



# MDC – Work Package 3 Archaeology Detailed Desk Based Assessment Farringdon Station

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# 1 Non-technical Summary

This report presents the results of Archaeological Detailed Desk Based Assessment (DDBA) of five sub-sites that form part of Crossrail Site 207 Farringdon Station, located within the Central Section, route window C6. The report assesses the impact of Crossrail works on archaeological deposits that may survive within the identified sub-sites (Eastern Ticket Hall, including 33-37 Charterhouse Square and 3 Hayne Street; Western Ticket Hall; and grout shafts at 67-69 Cowcross Street and Greenhill's Rents).

Farringdon Station is within both a London Borough Islington Archaeological Priority Area and within the City of London, which is considered to be equivalent to an Archaeological Priority Zone. The station site has a high potential for the Post-medieval urbanisation of the area, moderate potential for Medieval religious institutions and associated burial grounds; Prehistoric, Roman and Medieval secular remains, topographic evidence of the Fleet Valley, evidence for late 19th to early 20th century railway infrastructure; and low potential for early to middle Saxon burials and occupation. There is a particular potential for individual deeply cut features such as burials, pits, wells and ditches in the vicinity of Hayne Street and Charterhouse Square as they are situated within the Medieval cemetery of Charterhouse.

The DDBA has demonstrated that the construction of the existing underground line and retaining walls will have completely removed archaeological deposits from within its footprint including the northern and western sides of the Eastern Ticket Hall. However, archaeological deposits may survive beneath basements at 20-23 Long Lane; 8-10 Hayne Street; 3 Hayne Street; and at 33-37 Charterhouse Square.

Basements in the present buildings at the Eastern Ticket Hall will have removed much of the horizontal stratigraphy, although deeply cut features such as pits, wells, burials and ditches may survive below the level of the basements. Archaeological deposits may also survive at the sites of the grout shafts at 67-69 Cowcross Street and Greenhill's Rents from depths of 1m – 1.5m below ground level. The final location of the grout shafts is to be confirmed at detailed design.

Basements and the underground car park beneath Cardinal House have removed virtually all archaeological remains at the Western Ticket Hall. However, the course of the Faggesswell Brook is conjectured to have flowed east-west across the site somewhere between Cowcross Street and Charterhouse Street, and there is a low potential that the very base of the brook may survive cut deeply into the London Clay, beneath truncation by Cardinal House.

The construction of the grout shafts and the Eastern and Western Ticket Halls will remove all archaeological deposits that survive at those locations. The establishment of construction compounds associated with the grout shafts at 67-69 Cowcross Street and Greenhill's Rents will have no or minimal archaeological impacts.

Enabling Works that may also affect archaeological remains and/or Non-Listed Built Heritage and Street Furniture comprise utilities diversions in the vicinity of the Eastern Ticket Hall and the demolition of buildings at the Eastern and Western Ticket Halls.

A programme of archaeological field evaluation is required at the Eastern Ticket Hall (20-23 Long Lane; 8-10 Hayne Street; 3 Hayne Street; the space between 8 & 10 Hayne Street; and at 33-37 Charterhouse Square). The results of these evaluations will inform a mitigation strategy, comprising *preservation-by-record* (e.g. archaeological excavation and/or watching brief).

Archaeological mitigation will be required at the grout shaft locations, the methodology of which is to be confirmed at detailed design. Mitigation at the Crossrail worksites for Farringdon Station will also comprise general watching briefs on ground reduction within the footprint of the Western Ticket Hall; utilities diversions at Charterhouse Square; Charterhouse Street; and Fox and Knot Street; and in the road between 3 and 10 Hayne Street.

## 2 Introduction

### 2.1 Scheme Background

Crossrail is a major new cross-London rail link designed to serve London and the south-east. The scheme will include the construction of a twin bore tunnel on an east-west alignment under central London and the upgrade of existing rail lines to the east and west of central London. It also includes the construction of new central London stations, providing interchange with London Underground, National Rail and London bus services, and the upgrading or renewal of existing stations outside central London.

The Crossrail route is divided into four sections: a central section in central London, and outside of central London, western, north-eastern and south-eastern sections. Each section is further sub-divided into route windows, within which are located a number of sub-sites. The subject of this Detailed Desk Based Assessment (DDBA) is Site 207 Farringdon Station, located within the Central Section, route window C6.

### 2.2 Nature and Extent of Work

The Crossrail works at Farringdon Station can be sub-divided into the following key elements:

- Western Ticket Hall (Figure 1) located off Cowcross Street: a piled box with two shafts, providing ventilation, draft relief, service risers, intervention and emergency escape for Crossrail and a shared ticket hall with Thameslink.
- Eastern Ticket Hall (Figure 2) located off Lindsey Street: a diaphragm wall shaft providing draft relief, intervention and emergency escape for Crossrail and interchange to London Underground (LU) Barbican Station.
- The construction of a shaft on the site of 33-37 Charterhouse Square, adjacent to LU Barbican Station.
- Crossrail Platform tunnels: sprayed concrete lined tunnels running east-west between the East and West ticket halls; includes passenger tunnels and escalator tunnels.
- In order to mitigate the impacts associated with settlement at Farringdon Station compensation grouting will be undertaken from grout shafts at the rear of 67-69 Cowcross Street and within Greenhill's Rents.
- A large number of surface utilities are also being directly affected by the Crossrail construction works, some of which will require diversion.

The following sub-sites at the Crossrail works for Farringdon Station will be addressed in this DDBA:

- Eastern Ticket Hall, including sites at No. 3 Hayne Street and 33-37 Charterhouse Square.
- Western Ticket Hall.
- 67-69 Cowcross Street Grout Shaft.
- Greenhill's Rents Grout Shaft.

The Crossrail works are divided into Enabling Works and Main Works. Enabling Works are defined as those works that are required to facilitate the Main Works, and as such are required prior to the start of the Main Works programme.

The Construction and Construction Process Report, Section 12 of the Civil, Structural & Tunnel Engineering Report Farringdon Station Volume 3 of 8 (CR-SD-FAR-CE-RT-00002) provides a

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detailed sequence of Enabling and Main Works taking place at Farringdon Station. Section 12 is reproduced in Appendix 9.5.

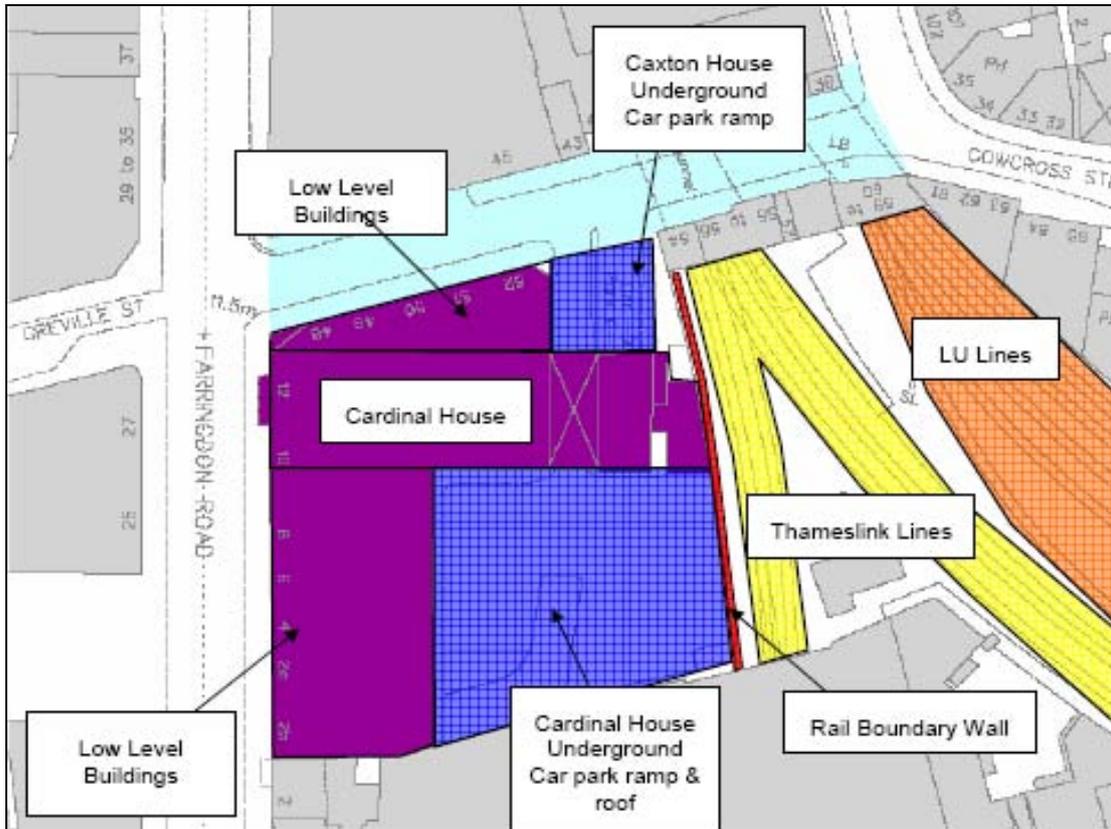


Figure 1. Western Ticket Hall and Surrounding Area

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Figure 2. Location of Enabling Works demolitions at the Eastern Ticket Hall

### 2.3 Limitations

The DDBA was limited by the following omissions:

- Access to buildings was limited, therefore information regarding basement depths is incomplete.
- Information regarding existing foundations is currently incomplete in the Running Tunnels & Shafts Obstructions Report (Crossrail 2007a).
- No consultation with users, custodians, and interested bodies has yet been carried out.

The following sources have not been examined in detail for this DDBA and are not considered relevant:

- Trade directories; wills, rate books; census returns; business accounts; historic photographs; lithographs; prospects and paintings; sale particulars; inland revenue maps; fire insurance plans;
- Land registry for property registers, title deeds and title plans, registered leases, conveyances, transfers, deeds, property agreements.

### 2.4 Surface Geology and Topography

The Farringdon Station Geotechnical Desk Study (Crossrail 2006a) collates information gathered from Crossrail (pre-2000) ground investigations, third party boreholes from the vicinity, historical borehole data from the British Geological Survey (BGS), the BGS LOCUS database for the London area and also reviews of previous desk studies undertaken by Arup (1992) and Mott MacDonald (2002, 2005). The interpretation of this data provides useful stratigraphic information for each sub-site and a general overview of the geology of the Farringdon Station

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area. Refer to drawings P30101-C1M10-G00-D-60101 and 60102 (Appendix 9.1) for geological profiles of the area.

The regional geology of the area around Farringdon Station is typical of that for the London Basin, comprising Cretaceous Chalk, overlain successively by Palaeogene Deposits (Thanet Sand Formation, Lambeth Group and London Clay Formation). River Terrace Deposits (Hackney Gravel) overlay London Clay over most of the site, with the exception of the former course of the Fleet River (forming the western boundary of the Crossrail worksites for Farringdon Station, approximately where Farringdon Road now runs) where the River Terrace Deposits have been eroded and Alluvial Deposits overlie the London Clay. The Fleet was the largest of London's former rivers and is now confined to a sewer beneath Farringdon Street and New Bridge Street.

East-west oriented tributaries were also present in the area, particularly Flaggeswell Brook, located between Cowcross Street and Charterhouse Street (Crossrail 2006b). Archaeological monitoring of Thameslink 2000 trial work at Farringdon (FNG02) indicates that no stream features are likely to survive within the existing railway cutting (Crossrail 2005). The route of the former Flaggeswell Brook is conjectured to pass across the site somewhere between Cowcross Street and Charterhouse Street and there is a slight possibility that the base of the brook may survive cut deeply into London Clays beneath Cardinal House. In some locations the natural superficial deposits have been completely excavated and replaced by Made Ground, within which archaeological deposits may survive. The top of the London Clay has also been modified by excavations for 19th century railway cuttings, retaining walls, sidings and other structures (Crossrail 2006b).

### **3 Aims and Objectives of the Assessment**

#### **3.1 Aims & Objectives**

The objective of the DDBA is to understand the site-specific issues of survival or past removal of potential archaeological remains, localised truncation from individual basements etc., and to identify any pertinent historical records relating to each site. The results of this analysis will be used to formulate site-specific Written Schemes of Investigation (WSIs).

In summary, the purpose of the DDBA is to:

- Identify more fully the actual ground conditions at each of the sub-sites;
- Review the construction impacts; and
- Identify further archaeological evaluation required at each of the sub-sites, which will in turn inform subsequent phases of mitigation planning.

### **4 Methodology**

#### **4.1 Approach**

The Detailed Desk Based Assessment (DDBA) is a targeted research exercise using existing written, graphic, photographic and electronic information to identify the likely character, extent, quality and value of the known or potential archaeological resource at a specific site.

DDBA is not required for every worksite and is carried out only in cases where additional information is required to inform decisions regarding an appropriate mitigation strategy. The decision as to whether DDBA is required at a particular site is based on:

- The importance of the known or potential archaeological resource;
- The nature of the construction works; and

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- Any gaps in the existing archaeology information gathered to date for the Crossrail ES and the Crossrail Archaeology Programming Assessment (1E0318-G0E00-00006 Rev. B).

A higher level Archaeological Desk Based Assessment (DBA) was carried out in 2003/4 for the Crossrail ES, comprising generic or area based research that fed into the archaeological baseline for the Crossrail scheme. This DDBA updates that baseline and takes into consideration the following data should they have the potential to contribute to the site-specific WSIs:

- Design development since the ES and all associated information collected by Crossrail;
- Changes to the Statutory and Local Authority designations;
- Targeted archaeological and documentary data;
- Targeted historical research, such as map regression;
- Geotechnical and/or geological data, and aerial and ground survey data;
- Any additional data, such as chance finds, relevant fieldwork results etc;
- Visual Site Appraisal; and
- Non-Listed Built Heritage Assessment.

#### 4.2 Standards and Guidance

This DDBA has been carried out in accordance with Crossrail standards and guidance:

- Crossrail. 2008c. Archaeology, Procedure for Detailed Desk Based Assessment, Document Number 23042008-96BA-OAKW.
- Crossrail. 2008f. Archaeology Generic Written Scheme of Investigation, Document Number 14022008-44ES-P2Z1.

#### 4.3 Sources Consulted

In producing this DDBA, data relevant to the individual sub-sites was collected from the following sources:

- NMR/SMR records, held by English Heritage and local authorities, provided by MoLAS in the following formats:
  - Shapefiles (.shp) of the full GLSMR dataset; burial grounds (polygons and points), Registered parks and gardens, Scheduled Monuments, and site codes;
  - PDFs (.pdf) maps showing the locations of the GLSMR dataset and Site Codes;
  - SMR Central Route Section Full Description: 948 Farringdon Station.doc; and
  - Links to the Greater London Sites and Monuments Record - Search Report listing full GLSMR descriptions for MDC 2, 3 and 4.
- Records of archaeological priority zones or equivalent areas designated by local authorities, provided by MoLAS as shapefiles (.shp);
- LAARC (London Archaeological Archive and Resource Centre) fieldwork database and summaries, provided by MoLAS in the following formats:
  - Farringdon Site LAARC summaries.doc;
  - Farringdon site summary table.doc;
- Historic mapping, provided by MoLAS, comprising the following maps:

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- 1988, 1983, 1970, 1961, 1953, 1938, 1914, 1896 and 1873 OS Mapping
- 1824 – Greenwood’s map of London
- 1799 – Richard Horwood’s map of London, Westminster and Southwark
- 1746 – John Rocque’s map of London
- 1682 – Ogilby & Morgan’s large scale map of the City as rebuilt by 1676
- 1658 – Fairthorne & Newcourt’s City of London map
- 1572 – Braun & Hogenberg
- 1562 – Agas’s Map of London
- Historic place names records;
- Unpublished archaeological reports, including data not yet available on the LAARC database, provided by MoLAS:
  - Crossrail MDC2 3 & 4 Archaeological Sites Not Available on the LAARC Website.doc
- Published secondary sources dealing with the geology, archaeology and built environment;
- Historic Building records; conservation area appraisals and management plans;
- Crossrail Geotechnical Desk Study for Farringdon Station, Document Number 1D0101-C1G10-00531. Includes reviews of the following datasets by the Crossrail geotechnical team:
  - Geological mapping (held by the British Geological Survey);
  - Previous geotechnical assessment of the site by Arup (Crossrail Geotechnical Interpretative Report Sectional Interpretative Report – Nov 1992)

Additional documentary materials used to inform the DDBA included:

- Further technical reports held by Crossrail:
  - Crossrail. 2006b. Archaeology Programming Assessment. Document Number 1E0318-G0E00-00006 Rev. B.
  - Crossrail. 2007a. MDC Work Package 3, Running Tunnels & Shafts Obstructions Report. Document Number CR-SD-CT1-CE-RT-00015.
  - Crossrail. 2005. Crossrail, Assessment of Archaeological Impacts, Technical Report. Part 2 of 6, Central Section: Westbourne Park to Stratford and Isle of Dogs. Document Number 1E0318-C1E00-00001.
  - Crossrail. 2008e. Crossrail, MDC3 Archaeology, Updated Baseline Assessment. Document Number 20032008-87MB-YYK5.
  - Crossrail. 2008a. Scheme Design Submission, Civil, Structural & Tunnel Engineering Report, Volume 3 of 8. Document Number CR-SD-FAR-CE-RT-00002.
  - Crossrail. 2006a. Geotechnical Desk Study, Farringdon Station. Document Number 1D0101-C1G10-00531.

