3.5 It is unclear when the first experiments in mechanised dried sludge lifting were carried out. The site plans imply that the drying beds were still being lifted manually in 1965 (TWUL dwg.P125, March 1965). By the 1960s the hand-lifting must have been becoming seriously archaic and in 1965 the first mechanically-lifted drying beds (1A-6A) were constructed to the south of the earlier beds (TWUL dwg P125, March 1965). These beds were over 500 metres long and c.19 metres (61'6") wide and used travelling elevators. These gantry-type structures traversed the beds, supported on raised tracks. These beds were immediately followed by a second phase to the west (beds 7B-12B) and a third phase was planned the same year (TWUL dwgs. P122 and

P125, Feb 1965 and March 1965). This extension would have extended the first phase beds right across the rivers to over 1 km in length. The construction of the third phase was suspended in June 1966 (TWUL dwg. 1P/138) and latterly the travelling elevators were superseded by mobile shovels (standard earth-moving machinery). The structure of these beds remained largely intact at the time of the survey (Plate 21). Fragments of the rails upon which the elevators ran still remained, set on low concrete walls. The rails were formed by lipped channel-shaped steel `ladders', fitted with closely spaced steel `rungs'. It appears likely that the `rungs' would have been engaged by pinions on the travelling elevators. A derelict machine found dumped elsewhere on site appeared to have been a diesel-driven winch for hauling the elevator along the beds (Plate 22).

5.3.6 Another new technology introduced with the travelling elevators was a conveyor system (TWUL dwg. P125, March 1965). The new beds were laid out to either side and it was used to move the dried sludge directly from the elevators to a sludge stacking area at the east end of the site. The conveyor had been dismantled, probably when the travelling elevators were suppressed. Traces of it remained *in-situ at* the time of survey, notably where it had crossed the river. Here the rollers remained in place, as the supports had been integrally-cast into the bridge decking (Plate 23).

5.3.7 The reason why a halt was called in the construction of the travelling-elevator drying-beds appears to have been the ascendancy of the use of mobile shovels. During 1965 a new design of drying beds was under construction to the north of the western travelling elevator (TWUL dwgs. P122, P136 and 1P/138, Feb 1965, Jan 1966 and June 1966). These beds (numbered W1-W14 Fig.2) were smaller and square in shape and were designed from the outset to be emptied by the mobile shovels which by June 1966 were also being used to empty the old manual beds. With the use of so much mechanised plant, a new workshop building was clearly needed and this building also features on the June 1966 plan (TWUL dwg. 1P/138, June 1966) for the first time (Plate 24). Unsurprisingly, there was no evidence that this building was ever used to service railway vehicles and it is probable that 1965-6 marked the end of regular use of the railway.

5.3.8 Following on from the success of the earth-walled sludge lagoons, a programme of constructing earth-built sludge lagoons of ever-increasing size had been implemented. These lagoons had initially been constructed on vacant sites on the southern and western parts of the site but by 1972 these sites were all occupied and the latest lagoons (lagoons P and Q) had to be constructed on the site of the 1965 mobile shovel drying beds (W1-W14) (TWUL dwg. 148/73 and 148/73/1, Nov 1972 and Nov 1973). The programme of lagoon-building culminated in the construction of the vast R and S lagoons (Plate 25). These lagoons, of 7.8 and 6.8 hectares respectively, with a depth of 8.5 metres, were built in 1978 and c.1986 (TWUL dwgs. 1P/306, 566/2/1B and 1P/138B, May 1978 and Sept 1986 and Nov 1987). These lagoons were built on much of the site formerly occupied by the old manually-lifted drying beds and it appears that the sludge was now being left to dewater for longer in the lagoons which meant less need for so many drying beds. Thus, in 1988 plans were formulated to build two further vast sludge lagoons (T and U) on the sites of the remaining drying-

beds on the eastern part of the site (TWUL dwg. 5945/0001, April 1988). Instead a compact centrifuge plant was designed in 1990 (TWUL dwgs. 5090/0010A and 5090/0011B, Feb 1990) (Plate 26).

5.3.9 At the time of survey several elements of the original plant continued to function in association with the centrifuges. One of these features was the original group of ten circular secondary sludge-digestion tanks, complete with valve equipment and ornamental trees. No.9 tank (with No.7 in reserve) was being used for supernatant water being returned to Mogden. Most of the tanks can still be used for reception and holding purposes and several are equipped with variable-height macerators adjacent to the outlets. The centrifuged sludge is proving to be more pungent than the bed-dried "cake" and air-stripping experiments are currently being carried out in tank No.10. Probably the most immediately noticeable of the retained elements was the pumping station. This was still required to pump the sludge from the sludge-digestion tanks to the centrifuges as well as being required to pump the supernatant water back to Mogden. Pumping was being done by a single small electric impeller-type located in the pump-well. Although the old diesel-driven duplex pumps had been superseded and the diesels engines had been removed, one of the duplex pumps remained *in-situ* whilst the other had been removed for preservation off-site. Most of the building remained in use for storage, garaging and maintenance purposes. Of the 1952 dewatering tanks, the northern block (Nos.11-13) had been knocked together and an entrance made in the south-western corner. The combined area was being used for parking mobile plant and it had clearly also been used for dried sludge ("cake") storage. The southern block (Nos.14-17) remained intact and had been in recent intermittent use as wet sludge holding tanks connected with the centrifuges. Problems with smell and experiments with air-stripping have recently led to a decline in the use of these tanks and a revival in the use of the original circular tanks for the air-stripping experiments and the southern block is scheduled for closure. TWUL plans supplied to Framework Archaeology also indicate that the last sludge lagoon constructed (lagoon S) may also be retained, at least in the short-term (TWUL dwg. 5090/0010A, Feb 1990 with amendments).