## 5 Results

### 5.1 Archaeological and Historical Background

The general archaeological potential in the Farringdon Station area is described in the Crossrail Archaeological Impact Assessment (Crossrail 2005) and subsequent Updated Baseline Assessment (Crossrail 2007b). This DDBA updates the baseline with data regarding archaeological interventions and GLSMR data from within and adjacent to the sub-sites. Site summaries and GLSMR data for each of the sites mentioned in this section are provided in Appendices 9.3 and 9.4. The locations of the archaeological sites mentioned in this section are presented in Drawing Number P30103-C1M10-E00-D-50001 (Appendix 9.1).

The site falls within both the LB Islington Archaeological Priority Area and the City of London, which is considered to be the equivalent to an Archaeological Priority Zone (Crossrail 2005).

Parts of the Roman City and Fort Walls and the Medieval city wall are Scheduled Monuments (LO26C; LO26D; LO26H; LO26R; LO26S; LO26T and LO26U), however, these fall outside of the Crossrail worksites for Farringdon Station. There is also a further Scheduled Monument (LO130), the Benedictine nunnery of St Mary Clerkenwell, located nearby, but also outside of the Crossrail worksites for Farringdon Station (Crossrail 2005).

The following burial grounds are located within 100m of the site:

- The Post-medieval churchyard for St Sepulchre (BG205) is shown approximately 100m south of the proposed locations of the Cowcross Street and Greenhill's Rents grout shafts on the 1672 Ogilby, 1746 Rocque and 1799 Horwood maps;
- The outer cemetery of Charterhouse (BG207) was a 14th century black death cemetery and possible later burial ground located at Charterhouse Square, and possibly extending into the Eastern Ticket Hall sub-site;
- The burial ground of St Bartholomew the Great (BG229), located just south of Long Lane is not expected to extend into the Crossrail sites; and
- St John burial ground (BG206) in Benjamin Street (now St John Garden), also not expected to extend into the Crossrail sites.

#### *Prehistoric*

There is little evidence for Palaeolithic activity around Farringdon Station although there is significantly more in the wider area. Scattered, isolated finds indicate increased activity in the area during the Mesolithic period, reflecting the potential of the two former river valleys, both of which demonstrate alluvial deposition that may contain or seal Mesolithic remains. There is a moderate potential for encountering evidence of the original topography and palaeoenvironment of the Fleet valley and its tributaries, such remains would be of moderate importance.

Evidence for the Neolithic, Bronze Age and Iron Age is fragmentary in the City and its immediate environs, probably due to extensive truncation from Roman and later occupation. Few features survive *in situ*, but the artefactual evidence suggests concentrations of activity for certain periods. The few possible Neolithic features indicate that a monumental landscape on the gravels did not exist here, but a relatively large number of polished stone axes suggest settlement in some form.

Although there is evidence of Early Bronze Age activity to the south of Farringdon, on the Southwark bank of the Thames, there is little in the City area itself. There is a suggestion of both occupation and funerary grounds in the City by the Middle Bronze Age. This may complement the relatively high number of metal artefacts from the Thames at London which suggests, from comparison with other such sites, ceremonial or ritual practice in the area. The best evidence for settlement is on the higher ground in the Late Bronze Age, contrasting with a

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relative scarcity of Iron Age material. However, residual Late Iron Age pottery from three sites in the Moorgate–Finsbury area, and an Iron Age ditch from Clerkenwell, may suggest pre-Roman settlement north of the City (Crossrail 2005). Residual finds of artefacts from the Palaeolithic through to the Iron Age in the area indicate a moderate potential for further Prehistoric remains to be encountered, such remains would likely be of moderate importance.

The course of the former Faggesswell Brook is conjectured to have flowed on an east-west orientation at some point between Cowcross Street and Charterhouse Street. There is a slight possibility that the bottom of this former waterway may survive cut deep into the London Clay, beneath truncation caused by the construction of Cardinal House. If encountered, the former brook could yield palaeoenvironmental remains and archaeological deposits relevant to our understanding of the Fleet river and its tributaries.

### *Roman*

By AD 55 the Roman town of *Londinium* was established including the predecessor of Aldersgate Street just to the east of Farringdon Station. The Crossrail route passes close to the northern edge of what later became the walled city. Here there was a degree of extra-mural settlement and burial grounds, both of which decrease in density away from the city walls.

The early development of the Cripplegate area (what is now Barbican) was removed by the construction of a fort early in the 2nd century. Its northern and western walls were subsequently incorporated into the main defensive circuit constructed on the landward sides of the city in the decades around AD 200. Both fort and city wall were reinforced on the outside by ditches of variable width and depth.

A Roman road is known to pass along Holborn Viaduct and Aldersgate Street and a road surface was excavated to the east (SBG87/94) of the Crossrail worksites for Farringdon Station. A Roman ditch system was also encountered at a site (CLO83) to the south of the Eastern Ticket Hall, on Long Lane, overlain by Medieval and Post-medieval deposits. There is therefore a moderate potential for Roman remains, such as roads, burials and occupation related activities, such remains would be of moderate importance.

### *Saxon*

Following the end of centralised Roman control of Britain in the early 5th century and the subsequent abandonment of *Londinium* the settlement focus shifted to the separate early/mid-Saxon trading port of *Lundenwic*, which was established further west around Aldwych, the Strand and Covent Garden. London became the capital of the East Saxon kingdom by AD 597 and St Paul's Cathedral was consecrated in AD 604.

More general re-occupation within the Roman walls occurred later, marked by the establishment of a fortified burgh (*Lundenburh*) by King Alfred around AD 886. Archaeological evidence suggests Saxon activity in the general vicinity of Farringdon Station. A group of pits excavated at St John's Square containing pottery, a buckle, and a loomweight are indicative of 5th to 6th-century occupation. Further south, at Cowcross Street, a small number of graves, possibly 7th-century, have been recorded. Furthermore, a chance find from Cowcross Street in 1879, of a Byzantine marriage disc reworked as earrings, is probably also from a burial in the area. These findings suggest Saxon occupation and a cemetery in the vicinity of the Crossrail worksites for Farringdon Station, on the gravel terrace overlooking the Fleet, which was probably navigable at that time. Further sites along the valley are therefore possible, however, the potential is considered to be low. Should Saxon deposits be encountered they would be of high importance.

### *Medieval*

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Following the Norman Conquest of 1066, the City defences were renewed and maintained throughout the Medieval period. Settlement expanded and limited space led to the foundation of monastic houses outside the City walls, particularly to the north-west in Clerkenwell and to the south in the Smithfield area, both of which are located in proximity to the Crossrail worksites for Farringdon Station. Four monastic houses were located in these areas: the Priory and Hospital of St Bartholomew founded in 1123; Charterhouse (1370); the priory/nunnery of St Mary Clerkenwell (c 1145); and the Priory of the Order of the Hospital of St John of Jerusalem, the headquarters of the Order in England, founded in 1144. By the 13th century the City of London boundaries extended to almost their present limits.

In proximity to the Crossrail worksites for Farringdon Station the Carthusian monastery (the Charterhouse) is reputed to have stood near Charterhouse Square, but was not encountered during evaluation (CSQ98), however, a child burial, probably from the time of the Black Death was identified. A number of east-west aligned adult male burials of Medieval date were revealed during a watching brief at Cloth Fair/Long Lane (CLO83) to the south of the Eastern Ticket Hall, confirming that this was the site of the monastic cemetery. The burials were sealed by a succession of gravelled surfaces, which correspond with the suggested site of the Medieval Bartholomew Fair. A large Medieval quarry pit, probably contemporary with the monastery was also identified at 2-5 Carthusian Street (CIN91) just to the north-east of the Eastern Ticket Hall. At Long Lane (LOG82), evidence of Medieval road metalling and garden soils were encountered during a watching brief, and excavations in 1989 at Cowcross Street (COW89), at a site to the north-east of the Cowcross Street grout shaft, identified significant foundations of Medieval and post-Dissolution Tudor structures and a number of Medieval burials.

There is a moderate potential for encountering archaeological remains relating to Medieval religious institutions and associated burial grounds of high importance, furthermore, there is a moderate potential for Medieval secular occupation remains, such as buildings, road, and related yard, garden, industrial and commercial activity. Such remains would be of moderate importance.

#### *Post-medieval*

From the Tudor period onwards the Medieval layout of the City did not change significantly. The expanding population gradually led to urbanisation of the remaining open areas outside the City walls. Braun and Hogenberg's map of 1572 shows the area of the Crossrail worksites for Farringdon Station, on the eastern side of the Fleet is developed, north to Clerkenwell and east through Smithfield to Moorgate, with further ribbon development along the road north from Bishop's Gate. This development was low density with extensive gardens and open areas.

By 1658, Fairthorne and Newcourt's map shows that the density of development is greater and more urban in character, particularly in proximity to the City walls near to the gates that still controlled access, such as on the eastern side of the Fleet into Smithfield. Leake's Survey of 1667 shows the devastation caused by the Great Fire inside the City walls and also demonstrates an accelerating density of development in the extramural suburbs with street frontages tightly packed and garden areas infilled. Remaining open areas, such as Smith Field and the surviving ecclesiastical precincts are more closely confined.

Rocque's map of 1746 illustrates the fully urban character of the Farringdon Station area at that time, with the exception of the reduced areas of Smith Field for livestock holding. In 1726 the River Fleet was largely covered over to form the twin culverts of the Fleet Sewer as far north as the former City boundary at Holborn Bridge on High Holborn, leaving an open channel through the Farringdon area beyond. In 1840–41 the route for a new street was cleared north of Holborn Bridge, to form Victoria Street, later Farringdon Road and the sewer from Farringdon Street northward was rebuilt, the former course being abandoned. By the time of the Ordnance Survey in 1868 the Fleet had been covered over at least as far north as the modern Clerkenwell Road.

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The 19th century saw major improvements in transport infrastructure with the railways allowing a larger workforce to access London from the outer suburbs. For example, the Farringdon area underwent significant change when the Metropolitan Line was constructed. The infilled Fleet valley provided the route for the first underground railway, the cut and cover Metropolitan Line from Paddington to Farringdon Street Station (Farringdon) opened in 1863. It was linked eastwards via Aldersgate Street (Barbican) as far as Moorgate Street Station (Moorgate) in 1865, and southwards to the London Chatham and Dover Railway via its Ludgate Hill Station in 1866. The Metropolitan line passes through the Crossrail worksites for Farringdon Station from the east, cutting directly through the location of the Eastern Ticket Hall before curving northwest into Farringdon Station and beyond. Associated road schemes at Holborn Circus and Charterhouse Street were also completed at this time with a new crossing of the Fleet valley - the Holborn Viaduct, opening in 1869.

Post-medieval remains are regularly encountered during archaeological interventions in the area. At Cloth Fair/Long Lane (CLO83), just south of the Eastern Ticket Hall, structural evidence of late 16th century houses were identified overlying Medieval remains. 17th/18th century cess-pits and brick walls were also found truncating Medieval remains at 2-5 Carthusian Street (CIN91) to the north-east of the proposed Eastern Ticket Hall, and at 84-85 Long Lane (LOG82) to the south. Further north, at Eagle Court (EGC04) an archaeological watching brief recorded 1-2m of modern and 19th century Made Ground, demolition debris and Post-medieval garden soils. Post-medieval and Modern period truncation was also identified on Cloth Fair (CFI06), in which existing basements and late 19th/early 20th century walls had removed the majority of archaeological deposits. Previous archaeological investigation in the area indicates that there is a high potential for evidence of Post-medieval urbanisation and other Post-medieval occupation features, which would be of moderate importance (Crossrail 2005).

Assessing the construction methodology of the cut and cover Metropolitan Line is difficult as it varied considerably along its route depending on a number of factors. Furthermore much of the documentary evidence was destroyed by bombing during WWII. However, anecdotal evidence suggests that factors affecting the construction methodology included whether it was in open space or an urban area; clays or gravels; what time of year it was; what the weather was like, e.g. was it raining; ground water levels; and the fact that different engineers and contractors were used for different segments of the route. A construction drawing from the mid 19th century (Drawing Number P30103-C1M10-E00-D-50141 – Appendix 9.1) demonstrates the extent of the planned construction of the Metropolitan Line when completed, but unfortunately does not illustrate the land-take required for the construction works. Figures 3 and 4 below demonstrate the scope and some of the construction methods used in building the Metropolitan Line. These two examples are not from the Farringdon Station area.



Figure 3. Photograph of the cut and cover construction of the Metropolitan Line at Praed St, Paddington c.1866 (Collection of the London Transport Museum)



Figure 4. Photograph of the cut and cover construction of the Metropolitan Line extension to Kensington c. 1867 (Collection of the London Transport Museum)

## 5.2 Site Specific Historic Map Regression

The impact of historic development on the sub-sites has been assessed through the analysis of historic mapping, 1940s bomb damage maps, Ordnance Survey mapping and observations

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made during a visual site appraisal and non-listed built heritage assessment. While early historic maps are a useful tool in the identification of archaeological potential, their inaccuracy means that they cannot be relied on for specific impact locations. Historic mapping becomes more accurate as time progresses, with the Ordnance Survey first edition providing the first reliable mapping resource for the identification of previous impacts and potential levels of truncation.

The historic maps consulted are listed in section 4.3, and can be viewed in appendix 9.1 (Drawing Numbers: P30103-C1M10-E00-D-50101 to 50118).

*Cowcross Street Grout Shaft*

16th century – In the mid to late 1500s the site is located on the edge of urbanised London, and while there was intermittent ribbon development on Cowcross Street at this time, it is probable that the site itself was undeveloped.

17th century – Mapping from the 1600s, although not as reliable as later maps, show a significant change in the density of building on the site before and after the Great Fire of 1666. Prior to the fire the site appears to have contained buildings fronting Cowcross Street, with open areas to the rear, probably representing small kitchen gardens, whereas post-fire mapping shows dense development on and around the site.

18th century – Building fronting onto Cowcross Street was present from at least the mid 1700s with areas of open space to the south of the site and a building marked ‘College’ to the immediate south-west.

19th century – The northern half of the site was occupied by housing fronting onto Cowcross Street from the early 19th century with the plots to the south, east and west being developed by the 1890s. Prior to the construction of the railway cutting the area to the immediate south of the site comprised a built up area with streets and small open spaces

20th century – The buildings on the site fronting onto Cowcross Street and the surrounding plots to the south, east and west, present on 1914 mapping were damaged beyond repair during WWII. These plots remained undeveloped until the late 1950s/early 1960s, when they were replaced by the buildings that now occupy these plots. The footprint of the grout shaft remains open space to the rear of these buildings.

*Greenhill's Rents Grout Shaft*

16th century - In the mid to late 1500s the site was located near to the edge of urbanised London. While there was some ribbon development on the surrounding streets, it is probable that the site itself was undeveloped and may have been situated in the garden of a building fronting Cowcross Street and St John Street.

17th century – Pre-Great Fire mapping shows that the site was probably open space in the mid 1600s and formed the gardens at the rear of properties fronting the surrounding streets. Mapping from after the Great Fire shows dense development to the immediate south, with the site itself probably located on the plots attached to the buildings fronting on to Cowcross Street.

18th century – Much of the site was open space at the end of the 1700s. A row of terraced houses at the western end of Greenhill's Rents may have infringed on the southern edge of the site. The 1746 map shows an alleyway that may fall within the footprint of the site called the ‘Blind Beggars’ that is not present on earlier or later mapping.

19th century – The site underwent a number of phases of development in the 1900s probably resulting from the construction of the railway. In 1824 the site was largely open space with some building in its southern area. By 1873 the railway had been constructed and a row of terraces had been built at the south-western end of Greenhills Rents. The open space behind the houses fronting Cowcross street had also been largely infilled. The site was predominantly open

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space again by 1896 and was enclosed by buildings to the east and west with a large Victorian building to the immediate south having also been built.

20th century – Buildings present on the northern part of the site in the early to mid 20th century were not recorded as being damaged by WWII bombing. The late Victorian building immediately to the south of the site was not damaged structurally, but suffered general blast damage.

The site today - The site does not currently contain standing buildings but is surrounded by mid to late 20th century development to the north, east and west with a large late Victorian building and the railway cutting immediately south.

*Eastern Ticket Hall, including 33-37 Charterhouse Square and 3 Hayne Street*

16th century – While the accuracy of the 16th century mapping is debatable the 1562 map shows that the majority of the site area was undeveloped and probably represented the enclosed gardens of buildings fronting onto Long Lane.

17th century – The site was developed both before and after the Great Fire, although the density of development was greater in the later 17th century. Prior to the fire the 1658 map depicts a row of housing fronting onto Long Lane, although it is likely that this is oversimplified.

18th century – The layout of the area was significantly different in the 1700s with fewer buildings and considerably more open space within the site area.

19th century – The construction of the cut and cover Metropolitan line resulted in major change to the site in the 19th century. The street layout and buildings between Long Lane and Charterhouse Lane were dramatically altered with the creation of Lindsey Street and Hayne Street to the east and west of the site respectively and the linkage of Charterhouse Street and Charterhouse Square to the north of the site. The railway cutting also extended to the south, probably resulting in the removal of many of the buildings within the Eastern Ticket Hall area; and also to the north, at the location now occupied by 33-37 Charterhouse Square. By 1873 the railway had been built and a row of buildings fronting onto the newly created Hayne Street were constructed. The line of the railway cutting is shown on Drawing Number P30103-C1M10-E00-D-50141 (Appendix 9.1). On the corner of Long Lane and Lindsey Street is marked a 'weighing machine' with a single large building set back slightly from the street immediately north.

The site of the Hayne Street shaft was a row of terraces in the early 19th century and was probably cleared during the construction of the railway only to be built up again at the end of the 19th century.

The site of 33-37 Charterhouse Square was at least partially truncated during construction of the railway cutting and retaining walls, as shown on the 1824 OS map, the existing buildings on the site were evident by the 1896 OS map

20th century – Although V1 flying bombs struck to the south and east of the site there was no recorded bomb damage to the site location during WWII. Prior to the war the southern half of the site contained a number of buildings fronting onto Long Lane, Hayne Street and the southern corner of Lindsey Street that are still extant today. The northern part of the site falls within the route of the Metropolitan Line railway cutting.

*Western Ticket Hall*

16th century – The 1562 and 1572 maps show that the approximate area of the Western Ticket Hall comprised open fields bisected by the former Fleet river. Major routes out of London passed to the south, east and west. Neither the Fleet river or any of these thoroughfares passed through the Western Ticket Hall footprint.

17th century – Prior to the Great Fire of London the area remained open fields alongside the Fleet river which ran to the rear of ribbon development along the routes out of London. After the Great Fire of London the area has been developed significantly with new buildings and road systems where a few years previously there has been only fields.

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18th century – The greater detail of the 1746 mapping shows that the site of the Western Ticket Hall was a block of buildings with the Fleet river partly culverted and partly exposed to the immediate west. The block of buildings also contained a number of small alleys and streets – ‘Stable Yard’; ‘Sharps A’; ‘Lewis Yard’; and ‘Carolina Court’. The Fleet river is not shown on the 1799 map but the footprint of the Western Ticket Hall comprised terraced buildings and small alleys and streets.

19th century – The area underwent massive change in the 1800s. There is little change in the footprint of the Western Ticket Hall between 1799 and 1824, by the first OS map of 1873 the Western Ticket Hall site was completely cleared. The road system still present today was in place and the Metropolitan Line and Smithfields Market had both been constructed. The construction of the Metropolitan Line railway would have significantly truncated archaeological deposits at the site. By the close of the 19th century the Western Ticket Hall footprint was the site of a Great Northern Railway (GNR) Goods Depot.

20th century – The Western Ticket Hall site continued in use as a GNR and then London and North Eastern Railway (LNER) Goods Depot until World War II when it was damaged beyond repair by a V2 long range rocket which struck on the 8<sup>th</sup> March 1945. To the immediate west of the Goods Depot a row of terraces were constructed fronting onto Farringdon Road. These terraced buildings were not destroyed by the V2 rocket and remained until the construction of Cardinal House in the 1960s.

### 5.3 Visual Site Appraisal

A Visual Site Appraisal (VSA) was carried out on the site. The aims of the VSA, where practicable, are to:

- Analyse the topography of the area and identify buildings, services or archaeological structures (above and below ground) which will have compromised the integrity of the resource or may act as a constraint on future evaluation or mitigation;
- Examine the immediate surroundings of the site for evidence of truncation that may continue in to the site;
- Note any topographical features, which might be a focus for human activity, and identify and describe any geomorphic or manmade activity that could mask archaeological sites;
- Determine the current state of preservation of monuments and surrounding land-use, noting current and potential activities that threaten their long term preservation.

### Results

#### *Cowcross Street grout shaft*

The site of the Cowcross Street grout shaft is located to the rear of a public house/restaurant and comprises an outdoor seating area attached to the public house/restaurant. It is situated very close to the edge of the existing railway cutting and as such, archaeological deposits may have been heavily disturbed during construction of the cutting and retaining walls.

#### *Greenhill's Rents grout shaft*

The Greenhills Rents grout shaft (Figure 5) is also located in proximity to the existing railway cutting and is currently in use as a road and a small car parking area enclosed by buildings. This site is also located in proximity to the railway cutting and as such may have been partially truncated during its construction.

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**Figure 5. Site of the Greenhill's Rents grout shaft site, facing south-west**

*Eastern Ticket Hall; 3 Hayne Street; and 33-37 Charterhouse Square*

The site of 3 Hayne Street (Figure 6) is currently occupied by a residential building called 'The Cottage'. This building is located on the very edge of the existing railway cutting and as such it is unlikely that archaeological deposits survive at this location due to truncation caused during construction of the railway cutting and retaining walls.



**Figure 6. View south down Hayne Street, on the western side of road is No. 3 Hayne Street and the Lindsey Street. Box is on the eastern side**

The central and western sections of the Eastern Ticket Hall site comprise an area enclosed to the east by retaining walls contemporary with the construction of the Metropolitan Line (Figure 9). The ground level within this area is the same as that of the Metropolitan Line that runs through the northern extent of the Eastern Ticket Hall footprint. 2-4 Lindsey Street are built from this level as are the brick arches beneath Lindsey Street. This level also comprises the basement level of Smithfields Market to the immediate west.

8 and 9 Hayne Street are built immediately on top of the retaining walls that extend south-east from the Metropolitan Line into the Eastern Ticket Hall. Similarly, buildings at the northern extent

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of the Eastern Ticket Hall site (54 Charterhouse Street & 5 Lindsey Street – Figure 7) are also built over the underground railway lines.

Consequently it is unlikely that archaeological deposits survive within the Eastern Ticket Hall footprint, with the possible exception of its southern extent, at 20-23 Long Lane (Figure 10); and eastern side, at 8-10 Hayne Street No. 3 Lindsey Street A former local business: “Edmond Martin Ltd Tripe Dressers, Meat & Offal Salesmen” (Figure 11), reflects the emphasis in this part of London on the meat industry.



**Figure 7. View of the Lindsey Street Box, facing south-east from Fox & Knot Street**



**Figure 8. View of the Lindsey Street. Box facing north-west from the overpass at Moorgate Station**

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**Figure 9. View of the Lindsey Street. Box facing north from the platform at Moorgate Station, demonstrating the level of truncation caused by the railway cutting**

In confirmation of historic map evidence, 33-37 Charterhouse House Square (Figure 8) are located on the edge of the existing railway cutting and consequently archaeological deposits may have been completely truncated by the construction of the railway cutting and retaining walls.



**Figure 10. View facing north-east of the Chambers & Partners Building (23 Long Lane) at southern end of the Lindsey Street Box**



Figure 11. View facing east of No. 3 Lindsey Street

#### 5.4 Known Disturbance to Archaeological Horizons

The known disturbance to archaeological horizons at the sub-sites is set out below, based on basement and buildings survey data; utilities mapping; the Running Tunnels & Shafts Obstructions Report (Crossrail 2007a); geotechnical information, historic mapping; and the results of the Visual Site Appraisal and Non-Listed Built Heritage assessment. It should be noted that the location of the grout shafts at Cowcross Street and Greenhill's Rents will be finalised at detailed design.

##### 67-69 Cowcross Street grout shaft

- The shaft is located to rear of 67-69 Cowcross Street, which has a single level basement and pad foundations (Drawing Numbers P30103-C1M10-E00-D-50160; 50161; and 50162) – Appendix 9.1). The basement at 67-69 Cowcross Street does not extend into the Crossrail worksite.
- Possible truncation caused by the construction of the cut and cover Metropolitan Line, the extent of which is unknown.

##### Greenhill's Rents grout shaft

- The Smokery (immediately north) is partially piled (Crossrail 2007a). The piles do not extend into the Crossrail worksite.
- The location of the shaft is unlikely to have been truncated by the construction of the cut and cover Metropolitan Line cutting to the south.
- There is some disturbance within the footprint of the shaft by utilities to a depth of c.1-2m below ground level. The following utilities may be affected by the grout shaft at Greenhill's Rents:
  - A 1520 x 901mm sewer in Greenhill's Rents (not in the footprint of the grout shaft).

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- A number of Ø300mm local foul and surface drainage pipes.
- A Ø63mm National Grid Gas main at the west end of Greenhill's Rents.

**Eastern Ticket Hall, including 33-37 Charterhouse Square and 3 Hayne Street**

- Construction of the Metropolitan Line railway cutting and retaining walls has truncated much of the northern half of the Eastern Ticket Hall footprint to the level of the London Clay. Buildings on the western side of the Eastern Ticket Hall footprint, fronting onto Lindsey Street are constructed from the same level as the railway cutting. The extent to which the area behind the retaining walls (now occupied by 8-10; and 3 Hayne Street) has been truncated is unknown. Similarly, it is unknown what the depth of truncation from basements and foundations is at 20-23 Long Lane.
- The cutting has also truncated the southern section of 33-37 Charterhouse Square for the construction of the retaining wall (Drawing Number P30103-C1M10-E00-D-50141 – Appendix 9.1). 33-37 Charterhouse Square also has a single basement across its length, which stretches northwards beneath the carriageway of Charterhouse Square (Drawing Number P30103-C1M10-E00-D-50142 – Appendix 9.1).
- The location of 3 Hayne Street, positioned on the very edge of the cutting is also likely to be truncated to some extent by the construction of the Metropolitan Line retaining wall, although the specific extent is unknown. 3 Hayne Street has a basement, but further information regarding its depth is to be confirmed at detailed design (Crossrail 2007).
- As well as the truncation resulting from the Metropolitan Line railway cutting, the buildings within the footprint of the Eastern Ticket Hall also have the following known basements. The foundation types at these buildings is unknown:
  - Basements on the west side of the Eastern Ticket Hall footprint (2-4 Lindsey Street.; 22-23 Long Lane) to depths of 113.00 to 111.64m ATD.
  - Full/single basements on east side of the Eastern Ticket Hall footprint (20-21 Long Lane; 8-9 Hayne Street) to depths between 115.18 to 114.36m ATD.
- Brick arches extend from Smithfields Market eastwards beneath Lindsey Street. These are constructed from the same ground level as the Metropolitan Line railway cutting.
- The following known utilities will be affected at the Eastern Ticket Hall:
  - Thames Water Assets*
    - A Ø225mm sewer running north up Hayne Street all the wall of the building between Hayne Street and Lindsey Street., cutting diametrically across the building from Hayne Street.
    - A Ø225mm sewer runs south down the middle of Hayne Street.
    - Thames water sub mains and local supplies feed the buildings around the Eastern Ticket Hall, including a Ø6" water main running down Hayne Street from Charterhouse Square.
    - A Ø3" sub main along the north wall of the Eastern Ticket Hall in Charterhouse Square connecting to the Ø150mm sub main from Fox and Knot Street at the corner of Lindsey Street and Charterhouse Square.

*EdF Assets*

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- A number of EdF Energy assets along Charterhouse Square; Hayne Street; Long Lane; and Lindsey Street.

*National Grid Gas Assets*

- National Grid Gas pipes in Charterhouse Square; Lindsey Street; Hayne Street; Long Lane; Charterhouse Street; and Fox and Knot Street.
- Ø125mm PE pipe along south footpath of Charterhouse Square to be relocated to the north side of Charterhouse Square.
- Ø125mm PE pipe along east pavement of Lindsey Street to be relocated to west side of Lindsey Street.
- Ø100mm DI pipe along Hayne Street to be abandoned and replaced by a Ø125mm PE pipe from Long Lane.

*Eon (Citigen)*

- Heating distribution, chilled water distribution and 11kV cables in a tunnel beneath Long Lane.

*Telecommunication Assets*

- A BT cable route along east footpath of Lindsey Street and south footpath of Charterhouse Square;
- Level 3 cable duct route along Charterhouse Street and down Lindsey Street.
- Cable & Wireless duct route along east side of the east footpath of Lindsey Street; in Hayne Street from Long Lane; in Charterhouse Square; and along Barbican Station northern platform wall.

**Western Ticket Hall**

- This site comprises Cardinal House, a 13 storey tower block and a 2 storey structure, both of which have a basement and are piled. The 13 storey block is piled with a shaft diameter of between 0.6m and 1.4m and bell diameters of 1.5m to 3.4m to a depth of 16.8m below basement level. Piling in the 2 storey building has 0.9m diameter and a bell diameter of 2.1m to 9.1m below basement level.
- The area, which was formally railway sidings were monitored archaeologically at Thameslink 2000 trial works. It was considered that no archaeological remains are likely to survive within the areas of the railway cutting.
- The following known utilities will be affected at the Western Ticket Hall:

*Thames Water Assets*

- Local Ø225mm sewer beneath Cardinal House.
- St. Johns Branch of the Fleeer Sewer. A 1448 x 914mm brick egg shaped sewer running down Turnmill Street, across Cowcross Street and about 1m beneath basement of Cardinal House along its eastern boundary.
- Numerous water main connections in Farringdon Road and Cowcross Street that service the buildings on the Western Ticket Hall site.

*EdF Assets*

- A number of EdF Energy assets around Cardinal House in Farringdon Road and Cowcross Street.

*National Grid Gas Assets*

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- National Grid Gas assets on Cowcross Street and Farringdon Road.
- Telecommunications Assets*
- BT cable route along east footpath of Farringdon Road and the south side of Cowcross Street.
  - Telewest duct route along Cowcross Street and down Farringdon Road serving 8-12 Farringdon Road and 48-52 Cowcross Street.
  - A Colt feed in Farringdon Road to 8 Farringdon Road.
  - Thus duct routes in Farringdon Road; Charterhouse Square; and Fox and Knot Street.