6 DISCUSSION AND INTERPRETATION

6.1.1 The site made a classic industrial-archaeological case study. When the plant was constructed in 1934 the Mogden/Perry Oaks plant was then as advanced as any plant in use in Germany or the USA, then considered to be leaders in this tehnology. At the time of the Framework Archaeology survey, much of the Perry Oaks site was in the first stages of the removal of redundant facilities. At that time, the site still illustrated perfectly a large industrial plant which had evolved to meet new demands and technologies. Whilst the site still retained substantial elements of each of its original key components (many of them still in use), it also displayed considerable features

and remains from each of its later phases. Between them, these features reflected three distinct phases in treatment, handling and transportation technology. In each case, the change has represented a transition from a manual, land hungry and intermittent process to one that is fully automated, compact and continuous. Whilst these changes have had a truly dramatic effect on the throughput of the plant and the area required for the processes, it is also remarkable how some elements of the original plant have proved their versatility and are likely to continue in use for the foreseeable future.

6.1.2 The principal changes to have occurred in the sixty year history of the site may be summarised thus:-

- Secondary sludge digestion
  - Originally a single-stage operation performed in 10 circular concrete tanks. c.1952 the area of concrete-lined tanks was supplemented by 7 large rectangular tanks.
  - From c.1948 to 1987, earth-walled lagoons of ever-increasing depth and area were constructed for further dewatering of digested sludge
  - After 1987 the construction of further lagoons was abandoned and after the introduction of the centrifuges, lagoons become slowly redundant.

- Sludge drying
  - From 1937-1965, manually-emptied drying beds of great extent are in use (50 acres to 1939, 72 acres thereafter).
  - In 1965, the area of beds was almost doubled by the construction of two new designs of drying bed, one type emptied by mobile shovel, the other by travelling elevator.
  - Mobile shovels latterly replace both manual and travelling elevator systems. Latterly, the beds became slowly redundant following the successful use of the centrifuge plant.
- Sludge transportation
  - From 1937 a 2ft gauge railway with portable rails for use on beds was in use.
  - In 1965 a conveyor system was introduced with the travelling elevator beds.
  - The conveyor system and the railway were latterly made redundant by increased use of mobile shovels which could load directly into lorries. The centrifuges now discharge directly and continuously into parked trailer units.
- "Cake" disposal
  - "Cake" tipped on site until 1940.
  - In 1940, the war-effort and increased pressure on the site led to the sale of dried sludge to farmers.
  - In 1965, a special dried sludge storage area was established for use with the conveyor system. This was superseded by loading lorries straight from the bed using mobile shovels. The centrifuges now often load continuously into parked trailers.

7 RECOMMENDATIONS

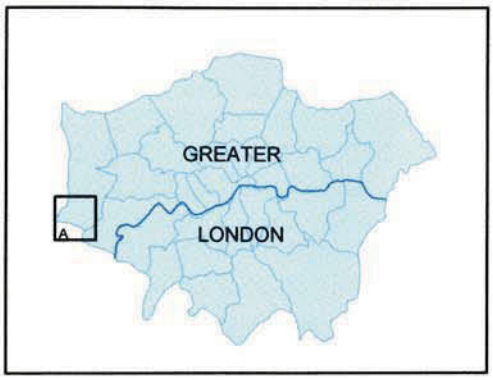
7.1.1 A small number of engineer's drawings supplied by Thames Water Utilities Ltd. (listed in Appendix 1) were referred to during this study. During the site survey, it transpired that there was a mobile office at the Perry Oaks site containing a substantial archive of historic and modern engineering drawings relating to the site. Brief examination of these drawing revealed that a substantial number were hand-coloured originals, many clearly dating to the 1930s. It is recommended that the complete archive (including the later drawings) be maintained in archivally stable conditions following any decommissioning of the works as it forms a valuable historical resource.