## 5.5 Deposit Modelling

The tables below set out the depths of known deposits at each of the sub-sites, based on information from geotechnical boreholes and archaeological interventions in the vicinity of each area. Please refer to the following drawings for the locations of boreholes, archaeological sites and for deposit summary sketches;

Geotechnical boreholes: P30101-C1M10-G00-D-60101 & 60102 (Appendix 9.1)

Archaeological sites: P30103-C1M10-E00-D-50001 (Appendix 9.1)

Deposit Summary Drawings: P30103-C1M10-E00-D-50150 and 50151 (Appendix 9.2)

BH/Site No.	BH F17	BH F4	BH F10	BF F5	FNG02	EGC04	XRC92
<b>Superficial Deposits (inc. Made Ground, Alluvium and River Terrace Deposits where encountered)</b>	111.88 to 107.48m ATD (4.40m in thickness)	112.99 to 111.49m ATD (1.5m in thickness)	114.01 to 106.41m ATD (7.60m in thickness)	106.60 to 106.10m ATD (0.50m in thickness)	111.30/113.00 to 105.40m ATD Truncated gravels at 105.50m ATD. Localised Alluvial deposits at c.0.5m depth (within railway cutting)	117.00m ATD to ? 1-2m of modern & 19th century Made Ground and demolition debris 1m of Post-medieval garden deposit Natural gravels at 113.50m ATD.	111.30/113.00m ATD to ?  Alluvial deposits at 104.30 to 106.60m ATD (cut feature or stream channel)
<b>London Clay</b>	107.48 to 98.38m ATD (9.10m in thickness)	111.49 to 100.09m ATD (11.4m in thickness)	106.41 to 92.36m ATD (14.05m in thickness)	106.10 to 99.20m ATD (6.90m in thickness)	105.40 to?	-	-
<b>Lambeth Group</b>	98.38 to 83.48m ATD (14.90m in thickness)	100.09 to 83.74m ATD (16.35m in thickness)	92.36 to 83.01m ATD (9.35m in thickness)	99.20 to 82.80m ATD (16.40m in thickness)	-	-	-
<b>Thanet Sands</b>	83.48m ATD to ?	83.74 to 73.74m ATD (10m in thickness)	83.01 to 72.61m ATD (10.40m in thickness)	82.80m ATD to ?	-	-	-
<b>Chalk</b>	-	>73.74m ATD	>72.61m ATD	-	-	-	-

**Table 1. 67-69 Cowcross Street grout shaft**

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BH/Site No.	BH F11	BH F10	XRC92	EGC04
<b>Superficial Deposits (inc. Made Ground, Alluvium and River Terrace Deposits where encountered)</b>	115.00 to 111.50m ATD (3.50m in thickness)	114.01 to 106.41m ATD (7.60m in thickness)	111.30/113.00m ATD to ?  Alluvial deposits at 104.30 to 106.60 (cut feature or stream channel)	117.00m ATD to ?  1-2m of modern & 19th century Made Ground and demolition debris  1m of Post-medieval garden deposit  Natural gravels at 113.50m ATD.
<b>London Clay</b>	111.50 to 90.20m ATD (21.3m in thickness)	106.41 to 92.36m ATD (14.05m in thickness)	-	-
<b>Lambeth Group</b>	90.20m ATD to ?	92.36 to 83.01m ATD (9.35m in thickness)	-	-
<b>Thanet Sands</b>	-	83.01 to 72.61m ATD (10.40m in thickness)	-	-
<b>Chalk</b>	-	>72.61m ATD	-	-

Table 2. Greenhill's Rents grout shaft

BH/Site No.	BH F1	BF F5	FNG02	XRC92
<b>Superficial Deposits (inc. Made Ground, Alluvium and River Terrace Deposits where encountered)</b>	111.36 to 101.79m ATD (9.57m in thickness)  Alluvial deposits (Fleet River) at 103.29 to 101.79m ATD	106.60 to 106.10m ATD (0.50m in thickness)	111.30/113.00 to 105.40m ATD  Truncated gravels at 105.50m ATD.  Localised Alluvial deposits at c.0.5m depth (within railway cutting)	111.30/113.00m ATD to ?  Alluvial deposits at 104.30 to 106.60m ATD (cut feature or stream channel)
<b>London Clay</b>	101.79 to 94.29m ATD (7.5m in thickness)	106.10 to 99.20m ATD (6.90m in thickness)	105.40 to ?	-
<b>Lambeth Group</b>	101.79 to 77.79m ATD (24m in thickness)	99.20 to 82.80m ATD (16.40m in thickness)	-	-
<b>Thanet Sands</b>	77.79m ATD to ?	82.80m ATD to ?	-	-
<b>Chalk</b>	-	-	-	-

Table 3. Western Ticket Hall

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BH/Site No.	BH F9	BH F13	BH F8	BH F14	CAA00	CFI06	CSQ98	CIN91	LOG82	CQC07	CLO 83
<b>Superficial Deposits (inc. Made Ground, Alluvium and River Terrace Deposits where encountered)</b>	117.36 to 111.76m ATD (5.60m in thickness)	109.00 to 108.50m ATD (0.50m in thickness)	108.89 to 107.29m ATD (1.60m in thickness)	116.08 to 111.58m ATD (4.50m in thickness)	Surface - 117.20m ATD Archaeological Deposits up to 116.45m ATD Made Ground up to 114.50 to 113.70m ATD Terrace Gravels encountered at 113.80 to 113.20m ATD	116.10m ATD to ? Terrace Gravel at 113.50m ATD (truncated by basements)	118.00m ATD to ? Archaeological Deposits at 116.60 to 117.70m ATD Brickearth at 116.60m ATD	118.50m ATD to ? Medieval Quarry Post-medieval features Terrace gravels at 114.7m ATD	117.70m ATD to ? At 2.5m Medieval & Post-medieval Deposits (incl. horizontal garden soil deposits) Skeletons at 2.4m depth Terrace Gravels at 115.70m ATD	117.90m ATD to ? Archaeological Deposits at c. 117.60m ATD Terrace Gravels at 115.90m ATD	117.10m ATD to ? Archaeological Deposits (Roman & Medieval) Terrace Gravels at 115.20m ATD
<b>London Clay</b>	111.76 to 89.29m ATD (22.47m in thickness)	108.50 to 88.50m ATD (20.00m in thickness)	107.29 to 85.99m ATD (21.30m in thickness)	111.58 to 82.58m ATD (29.00m in thickness)	-	-	-	-	-	-	-
<b>Lambeth Group</b>	89.29m ATD to ?	88.50m ATD to?	85.99m ATD to ?	82.58 to 66.33m ATD (16.25m in thickness)	-	-	-	-	-	-	-
<b>Thanet Sands</b>	-	-	-	66.33m ATD to?	-	-	-	-	-	-	-

Table 4. Eastern Ticket Hall, 3 Hayne Street shaft and 33-37 Charterhouse Square

## 5.6 Non-listed built heritage

Non-listed built heritage (NLBH) assessment and recording forms part of the archaeological mitigation strategy for Crossrail. The definition of NLBH adopted follows Information Paper D22 Archaeology and encompasses above ground historic features and structural elements of historical interest.

Two main groups are:

- Non-listed buildings proposed for demolition in conservation areas; and
- Historic street furniture and materials falling within a worksite and being temporarily or permanently impacted upon by the works.

The detailed scope for this element of works includes:

- Important non-listed buildings of historic interest proposed for demolition in conservation areas (as set out in Information paper D18, Listed Buildings and Conservation Areas);
- Important non-listed historic street furniture and materials;
- Other important non-listed buildings and structures of historic interest outside conservation areas (e.g. the standing walls at Stepney Green), locally listed station buildings and railway structures and any industrial and defence archaeology of significance.

The Crossrail Environmental Statement and supporting Specialist Technical Reports define the baseline built heritage resources (both statutorily protected and non-listed) across the route, the potential significant impacts, mitigation and any residual impacts after that mitigation is employed (Crossrail 2005).

The procedure for non-listed built heritage assessment and recording is set out in Document Number 23042005-JGEN-LNUV (Crossrail 2008b).

The results of a NLBH assessment of the Farringdon Station Area are outlined in Tables 6 and 7 below. The location of NLBH assets are shown on drawing number P30103-C1M10-E00-D-50004 (Appendix 9.1).

The NLBH assessment was supplemented by street furniture surveys carried out by EWMA, which identified all elements of street furniture at Farringdon Station. The results of the EWMA survey were reviewed to identify street furniture of historic significance (Table 7).

## Archaeology Detailed Desk Based Assessment – Farringdon Station

Name [Figure Ref]	Image	Description	Significance	Impact
3 Hayne Street [1]		<p>Three-storey building, plus attic, constructed in stock brick with whitewashed façade. Late 19th century in date. The west façade has been cosmetically altered with the addition of external shutters and replacement windows. However, there is potential for surviving internal fittings and fixtures.</p>	<p>Not listed, but located immediately adjacent to the Charterhouse Square Conservation Area. The building is of interest as part of the historic development of this area after the arrival of the railway.</p>	<p>To be demolished.</p>
8-9 Hayne Street [2]		<p>Truncated terrace of late 19<sup>th</sup> century office buildings. Four storeys plus attic, (behind parapet) and basement. Constructed from stock brick with red brick detailing. Architectural emphasis to ground floor with continuous impost band separated by large window openings and two recessed doorways. Paired window openings to upper floors. Iron grilles over basement windows. Evidence of truncation to north.</p>	<p>Not listed or located within a conservation area. The building remains of and historic interest as a good example of late 19<sup>th</sup> century architecture.</p>	<p>To be demolished.</p>

## Archaeology Detailed Desk Based Assessment – Farringdon Station

Name [Figure Ref]	Image	Description	Significance	Impact
Chimney to the rear of 20-21 Long Lane [3]		<p>Truncated brick chimney surviving to the rear of No 20-21 Long Lane, although not structurally attached to it. The chimney pre-dates No. 8 Hayne Street, suggesting that it is mid-19<sup>th</sup> century in date.</p>	<p>Not listed or located within a conservation area. However, it has historic interest as part of the industrial heritage of this area.</p>	<p>To be demolished.</p>
22 Long Lane [4]		<p>Narrow, four-storey building fronting Long Lane. Constructed from brick with plastered façade. Shop front at ground-floor level with deep plain fascia over large glazed frontage. Two steel framed casements to upper floors. The building is surmounted by a low parapet, painted with geometric wave pattern. The façade represents a continuation the mid-20<sup>th</sup> century 23 Long Lane; however, the cartographic evidence suggests that this is a re-frontage of an earlier structure.</p>	<p>Not listed or located within a conservation area. However, there is potential for earlier fabric to survive internally.</p>	<p>To be demolished.</p>

Archaeology Detailed Desk Based Assessment – Farringdon Station

Name [Figure Ref]	Image	Description	Significance	Impact
<p>2 Lindsey Street and 23 Long Lane [5]</p>		<p>5 storey mid 20th century building with frontages to both Long Lane and Lindsey Street. Constructed from brick with rendered elevations and distinctive Art Deco detailing. Commercial frontage to the ground floor with large steel-framed openings under a deep fascia. Steel framed casements above, divided by decorative panels, with examples of applied fan detail. 4th floor is distinguished by a continuous sill band with painted geometric wave detail. Above are large steel framed windows, divided by narrow piers.</p>	<p>Not listed or located within a conservation area. However, the building is an interesting example of Art Deco architecture.</p>	<p>To be demolished.</p>
<p>3 Lindsey Street [6]</p>		<p>Single-storey mid 19th century commercial building formerly in use as a tripe dresser. Glazed tile fascia bearing the name Edward Martin Ltd. The shop front is concealed by modern shutters. The building is surmounted by a timber louvre. To the north of the façade is a single surviving Corinthian pilaster, probably belonging to an earlier structure at No. 4 Lindsey Street.</p> <p>The building is currently vacant and in a poor structural condition.</p>	<p>Not listed or located within a conservation area. However, the building is of historic interest due to its association with the meat trade which dominated the historic development of the area.</p>	<p>To be demolished.</p>

Archaeology Detailed Desk Based Assessment – Farringdon Station

Name [Figure Ref]	Image	Description	Significance	Impact
Retaining arches below Hayne Street [7]		<p>Row of brick retaining arches running north-south below 8-9 Hayne Street. The arcade starts at the railway line, but it is unclear where it terminates. The arches are not depicted on the original plans for the Metropolitan railway, but appear to be of a contemporary date, possibly erected to support new buildings on Hayne Street.</p>	<p>Not listed or within a conservation area, but of historic interest as part of the development of the railway.</p>	<p>To be demolished.</p>
Retaining arches to Barbican Station [8]		<p>Row of brick retaining arches at Barbican Station. The arcade represents a continuation of the track and is distinct from the ornate brick arcade which forms part of the station. The arcade appears on the original plans for the Metropolitan railway.</p>	<p>Unlisted building within a conservation area but of historic interest as part of the development of the railway.</p>	<p>To be impacted by Crossrail works at the Eastern Ticket Hall</p>

Archaeology Detailed Desk Based Assessment – Farringdon Station

Name [Figure Ref]	Image	Description	Significance	Impact
<p>33-37 Charterhouse Square [9]</p>		<p>Wedge-shaped, late 19<sup>th</sup> century building located on the corner of Charterhouse Square and Hayne Street. Includes 33-35 and 36-37 Charterhouse Square as a single build, denoted by rusticated end pilasters. The structure is four storeys, plus attic and basement. Constructed from red brick with stone dressings. Large window openings to all floors with continuous sill and floor bands. Large double entrance to 36-37, under a single bracketed cornice. The entrance to 33-35 is located on the corner within a two-storey projection with classical pediment detail and large bracketed cornice.</p>	<p>Unlisted building which makes a positive contribution to the Charterhouse Square Conservation Area.</p>	<p>To be demolished.</p>
<p>54 Charterhouse Street &amp; 5 Lindsey Street (Smithfield House) [10]</p>		<p>Early 20<sup>th</sup> century, two-storey office and warehouse building located on the corner of Lindsey Street and Charterhouse Square. Rendered main façade to Charterhouse Square with large steel-framed casements to ground and first floor, set within recessed panel. The elevation is surmounted by a tall, central pediment, inscribed with 'Smithfield House'. The Lindsey Street elevation is simpler in execution with large casements to first floor. The ground floor contains a single entrance to the north, with evidence of a vehicle entrance to the south. The rest of the elevation is boarded.</p>	<p>Unlisted building within a conservation area. Although a later addition to the streetscape, it remains of historic interest to the industrial development of the site.</p>	<p>To be demolished.</p>

Archaeology Detailed Desk Based Assessment – Farringdon Station

Name [Figure Ref]	Image	Description	Significance	Impact
Barbican Station Signal Box [11]		<p>Signal box located at the western end of the central platform at the Barbican Station. Small concrete structure raised on piers. Access via a modern external stair. The east façade contains a central glazed and panel door, flanked by iron-framed casements.</p>	<p>Unlisted building within a conservation area. Historic interest as part of the development of the railway system.</p>	<p>To be demolished.</p>

**Table 5 Non-Listed Built Heritage within the Farringdon Station Area**

Name [Figure Ref]	Image	Description	Significance	Impact
Boundary Plaques attached to 8 Hayne Street [12]		<p>Group of three cast iron plaques denoting the ward boundary for the Boroughs of Finsbury and Smithfield. Dated to 1873, 1890 and 1900 respectively.</p>	<p>The plaques have significance as evidence of the historic ward boundary.</p>	<p>To be removed as part of the demolition of 8 Hayne Street</p>

## Archaeology Detailed Desk Based Assessment – Farringdon Station

Name [Figure Ref]	Image	Description	Significance	Impact
Historic surface to Charterhouse Square [13]		Historic granite sett surface surrounding New Church Hawe. Formed by a regular pattern of rectangular setts. Despite some patchwork repair, there is a comprehensive coverage and good level of survival.	The historic surface makes a positive contribution to the character and appearance of the Charterhouse Square Conservation Area.	Potential impact from diverted utilities.
Pillar Box outside 59-60 Cowcross Street [14]		Type 'C' pillar box with the Queen Victoria Royal Cypher dating it to pre-1901.	An early example of the Type 'C' pillar box which makes a positive contribution to the Charterhouse Square Conservation Area streetscape.	Potential impact from diverted utilities.

## Archaeology Detailed Desk Based Assessment – Farringdon Station

Name [Figure Ref]	Image	Description	Significance	Impact
Pillar box on Charterhouse Square [15]		Type 'C' pillar box with the Queen Victoria Royal Cypher dating it to pre-1901.	An early example of the Type 'C' pillar box which makes a positive contribution to the Charterhouse Square Conservation Area streetscape.	Potential impact from diverted utilities.

Table 6 Non-Listed Street Furniture in the Farringdon Station Area

## 6 Discussion

### 6.1 Summary and Interpretation of Results

#### **67-69 Cowcross Street Shaft**

##### *Natural*

Ground level varies around the sub-site from 114.01m ATD (BH F10) in the south-east decreasing to 111.88m ATD (BH F17) to the north-east of the site, with the ground level within the railway cutting as low as 106.60m ATD (BH F5). With the exception of the levels within the cutting, these heights reflect the natural topography with the top of the London Clay being lower towards the former course of the Fleet. Ground level at the site itself is at 114.00m ATD.

Information from geotechnical boreholes (BHs F4, F5 & F17) in the vicinity demonstrate that Made Ground has truncated Alluvial and River Terrace Deposits to the level of the London Clay, with the exception of a single borehole to the south-east (BH F10), which demonstrates only a thin layer of surviving River Terrace Deposits. Similarly archaeological sites (XRC92 & FNG02) within the railway cutting demonstrated only sporadic surviving alluvial deposits, probably from deeply cut features or possible stream channels cut into the London Clay.

River Terrace Deposits are unlikely to be encountered within the sub-site, with the exception of deeply cut features surviving within the London Clay, such as the conjectured Faggesswell Brook.

##### *The present buildings*

The site is located to the rear of 67-69 Cowcross Street and is not currently built on. 67-69 Cowcross Street has a single level basement and has pad foundations. Architectural drawings show that the basement does not extend into the grout shaft footprint (Drawing Numbers P30103-C1M10-E00-D-50160; 50161; and 50162) - Appendix 9.1). 64-65 and 66 Cowcross Street to the west, and 70 Cowcross Street to the east of the sub-site are all piled, although these do not extend to within the site footprint.

##### *Earlier buildings*

Historic maps show that the sub-site was sporadically developed or undeveloped until the early/mid 17th century when urban growth around the site accelerated, particularly the plots fronting onto Cowcross Street to the immediate north of the sub-site. The area suffered severe bomb damage in WWII and the damaged buildings were replaced with offices. The extent and consistency of cellaring associated with any of the earlier buildings is uncertain.

##### *Potential archaeological deposits*

The presence of Made Ground truncating London Clay (Section 5.5) demonstrated by nearby boreholes and archaeological interventions indicate that surviving archaeological deposits dating to before the Medieval period are likely to be minimal within the sub-site and it is unlikely that any horizontal stratigraphy will survive, however, the presence of very deep cut features such as pits, wells or stream channels cannot be entirely ruled out. If basements are not present, interventions in the surrounding area suggest that archaeological deposits may be present within the Made Ground from c. 1.5m. Archaeological intervention to the north of Cowcross Street (EGC04) encountered 1-2m of 19th century Made Ground and demolition debris overlying 1m of Post-medieval garden deposits and a possible thin late Medieval soil horizon before natural gravels were encountered. A number of Medieval burials, cesspits and building remains were also encountered at the Cowcross redevelopment on the northern side of Cowcross Street (COW89).

It is likely that the truncation demonstrated by the borehole data has removed all Medieval horizontal stratigraphy, however, the exact nature of specific buildings that may have existed on the site is unknown and the possibility remains that the bases of deeply cut features survive below the levels of truncation.

## Archaeology Detailed Desk Based Assessment – Farringdon Station

Archaeological interventions in the vicinity (FNG02 & EGC04) have encountered much evidence for Post-medieval urbanisation around the sub-site. There is a high potential for evidence of 16th to 19th century buildings and other Post-medieval occupation features surviving. There is also a moderate potential for evidence relating to late 19th to early 20th century railway infrastructure.

Previous archaeological work in the immediate vicinity indicates that there is very little potential for *in situ* Prehistoric, Roman or early/middle Saxon remains.

*Impact of Proposals – Enabling Works*

- The precise locations of the grout shaft will be confirmed at detailed design to assess whether there will be any impact during the Enabling Works relating to utilities diversions, however, it is likely that these will have no or minimal archaeological impact.
- Construction methodology for the grout shafts will be confirmed at detailed design, however they are likely to be c.4m in diameter (Farringdon Design Team *pers comm.*).
- Foundations in any associated compounds for accommodation (c. 0.4-0.8m deep), and batch plant (c.0.5-1.0m deep) will have no or minimal archaeological impact.

*Impact of Proposals – Main Works*

- The shaft would completely remove any archaeological deposits within its footprint.

**Greenhills Rents Shaft***Natural*

Ground level varies slightly around the sub-site from 114.01m ATD (BH F10) in the south-west rising slightly to 115.00m ATD (BH F11) to the north-east of the site, with the ground level within the railway cutting being significantly lower (XRC92). These heights reflect the natural topography with the top of the London Clay falling towards the former course of the Fleet. Ground level at the site itself is at 116.00m ATD.

Information from geotechnical boreholes (BHs F10 & F11) to the south-west and north-east of the sub-site respectively, demonstrate that Made Ground is present to depths of c. 108.00m ATD in BH F10 and c. 112.00m ATD in BH F11, beneath which survives approximately 1.5m of River Terrace Deposits before the London Clay is reached, indicating that River Terrace Deposits are likely to be encountered within the sub-site. Similarly an archaeological site (XRC92) to the west within the railway cutting demonstrated surviving alluvial deposits, probably from features or the bases of possible stream channels also deeply cut into the London Clay. EGC04 to the north also encountered gravels beneath 3-4m of Post-medieval and Medieval deposits.

*The present buildings*

The site itself is located to the south of The Smokery and is not currently built on. The Smokery is partially mini-piled (Crossrail 2007), however these do not extend into the footprint of the grout shaft. There is also surface disturbance within the sub-site by utilities, probably to a depth of c.1-2m BGL.

*Earlier buildings*

Historic mapping shows that the area around the sub-site has undergone a number of phases of development, however the sub-site itself has only seen sporadic building and may have retained areas that were largely undeveloped in terms of large scale buildings. The extent and consistency of cellaring associated with former buildings is uncertain. The site has not been

## Archaeology Detailed Desk Based Assessment – Farringdon Station

truncated by the construction of the Metropolitan Line cut and cover tunnel located immediately south.

*Potential archaeological deposits*

Borehole data indicates that archaeological deposits in this sub-site may survive from c. 1.5m to c. 9.6m BGL (to c. 106.41m ATD) including approximately 1.5m of River Terrace Deposits at the bottom of the sequence of superficial deposits at which point the London Clay is reached. Surviving archaeological deposits would be limited to the bases of deeply cut features. Archaeological intervention to the north (EGC04) encountered 1-2m of 19th century Made Ground and demolition debris overlying 1m of Post-medieval garden deposits and a possible thin late Medieval soil horizon before Terrace Gravels were encountered.

Archaeological interventions in the vicinity (FNG02 & EGC04) have encountered much evidence for Post-medieval urbanisation around the sub-site. There is a high potential for evidence of 16th to 19th century buildings and other Post-medieval occupation features surviving. There is also a moderate potential for evidence relating to late 19th to early 20th century railway infrastructure.

Previous archaeological work in the vicinity indicates that there is very little potential for *in situ* Prehistoric, Roman or early/middle Saxon remains.

*Impact of Proposals – Enabling Works*

- The precise locations of the grout shaft will be confirmed at detailed design to assess whether there will be any impact during the Enabling Works relating to utilities diversions, in particular in relation to Greenhill's Rents sewer and local foul and surface drainage pipes. It is likely that these will have no or minimal archaeological impact.
- Construction methodology for the grout shafts will be confirmed at detailed design, however they are likely to be c.4m in diameter (Farringdon Design Team *pers comm.*).
- Foundations in any associated compounds for accommodation (c. 0.4-0.8m deep), and batch plant (c.0.5-1.0m deep) will have no or minimal archaeological impact.

*Impact of Proposals – Main Works*

- The grout shaft will completely remove potential archaeological remains within its footprint.

**Eastern Ticket Hall, including 33-37 Charterhouse Square and 3 Hayne Street***Natural*

Ground level around the sub-site falls gradually from approximately 118.00m ATD in the northeast (CSQ98) to approximately 116.00m ATD in the south-west (CFI06). With significantly lower levels of c. 109.00m ATD recorded within the railway cutting (BH F13 & BH F8). The ground level is consistent with the natural geology of the area with the London Clay dipping around the eastern edge of the site before rising slightly and then falling away towards the Fleet valley to the west.

Geotechnical boreholes (BHs F8 & F13) around and within the sub-site demonstrate that in the central and northern parts of the Eastern Ticket Hall the Metropolitan Line cut and cover cutting has been excavated to the level of the London Clay, overlain by a thin layer of Made Ground. Just north of the site, BH F9 demonstrates approximately 1m of River Terrace Deposits overlying the London Clay. Archaeological sites in the surrounding area (CAA00, CFI06, CSQ98, CIN91, LOG82, CQC07 & CLO83) also encountered River Terrace Deposits at depths of between 115.90m ATD and 113.50m ATD underlying Made Ground deposits, indicating that

## Archaeology Detailed Desk Based Assessment – Farringdon Station

River Terrace Deposits may survive beneath existing basements and in areas without basements in parts of the site not truncated by the railway cutting.

*The present buildings*

There is a railway cutting (the cut and cover Metropolitan Line) in the northern third of the Eastern Ticket Hall and an area of former railway sidings that extend southwards into the sub-site. Construction of the existing railway cutting and retaining walls has truncated much of the northern half of the Eastern Ticket Hall to the level of the London Clay (Drawing Number P30103-C1M10-E00-D-50150 - Appendix 9.2). Buildings on the western side of the Eastern Ticket Hall, fronting onto Lindsey Street, are built from the level of the cutting (3-4 Lindsey Street) in the area excavated for the railway siding. The extent to which the deposits behind the railway retaining walls (now occupied by 8-10 and 3 Hayne Street) have been truncated is unknown.

The cut and cover Metropolitan Line cutting has also truncated the southernmost section of 33-37 Charterhouse Square, part of which sits above the railway retaining wall (Drawing Number P30103-C1M10-E00-D-50151 - Appendix 9.2). 33-37 Charterhouse Square also has a single basement across its length, which stretches northwards beneath the pavement and Charterhouse Square roadway (Drawing Number P30103-C1M10-E00-D-50142 - Appendix 9.1).

The brick arches extending under Lindsey Street from Smithfield Market do not fall within the site boundary, however these arches connect the basement of Smithfields to the level of the railway cutting in the Eastern Ticket Hall footprint.

It is uncertain the extent to which the construction of the Metropolitan Line removed archaeological deposits in the road between 3 and 10 Hayne Street. Utilities are also known at this location to a depth of c. 1-2m below ground level.

*Earlier buildings*

Construction of the Metropolitan Line railway by 1873 dramatically altered the street layout and buildings between Long Lane and Charterhouse Lane with Lindsey Street and Hayne Street both being created then. It is likely that all of the 19th century buildings on the site were demolished at that time. Historic mapping shows that the majority of the site was probably undeveloped until the 17th century. The extent of cellaring associated with former buildings across the site is unknown.

*Potential archaeological deposits*

Within the existing railway cutting borehole data (BHs F8 & F13) demonstrates that truncation has occurred to the level of the London Clay and therefore archaeological deposits are not expected to survive. The presence of basements across the remaining southern area of the site means that the depth of surviving archaeological deposits will vary. Furthermore, it is possible that truncation caused by the construction of the retaining walls has not completely removed all archaeological remains at 3 and 10 Hayne Street, the extent of basements at these two buildings is unknown.

Archaeological sites and geotechnical boreholes in the area show that Made Ground deposits can generally be expected at approximately 116.00 to 113.00m ATD overlying c.1m of River Terrace Deposits. Therefore, horizontally stratified archaeological deposits are not expected to survive beneath the basements at 22-23 Long Lane and 2 Lindsey Street, which are between c. 114.00 and 113.00m ATD, however, cut features, such as burials may survive within a layer of River Terrace Gravels overlying the London Clay.

The depth of truncation by basements is slightly less on the eastern side of the station box with the majority of basement depths between 115.18 and 114.36m ATD beneath 20-21 Long Lane. Archaeological deposits may survive within the Made Ground not truncated by basements, and

## Archaeology Detailed Desk Based Assessment – Farringdon Station

cut features, such as burials, may be present within the River Terrace Deposits that overlie the London Clay. There is a particular potential for individual deeply cut features such as burials, pits, wells and ditches in the vicinity of Hayne Street and Charterhouse Square as they are situated within the Medieval cemetery of Charterhouse.

It is unlikely that archaeological remains will survive at 3-4 Lindsey Street, which are built from the level of the railway cutting in the area formerly used as railway sidings.

*Impact of Proposals – Enabling Works*

- Utilities abandonment, protection and diversion on Charterhouse Square; Charterhouse Street; and Fox & Knot Street could disturb archaeological remains, possibly relating to the Medieval cemetery of Charterhouse.
- Demolition of the buildings in the Enabling Works phase is unlikely to impact on archaeological deposits, however, the following buildings and features have been identified as Non-listed built heritage (section 5.6) and therefore require internal inspection and potentially recording prior to demolition:
  - 3 Hayne Street;
  - 8-9 Hayne Street;
  - Chimney to rear of 20-21 Long Lane;
  - 22 Long Lane;
  - 2 Lindsey Street and 23 Long Lane;
  - 3 Lindsey Street;
  - Retaining Arches below Hayne Street;
  - Retaining Arches to Barbican Station;
  - 33-37 Charterhouse Square;
  - 54 Charterhouse Street and 5 Lindsey Street (Smithfield House); and
  - Barbican Station Signal Box.
- The following street furniture has been identified as non-listed built heritage and may be affected by enabling works:
  - Boundary plaques attached to 8 Hayne Street;
  - Historic surface to Charterhouse Square; and
  - Pillar Box on Charterhouse Square.
- Furthermore, it is possible that as yet unidentified non-listed railway heritage may also exist within the site footprint.

*Impact of Proposals – Main Works*

- The staged construction at the Eastern Ticket Hall will remove all surviving archaeological deposits beneath basements of the existing buildings and road at 20-23 Long Lane; 8-10 Hayne Street; 3 Hayne Street; the road between 3 & 10 Hayne Street; and at 33-37 Charterhouse Square.
- It is unlikely that archaeological remains survive in the remainder of the site due to truncation by the Metropolitan Line railway cutting, however, should isolated deposits survive they will be completely removed by the construction works.

## ***Western Ticket Hall***

### *Natural*

The sub-site lies within an area of former railway sidings and therefore the ground level is the same as that within the railway cutting. Ground level at BH F5, located just east of the site and within the railway cutting is at 106.60m ATD. BH F5 also demonstrated only 0.50m of superficial deposits (Made Ground) beneath which lay London Clay. Similarly, archaeological monitoring at Thameslink 2000 trial work at Farringdon (FNG02) showed that archaeological remains are unlikely to survive in the footprint of the railway cuttings.

### *The Present buildings*

The site is currently occupied by Cardinal Tower, which has a double basement, with an adjacent NCP car park, also at double basement level.

### *Earlier buildings*

The site was open fields alongside the Fleet River until the 17th century when development accelerated after the Great Fire. In the 18th century the site comprised a block of buildings and a number of small alleys and streets. The area underwent massive change in the 1800s with the construction of the Metropolitan Line and Smithfields Market and by the close of the 19th century the Western Ticket Hall footprint was the site of a Great Northern Railway (GNR) Goods Depot. In the 20th century the site continued as a Depot until World War II when it was damaged beyond repair by a V2 long range rocket. To the immediate west of the Goods Depot a row of terraces were constructed fronting onto Farringdon Road. These buildings were not destroyed by the V2 rocket and remained until the construction of Cardinal House in the 1960s.

### *Potential archaeological deposits*

Previous work carried out at FNG02 indicates that there is very little potential for the survival of archaeological deposits due to truncation by the railway cutting and goods yard followed by the construction of Cardinal House. However, the course of the Faggesswell Brook is conjectured to have flowed east-west somewhere between Cowcross Street and Charterhouse Street, therefore there is a slight possibility that the base of the brook could fall within the Cardinal house site, cut into the London Clay beneath the level of truncation. The brook could provide palaeoenvironmental deposits and archaeological remains relevant to our understanding of the Fleet river and its tributaries.

### *Impact of Proposals – Enabling Works*

There will be no impact to archaeological deposits at the Western Ticket Hall during Enabling Works.

### *Impact of Proposals – Main Works*

Ground reduction in the footprint of the piled box will remove any surviving archaeological deposits cut deep into the London Clay.

## 6.2 Predicted Impacts to the Archaeological Resource

The table below summarises the construction impacts discussed above.

Sub-Site	Summary of Scheme Design	Maximum Depth of Impact (m ATD)	Impact to Archaeology		Predicted Depth of Archaeological Remains
			Enabling Works	Main Works	
67-69 Cowcross Street Shaft	Grout shafts at rear of 67-69 Cowcross Street extending below the base of the terrace gravels into the Lambeth Group, with associated construction compound and utilities diversions.  Location of grout shaft to be confirmed at detailed design	99.00	The precise locations of the grout shaft needs to be confirmed at detailed design to assess whether there will be any impact during the Enabling Works relating to utilities diversions, however, it is likely that these will have no or minimal archaeological impact.  Foundations in any compounds for accommodation (c. 0.4-0.8m deep), and batch plant (c.0.5-1.0m deep) will have no or minimal archaeological impact.	Shaft will completely remove potential archaeological remains within its footprint.	From c.1.5m below ground level, if no basements are present.
Greenhill's Rents Shaft	Grout shafts at Greenhill's Rents extending below the base of the terrace gravels, with associated construction compound and utilities diversions.  Location of grout shaft to be confirmed at detailed design.	100.00	The precise locations of the grout shaft needs to be confirmed at detailed design to assess whether there will be any impact during the Enabling Works relating to utilities diversions, in particular in relation to Greenhill's Rents sewer and local foul and surface drainage pipes. It is likely that these will have no or minimal archaeological impact.  Foundations in any compounds for accommodation (c. 0.4-0.8m deep), and batch plant (c.0.5-1.0m deep) will have no or minimal archaeological impact.	Shaft will completely remove potential archaeological remains within its footprint.	c. 1.5m to c.9.6m (to approx 106.41m ATD) below ground level, if no basements are present.