Appendix 1 TWUL Engineering Drawings Consulted

originator	drawing title	drawing no.	date of drawing	Comments
MCC	Digestion tanks - sections	P2/12 part	??	Section through large concrete tanks
D & W	Puddle wall sections	101 MP	1933 Aug	This shows original clay puddle wall sections East of Rivers
D & W	Puddle wall at Perry Oaks	P1/2	1933 Aug	This shows original clay puddle wall layout East of Rivers
D & W	Drying bed trial holes BHoles	200MP	1934 May	This shows original works sludge drying bed area
D & W	Key plan and site plan	P2/1	1934 May	This shows original works sludge drying beds and digestion tanks
MCC	whitemead exts. Gen Plan, BH	P4.1	1949 Feb	General layout showing area of Extension west of twin rivers
MCC	Proposed water service	P4	1949??	Water main
MCC	Whitemead Extensions record dr	P4.5	1952 May	B1 drawing showing the new layout of lagoons at Northwest
MCC	layout of New sludge lagoons	P57	1952 Oct	Details of New sludge lagoons (concrete) at East end of site
Air Minist	Perry Oaks Sludge disposal wor	8201/54	1954	Conveyancing drawing for runway extensions
GLC	sludge beds stage 3	P108	1964 May	New sludge drying beds Southwest corner West of the rivers Stage 3
GLC	Recon of sludge lagoons	P134	1965 Dec	Reconstruction of sludge lagoons in SE corner
GLC	Temp sludge drying beds	P122	1965 Feb	location of temp drying beds in SW corner West of rivers
GLC	sludge beds stage 3B	P125	1965 March	New sludge drying beds Southwest corner West of the rivers
GLC	W Area - Const details J & K	P/136	1966 Jan	Detail drawing for lagoons J and K. Drawing also shows the location of the drying beds.
GLC	Plan of development 1966	1P/138	1966 June	Plan of development in 1966 -shows situation with drying beds and lagoons -(Prior Lagoons R
GLC	Survey of lagoon "O sht 4 of 4	IP/146	1968 Nov	Survey of Lagoon "O"
GLC	Survey of lagoon D	P/148	1970 Feb	Survey of Lagoon D
GLC	Survey of lagoon A after enlar	1P/191	1971 Nov	Survey of Lagoon A after enlargement
GLC	Survey of recon lagoon B	1P/194	1972 July	Survey of Lagoon B after emptying and reconstruction
GLC	Survey of lagoon P -Nov 72	148/73	1973	Survey of Lagoon P after construction - Nov 72
GLC	Survey of lagoon Q - Nov 73	148/73/1	1973	Survey of Lagoon Q after construction - Nov 73
TW	Areas liable to flood		1974 May	Map Areas liable to flood showing River Colne catchment area
BAA	Foul Drainage	sht 2	1975 Feb??	Location of Foul drainage - from OS maps
BAA	Foul Drainage	sht 9	1975 Feb??	Location of Foul drainage - from OS maps
TW	Survey sht 1 of 4	2450/77/1	1977 Sept	Survey of existing works
TW	Survey sht 2 of 4	2450/77/2	1977 Sept	Survey of existing works
TW	Survey sht 3 of 4	2450/77/3	1977 Sept	Survey of existing works
TW	Survey sht 4 of 4	2450/77/4	1977 Sept	Survey of existing works
OS	OS Map	TQ0676NE	1978 Dec	OS Map showing sludge main
OS	OS Map	TQ0576NE	1979 Jan	OS Map showing sludge main
OS	OS Map	TQ0576SE	1979 Jan	OS Map showing sludge main
OS	OS Map	TQ0676NW	1979 Jan	OS Map showing Sludge main
CS	OS Map	TQ0676SW	1981 March	OS Map showing Sludge main
TW	Lagoon S - Planning app	566/2/1B	1986 sept	Planning application for lagoon S
TW	works layout	1P/138B	1987 Nov	Layout of works
TW	works layout + pumpmains	1P/138B2	1987 Nov	Layout of works marked-up with Pump mains
TW	Lagoons T and U - Planning app	5945/0001	1988 April	Planning application for lagoons T and U - not proceeded with
TW	drawing of East drying beds	1502A	1988 Aug	Exist drying beds. It would appear to be instructions to decommission a conveyor.

originator	drawing title	drawing no.	date of drawing	Comments
TW	Sludge Lagoon Levls sht1 of 2	Z1791/1	1988 Aug	Sludge lagoon Levelling
TW	Sludge Lagoon Levls sht 2 of 2	Z1791/2	1988 Aug	Sludge lagoon Levelling
BAA TW	survey of dry beds E of rivers	1553/33	1988 ~~Aug ?~~	Survey of drying beds East of rivers (Working plot of 1791/1 and 2)
TW	Location and Site plan	5090/0010A	1990 Feb	1990 survey marked up with handover phasing
TW	Sludge dewatering plant	5090/0011B	1990 Feb	sludge dewatering plant

Lagoon R. Layout — 1P/206 1980 July ? 1980



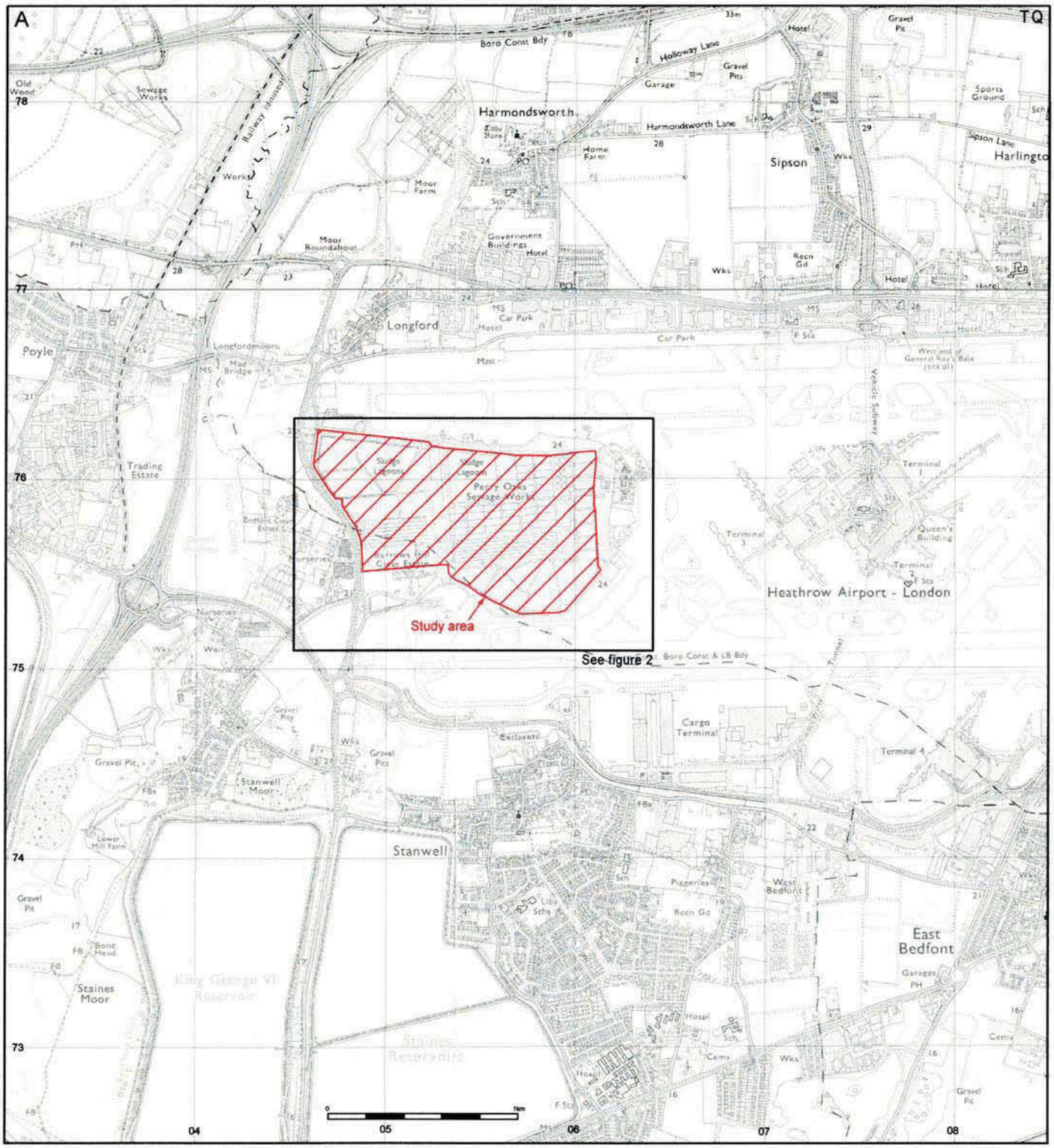


Figure 1: Location plan

Figure 2 : Phased plan of sludge works

Plate 1: Secondary sludge-digestion tanks from the north-west (tank no.2 in foreground). Note the ornamental planting of chestnut trees in the gaps between the tanks.