## Archaeology Detailed Desk Based Assessment – Farringdon Station

Sub-Site	Summary of Scheme Design	Maximum Depth of Impact (m ATD)	Impact to Archaeology		Predicted Depth of Archaeological Remains
			Enabling Works	Main Works	
Eastern Ticket Hall, including 33-37 Charterhouse Square and 3 Hayne Street	Utilities diversions at Charterhouse Square; Charterhouse Street; and Fox & Knot Street.		Disturbance of archaeological deposits relating to the Medieval cemetery of Charterhouse.  Damage to historic sett surface on Charterhouse Square		There is a potential for archaeological remains relating to Charterhouse Cemetery at any depth beneath street level.

## Archaeology Detailed Desk Based Assessment – Farringdon Station

Sub-Site	Summary of Scheme Design	Maximum Depth of Impact (m ATD)	Impact to Archaeology		Predicted Depth of Archaeological Remains
			Enabling Works	Main Works	
Eastern Ticket Hall and 3 Hayne Street Shaft  Western Ticket Hall	Utilities diversions Construction of , demolitions and construction of stair and lift shaft to concourse interchange level at Charterhouse Square temporary construction shaft at 33-37 Charterhouse Square.	Approximate underside of base slab level: 77.80  Approximate pile toe depth: 65.00	A number of existing utilities are known in and around the Eastern Ticket Hall and 3 Hayne Street shaft including water mains; sewers; EDF cables; Cable & Wireless Cables, BT Cables and Level 3 Cables. Abandonment, diversion and protection measures are likely to have no or minimal archaeological impact.  Demolition of the buildings in the Enabling Works phase is unlikely to impact on archaeological deposits, however, a number of the buildings have been identified as Non-listed built heritage (section 4.6) and will therefore require building recording. Furthermore, it is possible that as yet unidentified non-listed railway heritage may also exist within the site footprint.	Removal of all archaeological deposits surviving beneath the basements of 33-37 Charterhouse Square.	No archaeological deposits expected in the railway cutting.  Remains relating to the Medieval Charterhouse Cemetery may be present at any depth beneath Charterhouse Square; Charterhouse Street and Fox & Knot Street.  Cut features may survive beneath basements at 20-23 Long Lane to c.111.58m ATD.  Cut features may survive beneath basements at 3 and 8-10 Hayne Street. Depths of deposits is unknown.  Cut features may survive beneath 33-37 Charterhouse Square to c.111.76m ATD.

Archaeology Detailed Desk Based Assessment – Farringdon Station

Sub-Site	Summary of Scheme Design	Maximum Depth of Impact (m ATD)	Impact to Archaeology		Predicted Depth of Archaeological Remains
			Enabling Works	Main Works	
	Utilities diversions, demolitions and the construction of the below ground station concourse between Lindsey Street. and Hayne Street. (Diaphragm Wall Box – approximately 32m long by 27m wide)	Approximate underside of base slab level: 77.80 Approximate pile toe depth: 65.00 Approximate pile toe depth: 63.00	A number of existing utilities are known in and around the Eastern Ticket Hall and 3 Hayne Street shaft but are likely to have no or minimal archaeological impact.  Demolition of the buildings in the Enabling Works phase is unlikely to impact on archaeological deposits, however, a number of the buildings, structures and street furniture have been identified as Non-Listed Built Heritage (section 5.6) and will therefore require further assessment and recording.	Removal of all archaeological deposits surviving underneath the basements of the existing buildings (20-23 Long Lane)..	No archaeological deposits expected in the railway cutting.  Remains relating to the Medieval Charterhouse Cemetery may be present at any depth beneath Charterhouse Square; Charterhouse Street and Fox & Knot Street.  Cut features may survive beneath basements at 20-23 Long Lane to c.111.58m ATD.  Cut features may survive beneath basements at 3 and 8-10 Hayne Street. Depths of deposits is unknown.
	Demolition of 3 and 10 Hayne Street and construction of a ventilation shaft.			Removal of all surviving archaeological remains beneath 3 and 8-10 Hayne Street, and not previously truncated by the construction of the Metropolitan Line and associated retaining walls.	Cut features may survive beneath 33-37 Charterhouse Square to c.111.76m ATD.  Beneath the existing basements.
	Ground reduction within the footprint of the Piled Box.			Removal of surviving archaeological deposits relating to the base of the Faggesswell Brook, which may survive cut deeply into the London Clay.	

Table 7 Summary of construction impacts

## 7 Recommendations

### 7.1 Proposed Evaluation Strategy

Archaeological evaluation will establish the degree of archaeological survival and thereby refine the time required for further archaeological excavations (if needed). Archaeological field evaluation can include methods such as non-intrusive surveys (e.g. geo-archaeological investigation); small-scale intrusive surveys (e.g. observation and recording works integrated with geotechnical site investigations, drilling of geo-archaeological boreholes); and excavation of archaeological trial trenches. Further descriptions of archaeological evaluation can be found in the Crossrail Archaeology Generic Written Scheme of Investigation (2008f). Set out below are the archaeological field evaluations required to inform further mitigation.

#### *Eastern Ticket Hall*

At Enabling Works stage:

- Archaeological field evaluation comprising trial pits/trenches to establish the level of previous piling, archaeological significance and level of survival at the following locations: 20-23 Long Lane; 8-10 Hayne Street; 3 Hayne Street; 10 Hayne Street; and at 33-37 Charterhouse Square, during the demolition process, (at the soft strip stage), after the removal of asbestos).
- The details of the archaeological evaluation are to be determined at detailed design and will be programmed according to feasibility in the construction sequence.

#### *Cowcross Street Grout Shaft and Greenhill's Rents Grout Shaft*

See section 7.3 for proposed archaeological mitigation at these locations.

### 7.2 Non-Listed Built Heritage Assessment and Recording

The following further built heritage assessment and recording is required at Farringdon Station.

Internal inspection is required at the following locations to establish an appropriate level of archaeological recording:

- 3 Hayne Street;
- 8-9 Hayne Street;
- 22 Long Lane;
- 2 Lindsey Street and 23 Long Lane;
- 3 Lindsey Street;
- 33-37 Charterhouse Square; and
- 54 Charterhouse Square and 5 Lindsey Street (Smithfield House).

A Level II English Heritage survey should be undertaken at the following locations prior to demolition:

- Chimney to rear of 20-21 Long Lane;
- Retaining arches below Hayne Street;
- Retaining arches to Barbican Station; and
- Barbican Station signal box.

The following further mitigation is required for elements of street furniture;

- Boundary Plaques attached to 8 Hayne Street will be reinstated in original position on the new structure;

## Archaeology Detailed Desk Based Assessment – Farringdon Station

- Works necessitating the removal of the historic sett surface in Charterhouse Square (e.g. geotechnical investigations and utilities diversions) will replace the surface in original position upon completion; and
- Works necessitating the temporary removal of pillar boxes outside 59-60 Cowcross Street and on Charterhouse Square (e.g. utilities diversions) will replace the pillar boxes in original position upon completion.

### 7.3 Proposed Mitigation Strategy

#### *Cowcross Street grout shaft and Greenhill's Rents grout shaft*

Archaeological mitigation in the form of *preservation-by-record* (e.g. archaeological excavation and/or watching brief). No details are available on construction sequence and methodology at the shaft sites or the finalised locations, however, it is envisaged that archaeological excavation will occur after Enabling Works, when utilities have been diverted, and prior to Main Construction.

- The specific locations of the compensation grout shafts at these three sites will be determined at the detailed design phase.

#### *Eastern Ticket Hall*

- The results of the archaeological field evaluation will inform the mitigation design, will constitute *preservation-by-record* (e.g. archaeological excavation and/or watching brief). Archaeological mitigation, if required, would be undertaken commensurate with the Main Works. These mitigation measures are defined in the Crossrail Archaeology Generic Written Scheme of Investigation (2007f).
- General Watching Brief at utilities diversions at Charterhouse Square; Charterhouse Street; and Fox & Knot Street.
- General Watching Brief in the road between 3 & 10 Hayne Street, at the Enabling Works stage, following on from utilities works at this location.

#### *Western Ticket Hall*

- General Watching Brief during ground reduction in the footprint of the piled box, commensurate with the Main Works.

## 8 References

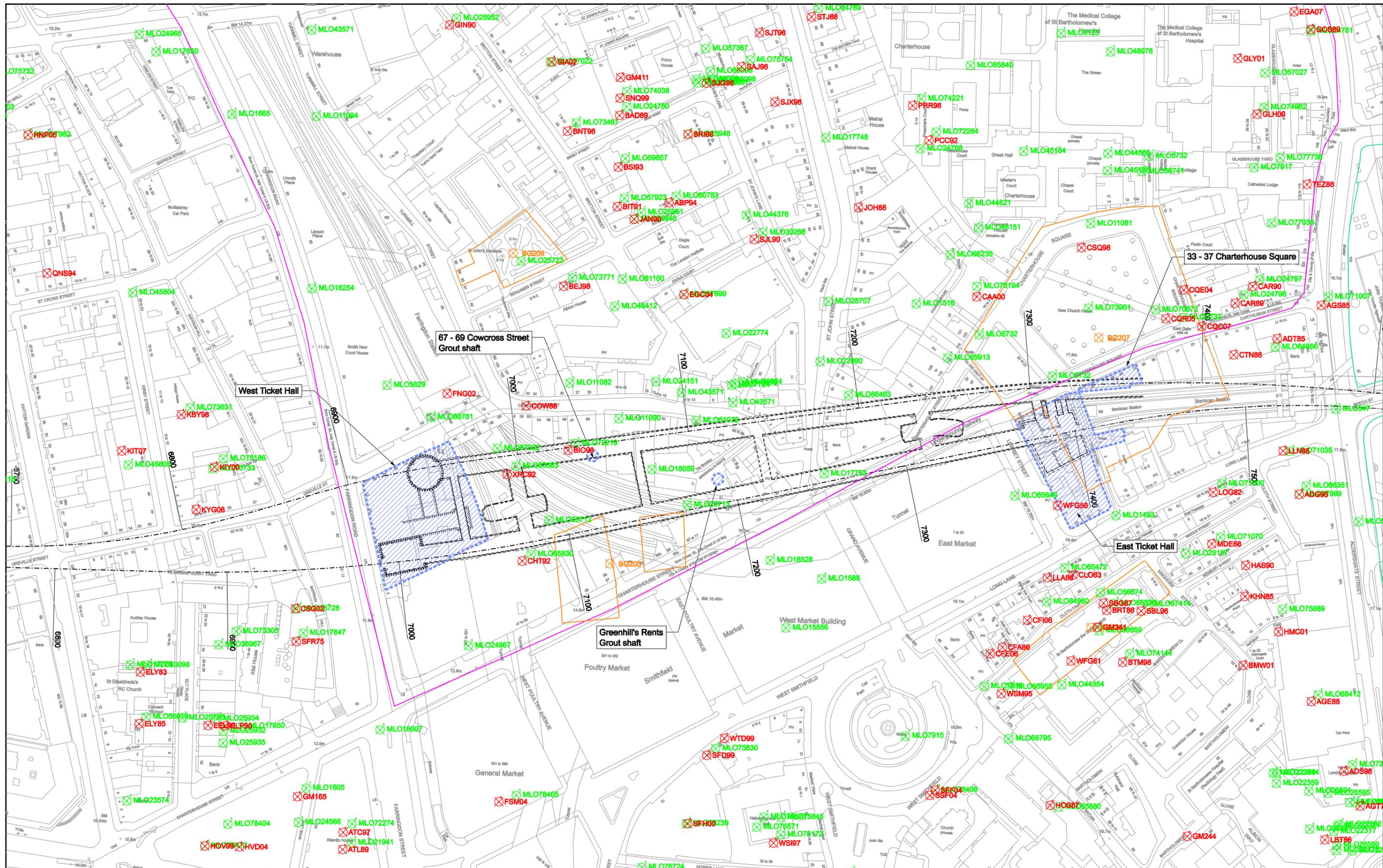
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## 9 Appendices

### 9.1 Plans and Illustrations

#### Drawing Index

Title	Drawing Number
Archaeological Baseline	P30103-C1M10-E00-D-50001
Archaeology Areas for Evaluation	P30103-C1M10-E00-D-50003
Non-Listed Built Heritage Location Plan	P30103-C1M10-E00-D-50004
Farringdon Station Historical Mapping 1562 – Agas's Map of London (West)	P30103-C1M10-E00-D-50101
Farringdon Station Historical Mapping 1562 – Agas's Map of London (East)	P30103-C1M10-E00-D-50102
Farringdon Station Historical Mapping 1572 – Braun & Hogenberg	P30103-C1M10-E00-D-50103
Farringdon Station Historical Mapping 1658 – Fairthorne & Newcourt's City of London map	P30103-C1M10-E00-D-50104
Farringdon Station Historical Mapping 1682 – Ogilby & Morgan's large scale map of the City as rebuilt by 1676	P30103-C1M10-E00-D-50105
Farringdon Station Historical Mapping 1746 – John Rocque's map of London	P30103-C1M10-E00-D-50106
Farringdon Station Historical Mapping 1799 – Richard Horwood's map of London, Westminster and Southwark (North)	P30103-C1M10-E00-D-50107
Farringdon Station Historical Mapping 1799 – Richard Horwood's map of London, Westminster and Southwark (South)	P30103-C1M10-E00-D-50108
Farringdon Station Historical Mapping 1824 – Greenwood's map of London	P30103-C1M10-E00-D-50109
Farringdon Station Historical Mapping 1873 - OS	P30103-C1M10-E00-D-50110
Farringdon Station Historical Mapping 1896 – OS	P30103-C1M10-E00-D-50111
Farringdon Station Historical Mapping 1914 – OS	P30103-C1M10-E00-D-50112
Farringdon Station Historical Mapping 1938 – OS	P30103-C1M10-E00-D-50113
Farringdon Station Historical Mapping 1953 – OS	P30103-C1M10-E00-D-50114
Farringdon Station Historical Mapping 1961 – OS	P30103-C1M10-E00-D-50115
Farringdon Station Historical Mapping 1970 – OS	P30103-C1M10-E00-D-50116
Farringdon Station Historical Mapping 1983 – OS	P30103-C1M10-E00-D-50117
Farringdon Station Historical Mapping 1988 – OS	P30103-C1M10-E00-D-50118
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37-39 Cowcross Street – Basement Plan, 1959	P30103-C1M10-E00-D-50162
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Farringdon Station, Eastern Ticket Hall – Potential survival of archaeological deposits 2	P30103-C1M10-E00-D-50151
Farringdon Station, Geological Section, Eastbound Tunnel	P30101-C1M10-G00-D-60101
Farringdon Station, Geological Section, Westbound Tunnel	P30101-C1M10-G00-D-60102



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- MLO21941 Greater London Sites and Monuments Record
- ATL89 Site Codes
- Archaeological Priority Zone
- BG205 Burial Ground
- L036 Scheduled Ancient Monuments
- Registered Parks and Gardens
- Crossrail Worksite

Scale 1:1000

North arrow pointing up.