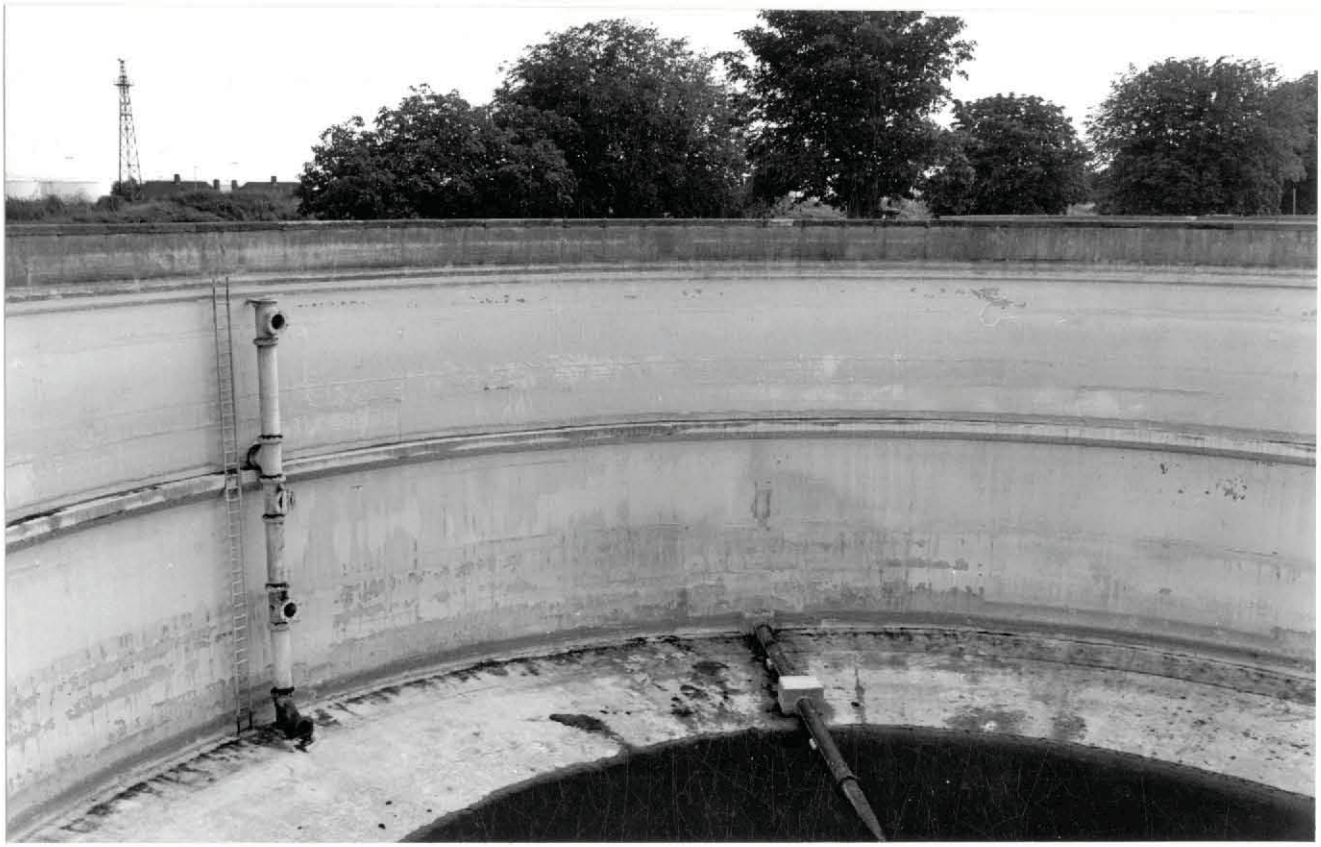


Plate 2: The interior of secondary No.1 sludge-digestion tank, looking south. Note the vertical leg of the delivery pipe with its four outlets (on left) and the suction pipe for the settled-out sludge on the floor. Both this tank and the adjacent No.2 tank have a resting-corbel at mid-height for the planned-but-never-built gasholder-cover.

Plate 3: General view over the remaining sludge-drying beds from the north, showing the north-south concrete roadway which divided the southern end of the primary drying beds (beds D8-11) from the slightly later block E/F8-11. Note the supernatant water draw-off chambers in the near corners and middle distance. The original dividing walls between the beds are missing as they obstructed the later practice of machine-removal of the dried sludge.

Plate 4: Primary north-south lane dividing former beds C8-11 from D8-11 with 2-foot gauge light-railway still *in-situ*. Note supernatant water draw-off in near corner.

Plate 5: Former locomotive shed from the south-east. This building was originally a through-shed, with doors at both ends.

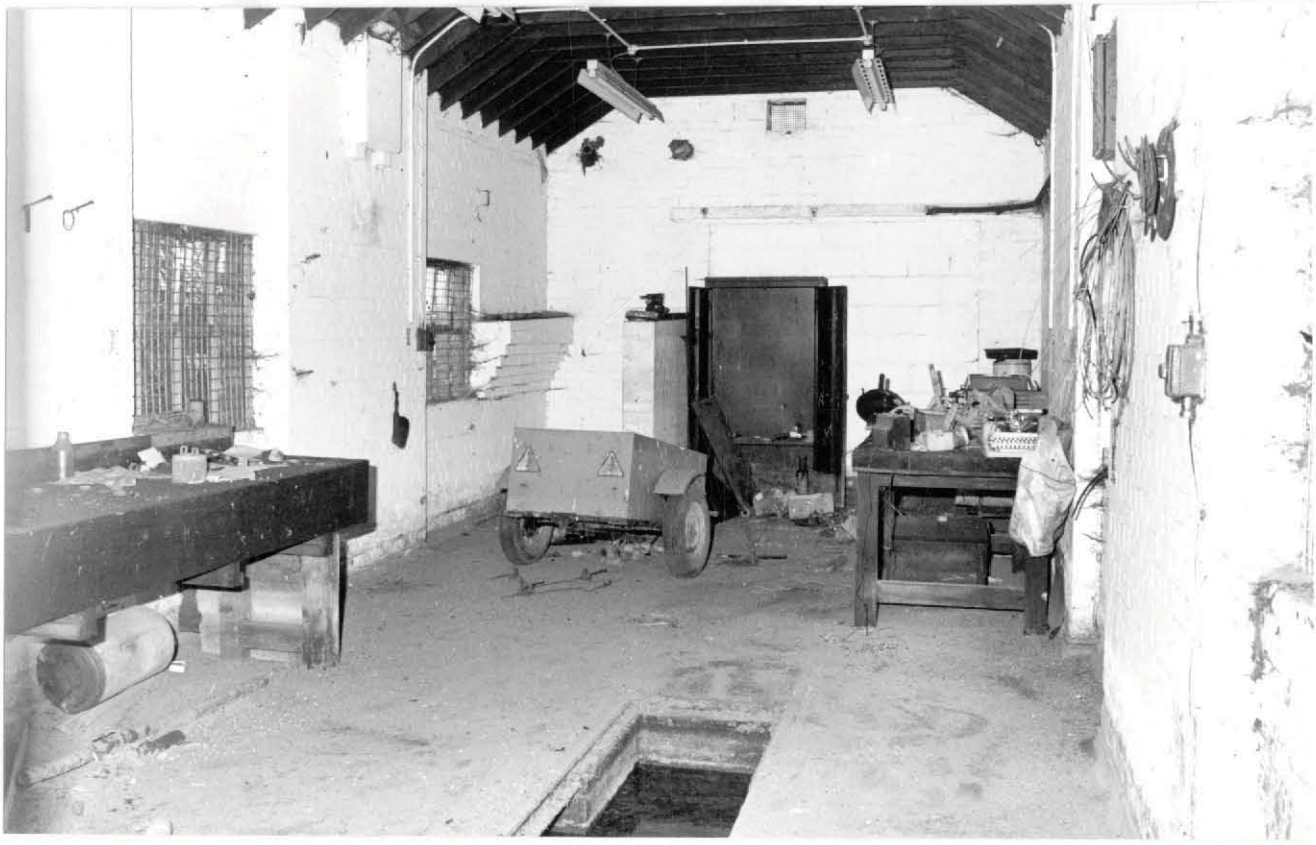


Plate 6: The locomotive shed was clearly used for maintenance purposes, as evidenced by the maintenance pit (with rails *in-situ*), benches and a thickening of the side walls at mid-point, probably for a gantry.

Plate 7: Typical junction between a division wall between sludge-drying beds and a north-south lane. Note the supernatant water draw-off chamber with its loosely-fitting decanting boards as well as the steps and the walkway, the latter formed by the widening of the top of the dividing wall

Plate 8: Typical external wall of a sludge-drying bed, showing impressions left by the steel formwork. The original formwork appears to have been reused for the extensions to the primary drying beds.

Plate 9: Typical junction between a north-south lane and drying bed division walls showing how the lane widened to allow the railway to be extended onto the dried sludge for the manual emptying of the beds. Normally the railway, still just visible in the middle distance embedded in the concrete of the lane, ran straight through at such points, on a removable track section. When a bed required emptying, the stop-planks to left or right would be removed and a standard turnout would be inserted (along with further pre-fabricated track panels onto the surface of the dried sludge) allowing the sludge to be manually loaded directly into side-tipping 'Jubilee' wagons.

Plate 10: Detail showing the stop-boards and the slightly sunken part of the lane surface where the removable track panel would have lain.

Plate 11: The original pumping-station from the west.