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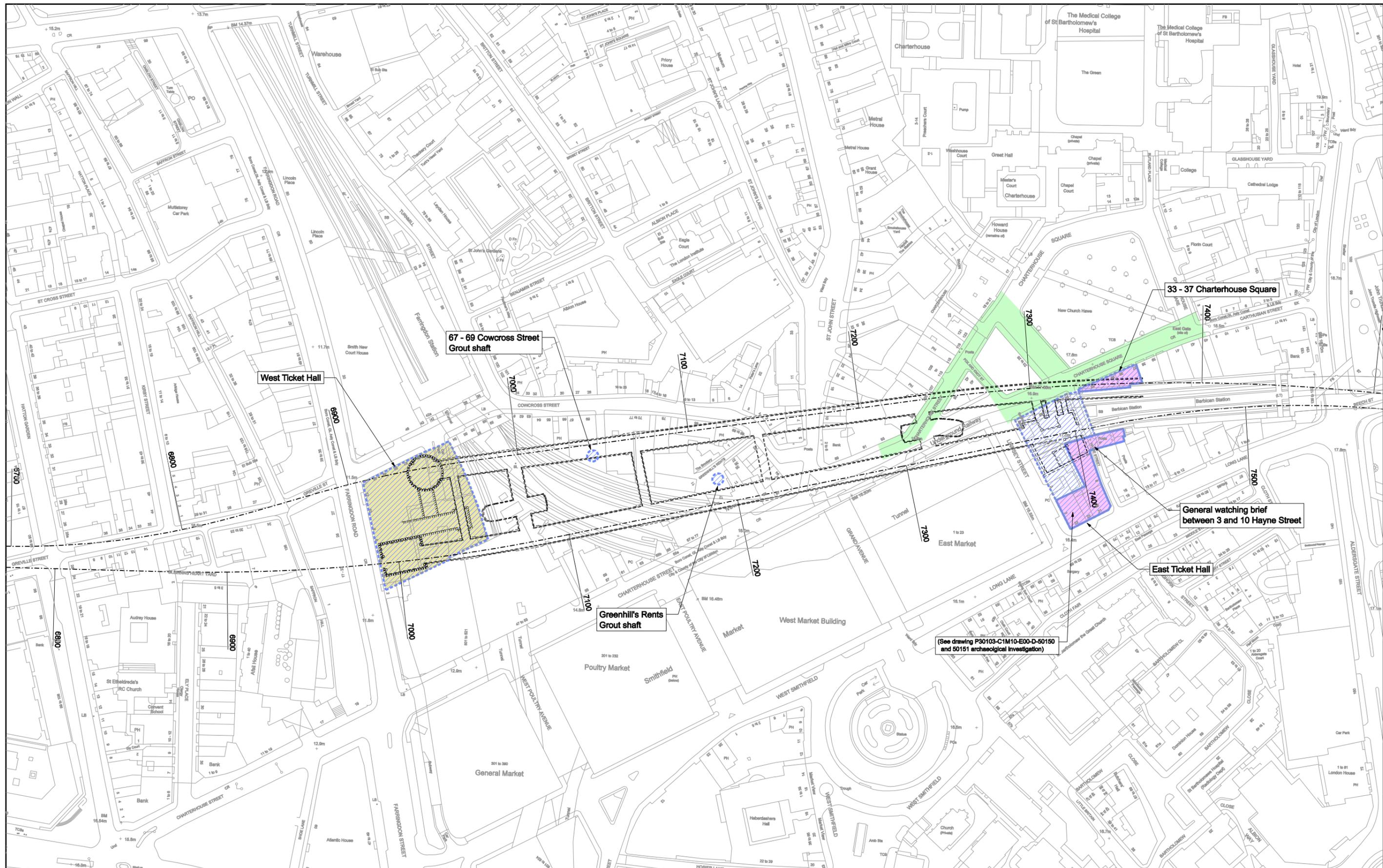
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- Crossrail Worksite
- General watching brief at utilities diversions
- Trial trench evaluation during enabling works
- General watching brief at main works

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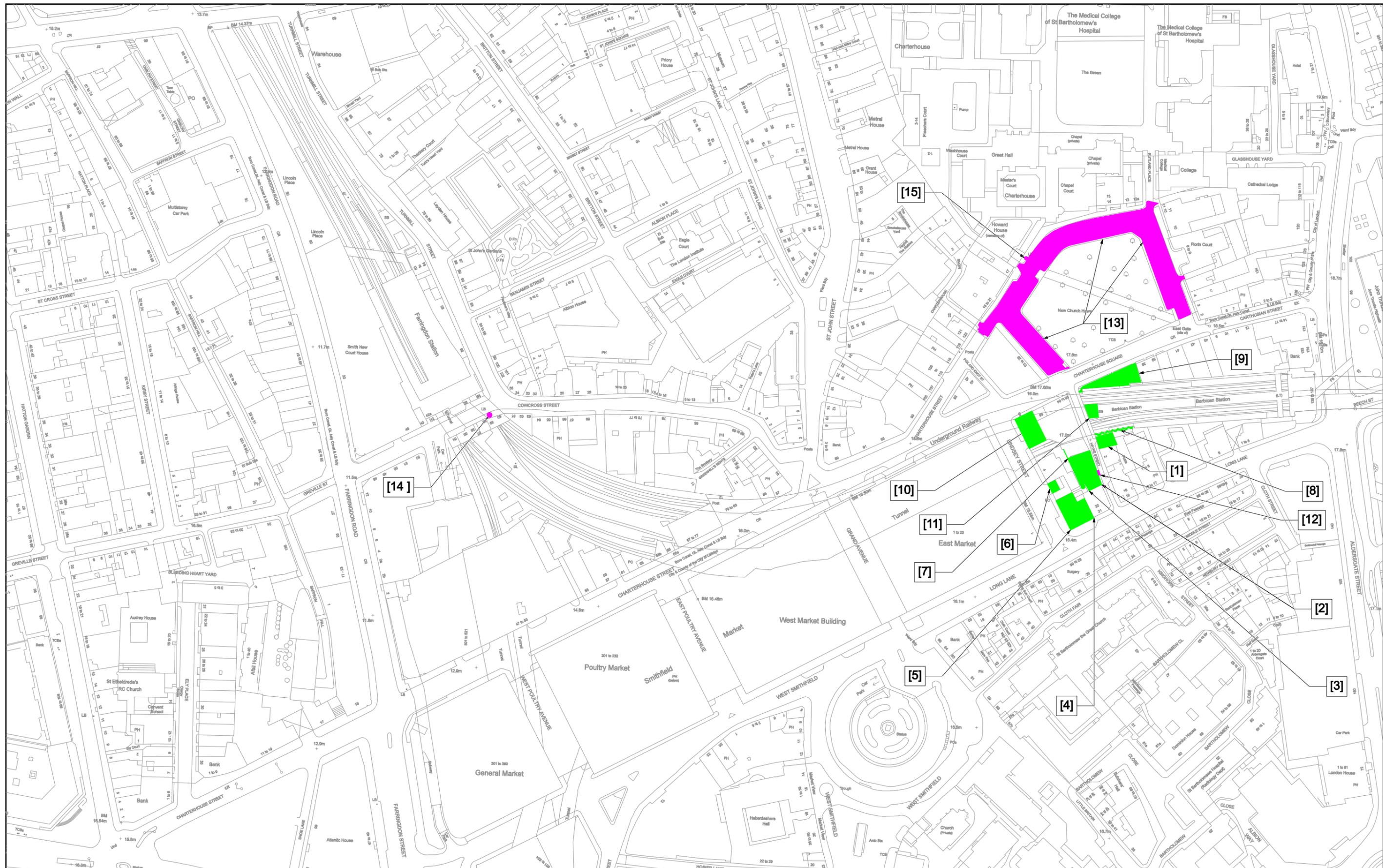
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Non-listed historic building