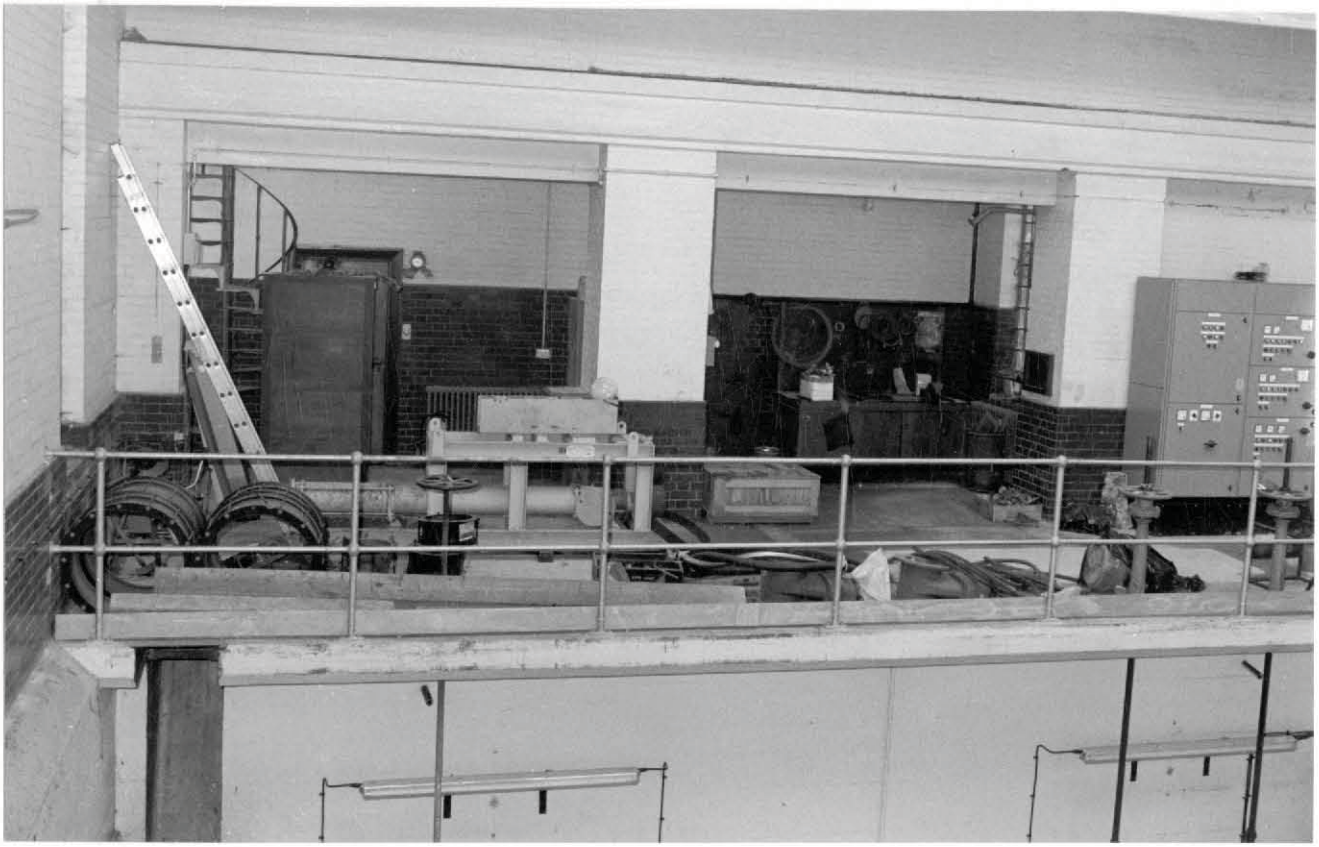


Plate 12: The interior of the pumping-station looking south. The spiral staircase on the left accesses the gallery which still houses the cold-water cistern and fuel tank which formerly supplied the diesel engines which drove the pumps. The diesel engines (reputed to have been designed for use in submarines) were located behind the railings. They drove the pumps (located in the pump-well in the foreground) through belting which passed through slots in the floor. One of these slots is visible on the left of the picture.

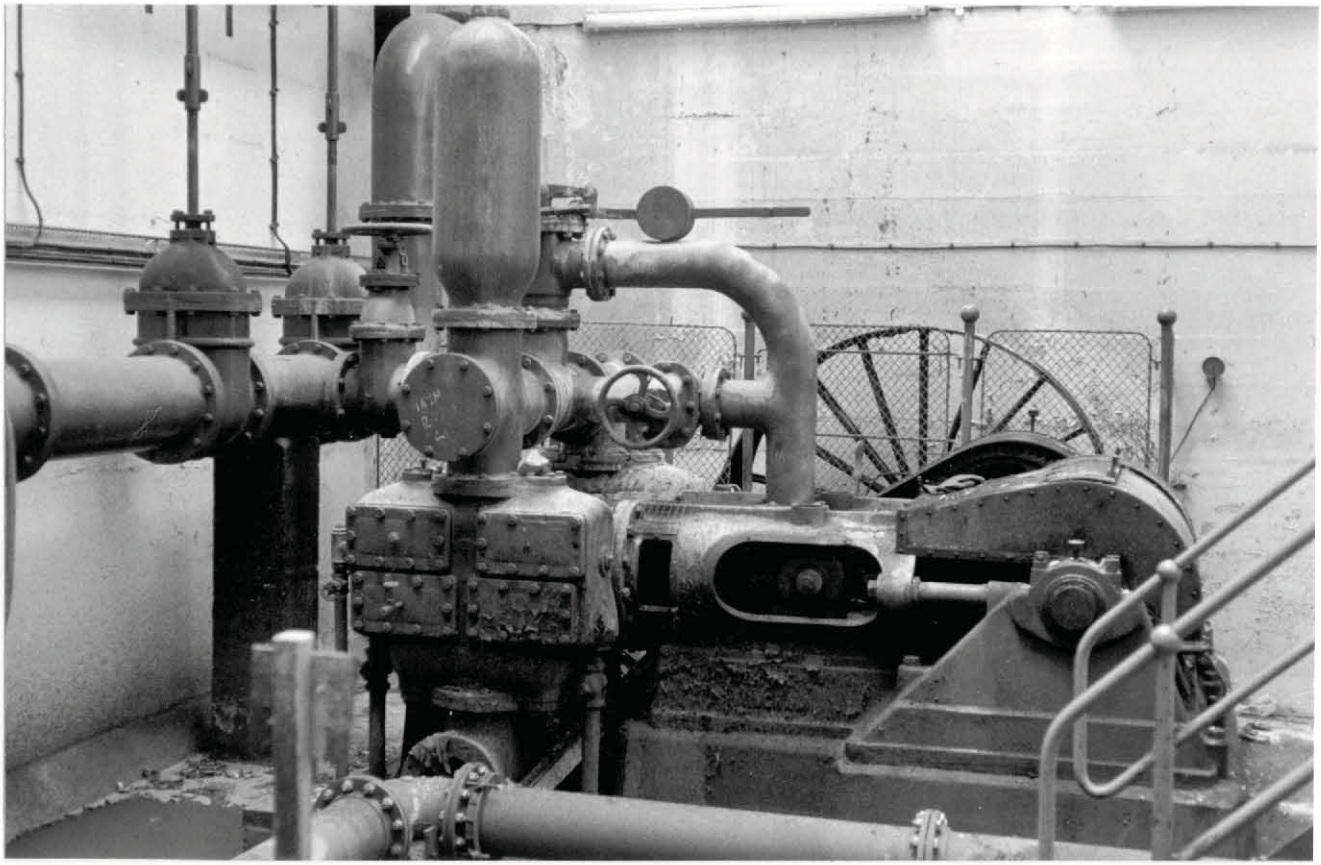


Plate 13: The remaining duplex pump, supplied by M.B.Wild & Co.Ltd. of Birmingham. Its former partner has been preserved off-site.

Plate 14: The cylinder covers of the pumps bear the monogram of Wild & Co.

Plate 15: Apart from an increase in the area occupied by the drying-beds carried out during 1939 (beds E2-E11 & F2-F11), the Perry Oaks site needed no further modification until c.1948. The first substantial change to occur would appear to have been the building of a new type of earth-walled sludge lagoon. The first to be built (A) was located to the south of the drying beds. These served a similar function to the digestion tanks, the sludge being allowed to settle to the bottom, from whence it was pumped to the drying beds. Supernatant water was drawn-off through sluices round the perimeter for return to Mogden. The above photo shows lagoon A at the time of survey. It had been completely rebuilt in 1971.

Plate 16: Under the original scheme, dried sludge had been tipped on land lying between the Duke of Northumberland's river and the Longford river which originally flowed in from a north-westerly direction. As part of the modifications of the late 1940s and early 1950s, the latter river was diverted to run parallel to the former, allowing further land to be annexed for tips and sludge lagoons C, D and E (built 1948-1950).

Plate 17, The parallelling of the rivers required new bridges. The northernmost of these still had railway track set into the concrete road surface at the time of survey.

Plate 18:.The north railway bridge cannot have carried rail traffic for long as the line had been overlain by 1949 by a new D lagoon , seen here from the north. For a period in the 1960s the northern part of this lagoon was divided off, forming lagoon H, the two parts being reunited (and probably rebuilt) by 1970

Plate 19: No.14 sludge-dewatering tank. The next substantial change at the Perry Oaks plant was the building in 1952 of two sets of concrete-lined dewatering tanks (sludge lagoons) Nos.11-17 adjacent to the circular sludge-digestion tanks and pumping-station at the extreme eastern end of the site. These served a similar function to the digestion tanks, the sludge being allowed to settle to the bottom before being pumped to the earth-walled lagoons or directly to the drying beds. Supernatant water was drawn-off for return to Mogden.

Plate 20: Apart from the difference in shape, the principal difference between the original digestion tanks and the sludge lagoons was that whereas the original tanks had four-level input legs and three-level supernatant water drainage outlets, the newer tanks (and the earth-walled lagoons) were fed at low level and the supernatant water was drawn off through sluices fitted with decanting boards. These can be fully closed or progressively opened, thus leaving small gaps between the boards through which the supernatant water can be run off whilst keeping the more solid material in the tank.

Plate 21: By the 1960s the hand-excavation of the drying beds was becoming increasingly archaic. Thus, in 1965 the first mechanically-lifted drying beds (1A-6A) were constructed to the south of the earlier manually-lifted beds. These used travelling elevators which effectively were gantry-type structures which traversed the beds, supported on raised tracks. More recently these beds have been emptied using earth-moving machinery but much of the structure has remained intact. This view shows the raised tracks which divided beds 1A-3A from 4A-6A. Similar tracks were provided along the northern and southern edges.

Plate 22: Though laid-up on a different part of the site at the time of survey, this machine would appear to have seen use on the mechanically-lifted beds.

Plate 23: Another new technology introduced at the same time as the mechanical emptying of the beds was a conveyor system, leading from the new drying beds to a sludge stacking area at the east end of the site. Vestiges of this remained *in-situ* after decommissioning, principally where integrally-cast into the decking of a bridge over the two rivers. This bridge connected the phase I mechanical-lifted drying beds (1A-6A) to a second phase to the west of the rivers (7B-12B). A planned third phase would have extended the phase I mechanical beds across the river at this point.

Plate 24: Also during 1965 a new design of drying beds was inaugurated to the north of the Phase II beds. These (numbered W1-W14) were designed to be emptied by mobile shovel (standard earth-moving machinery). It is likely that this coincided with the change-over to the use of mobile shovels for emptying the original manually-lifted drying-beds and the abandonment of plans to continue the construction of the travelling-elevator mechanically-lifted beds. With the use of so much mechanised plant, a new workshop building was constructed adjacent to the old locomotive shed.

Plate 25: Following on from the success of the earlier earth-walled sludge lagoons, a rolling programme of constructing further lagoons of ever-increasing size had been embarked on. These were initially constructed on vacant sites on the southern and western parts of the site but by 1972 these sites were fully occupied and the latest lagoons (lagoons P and Q) had to be constructed on the sites of the mobile shovel beds (W1-W14). The largest lagoons constructed, lagoons R and S (built 1978 and 1987 respectively), were built on much of the site formerly occupied by the manually-lifted drying beds. This view shows 'S' sludge lagoon from the south with decanting chambers visible in foreground and background.

Plate 26: Plans in 1988 to build two further vast sludge lagoons (T and U) on the sites of the remaining manual- and mechanically-lifted drying-beds on the eastern part of the site were not implemented. Instead a set of centrifuges was designed in 1990.

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