Historic street furniture

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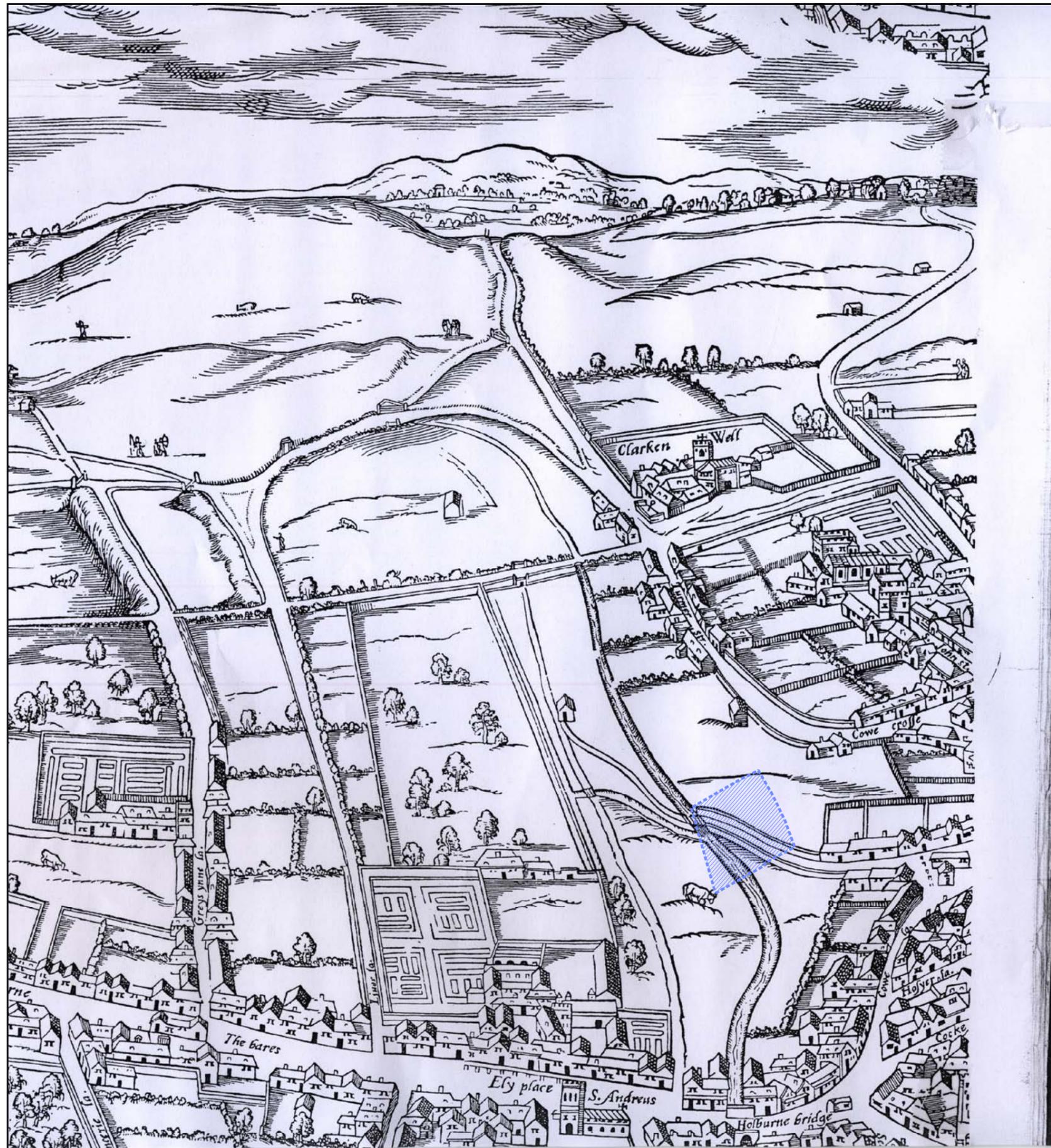
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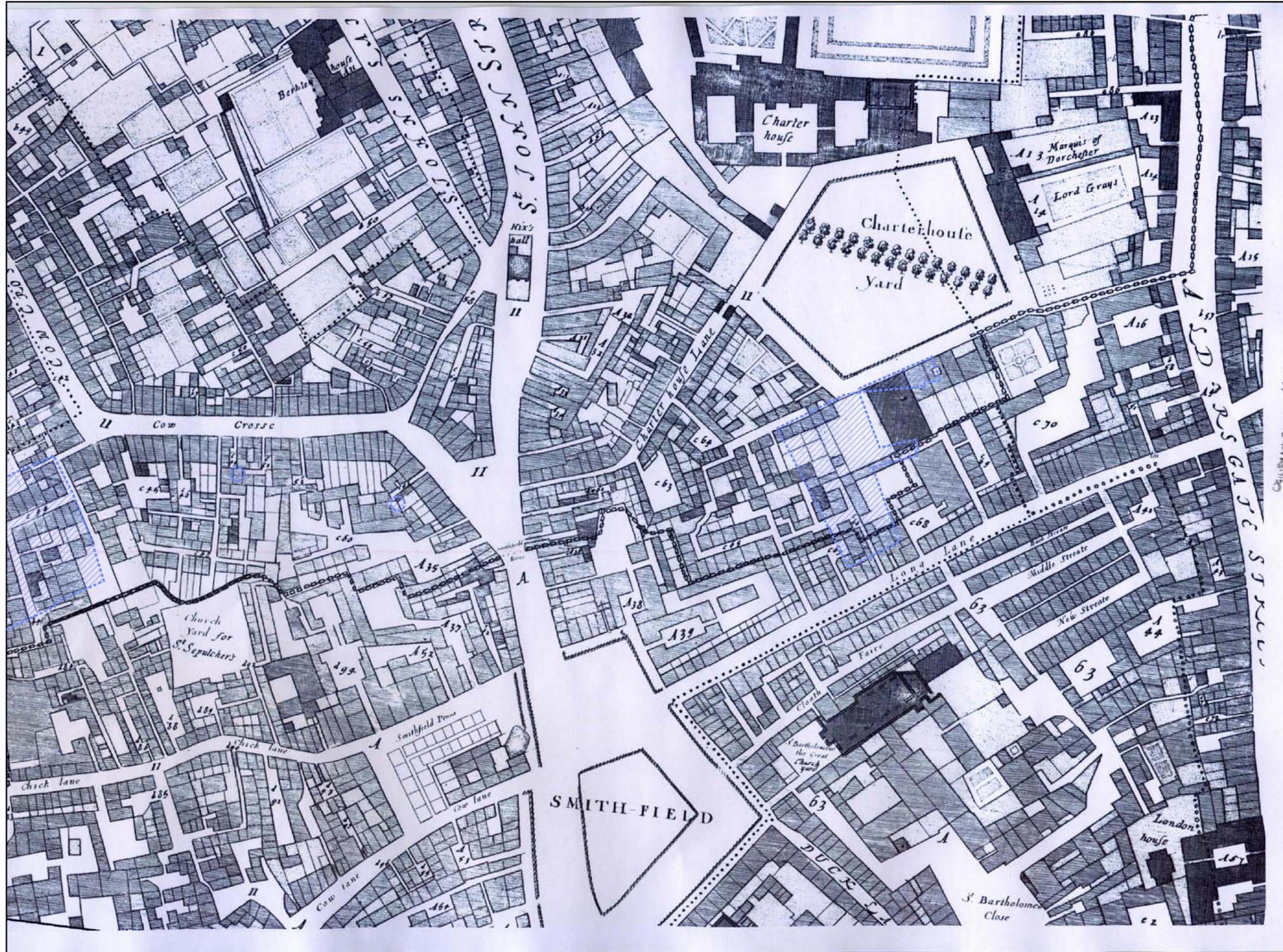
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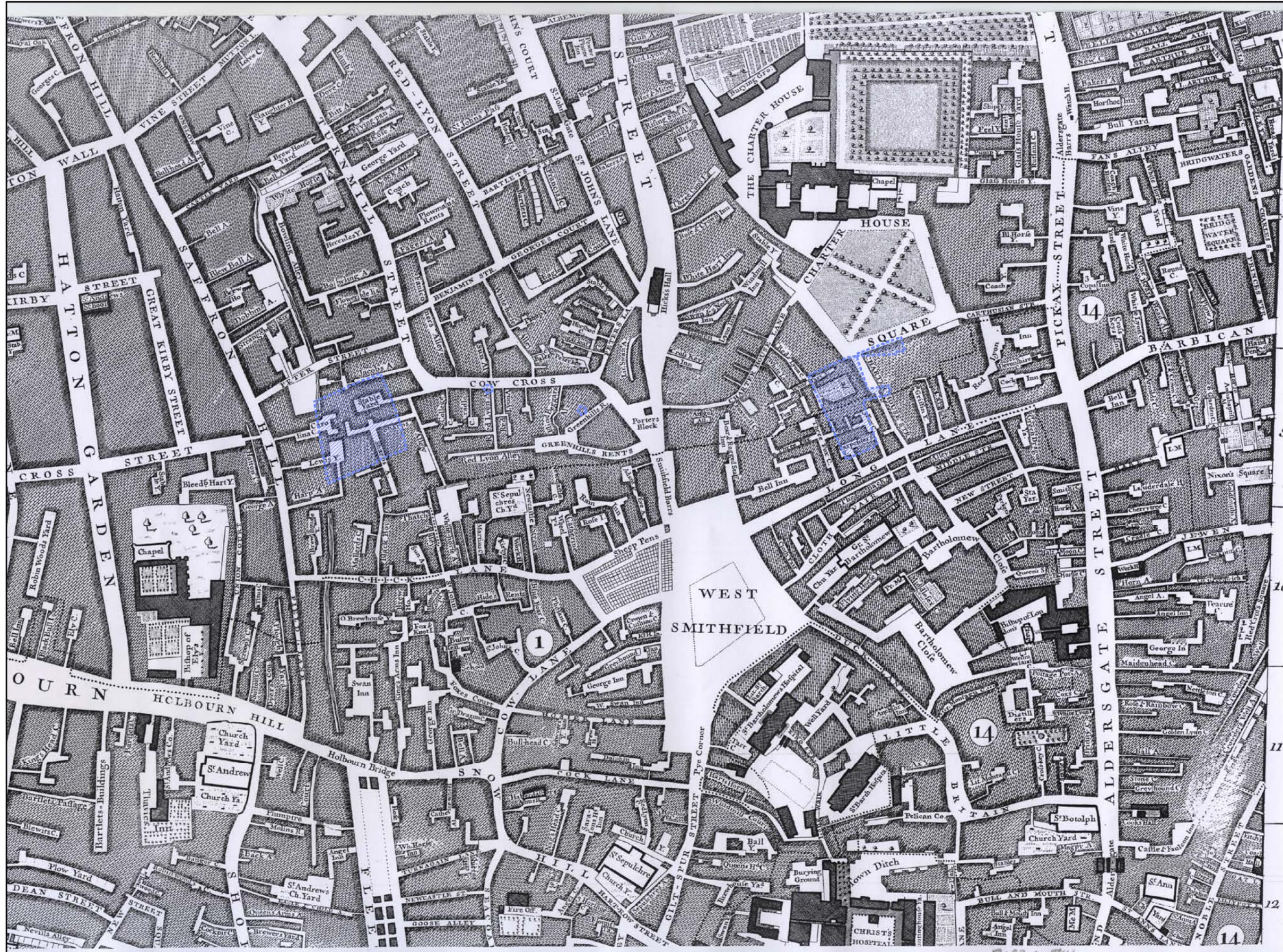
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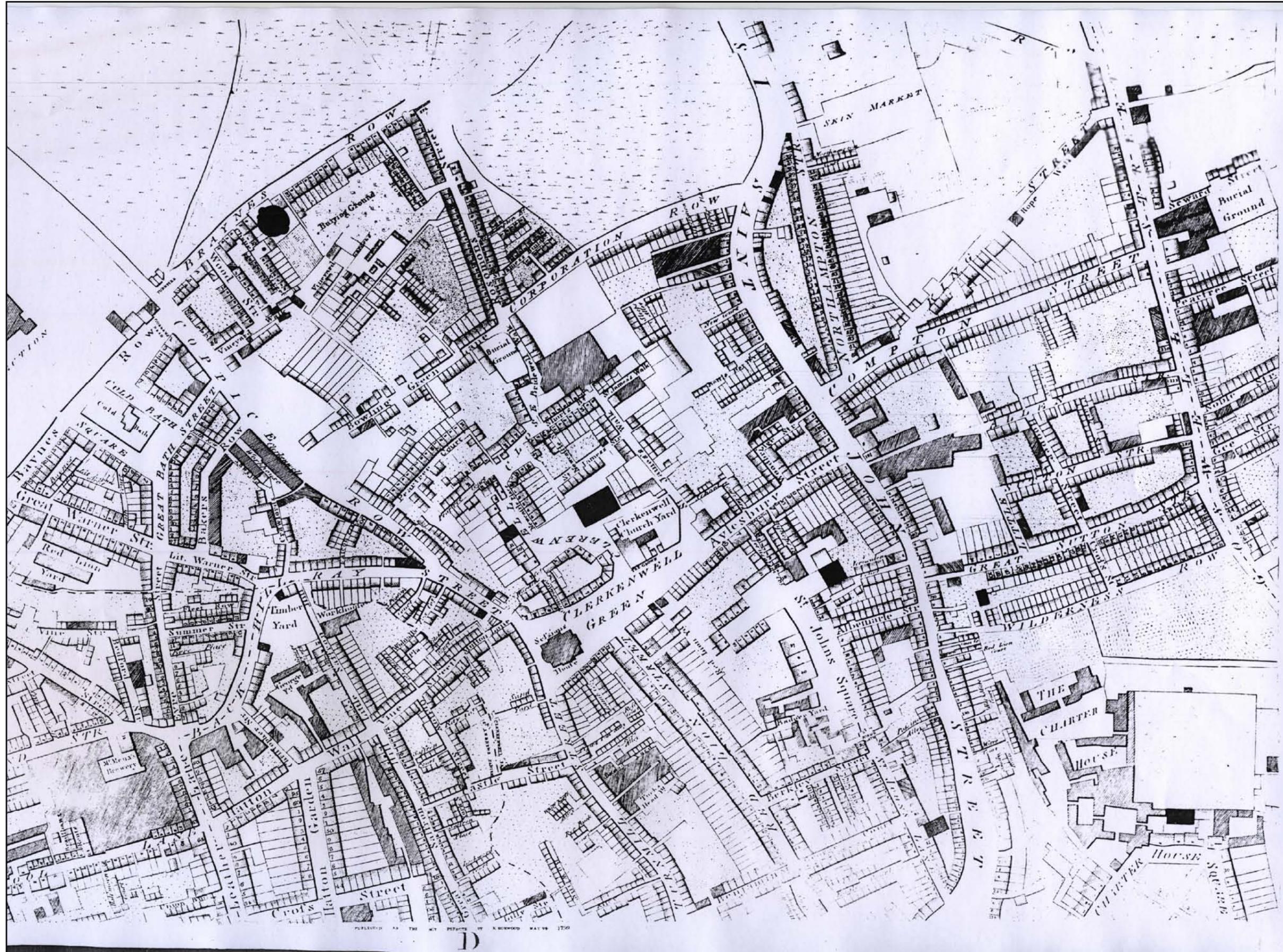
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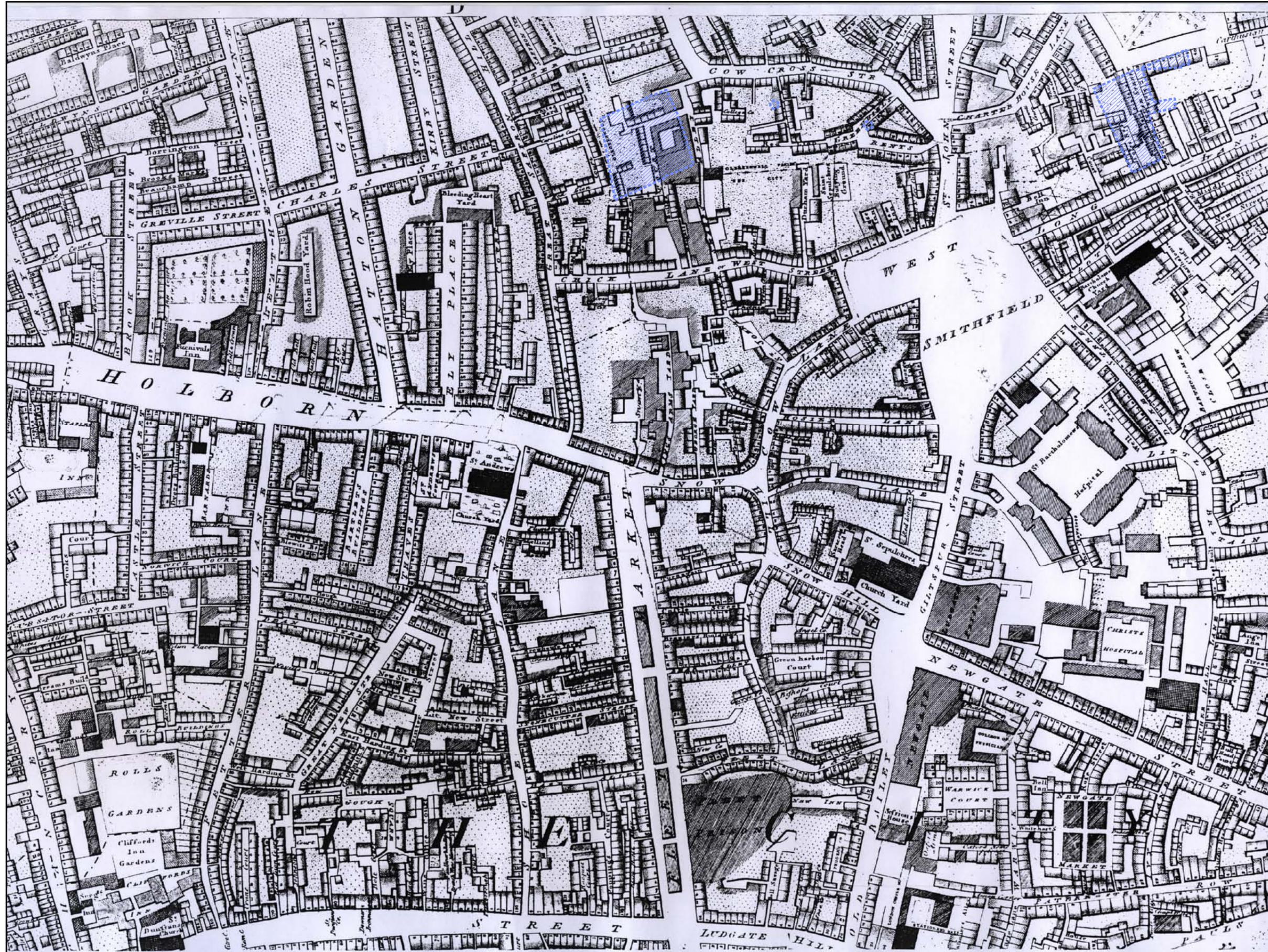
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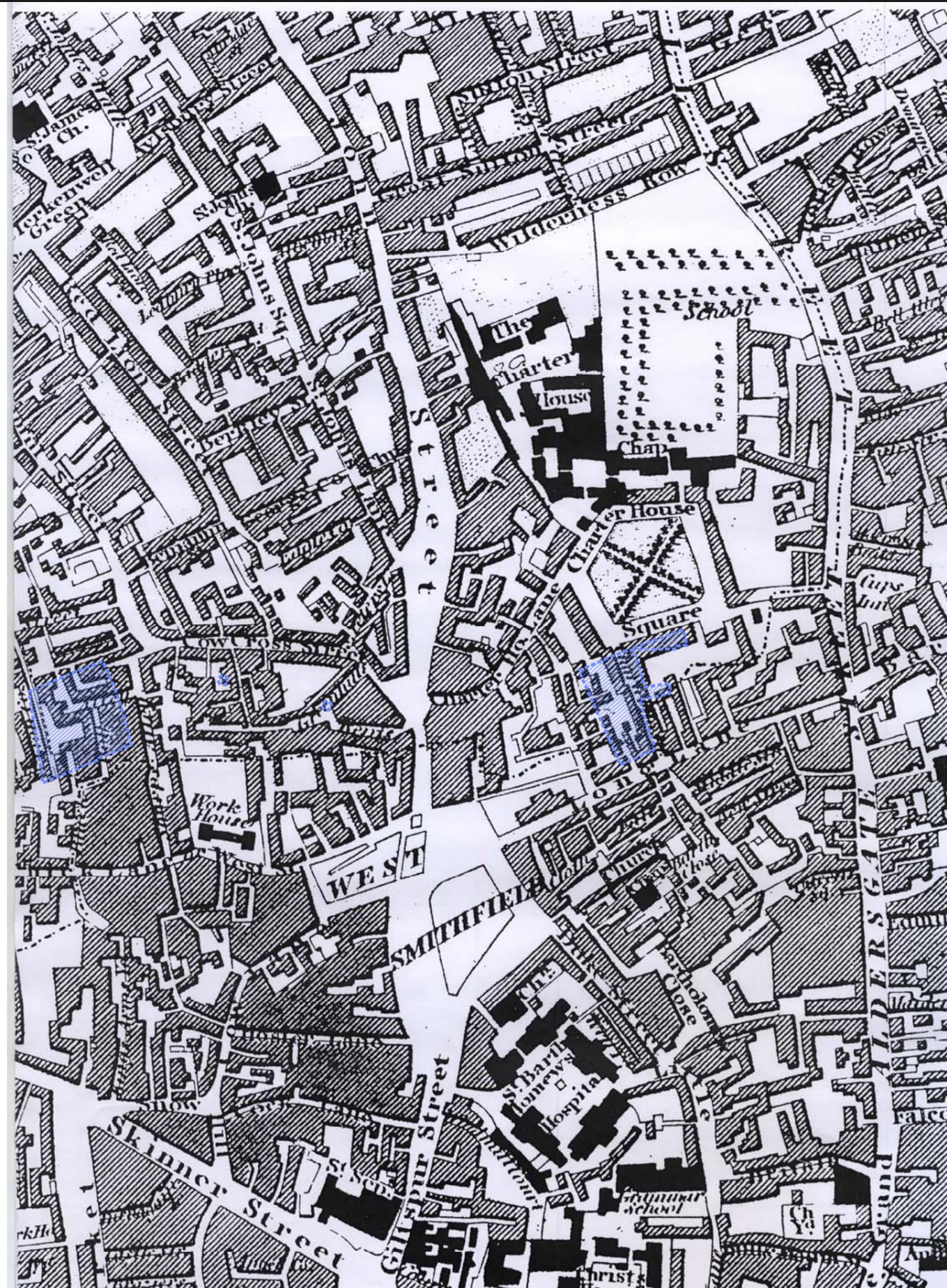
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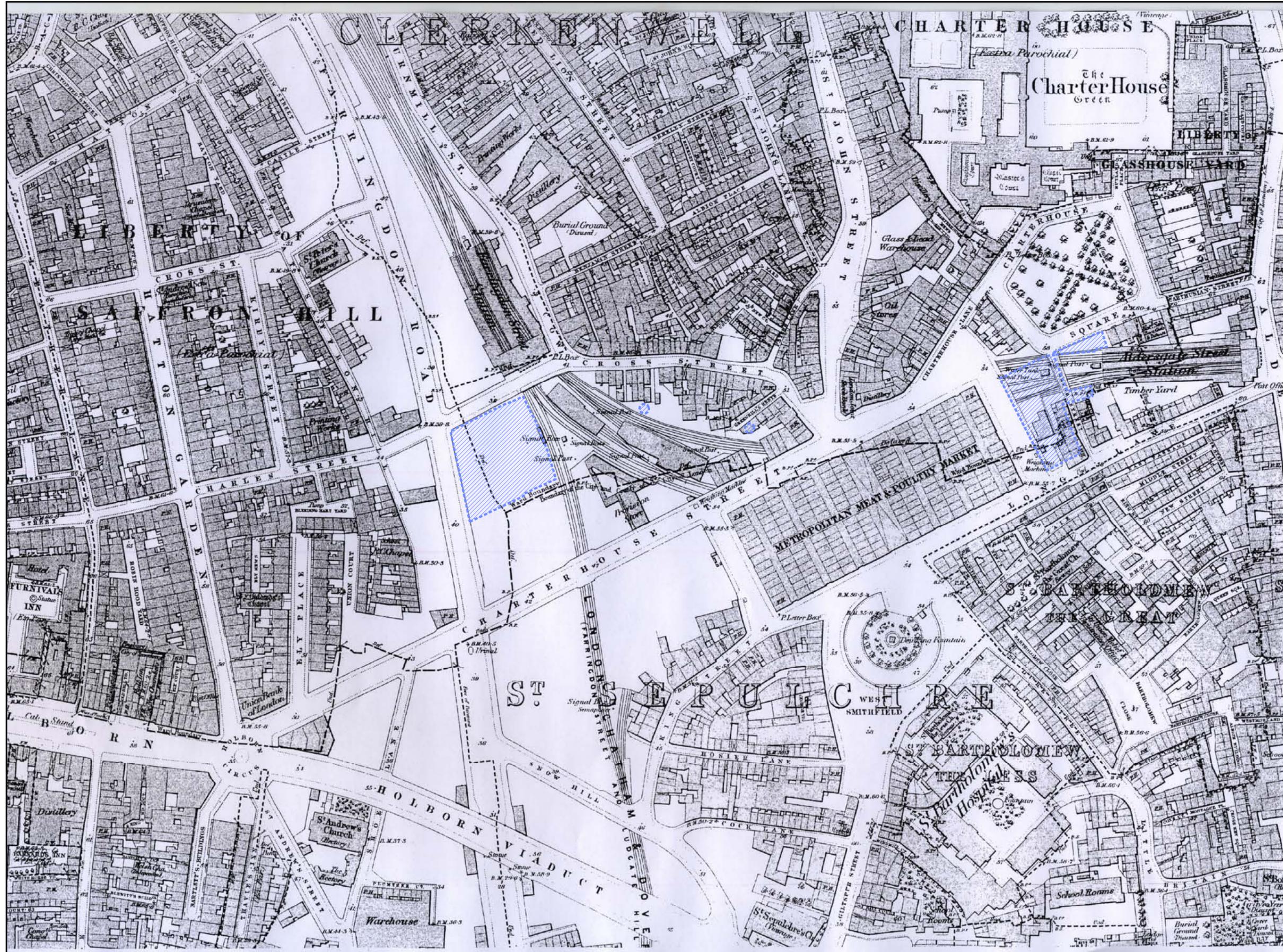
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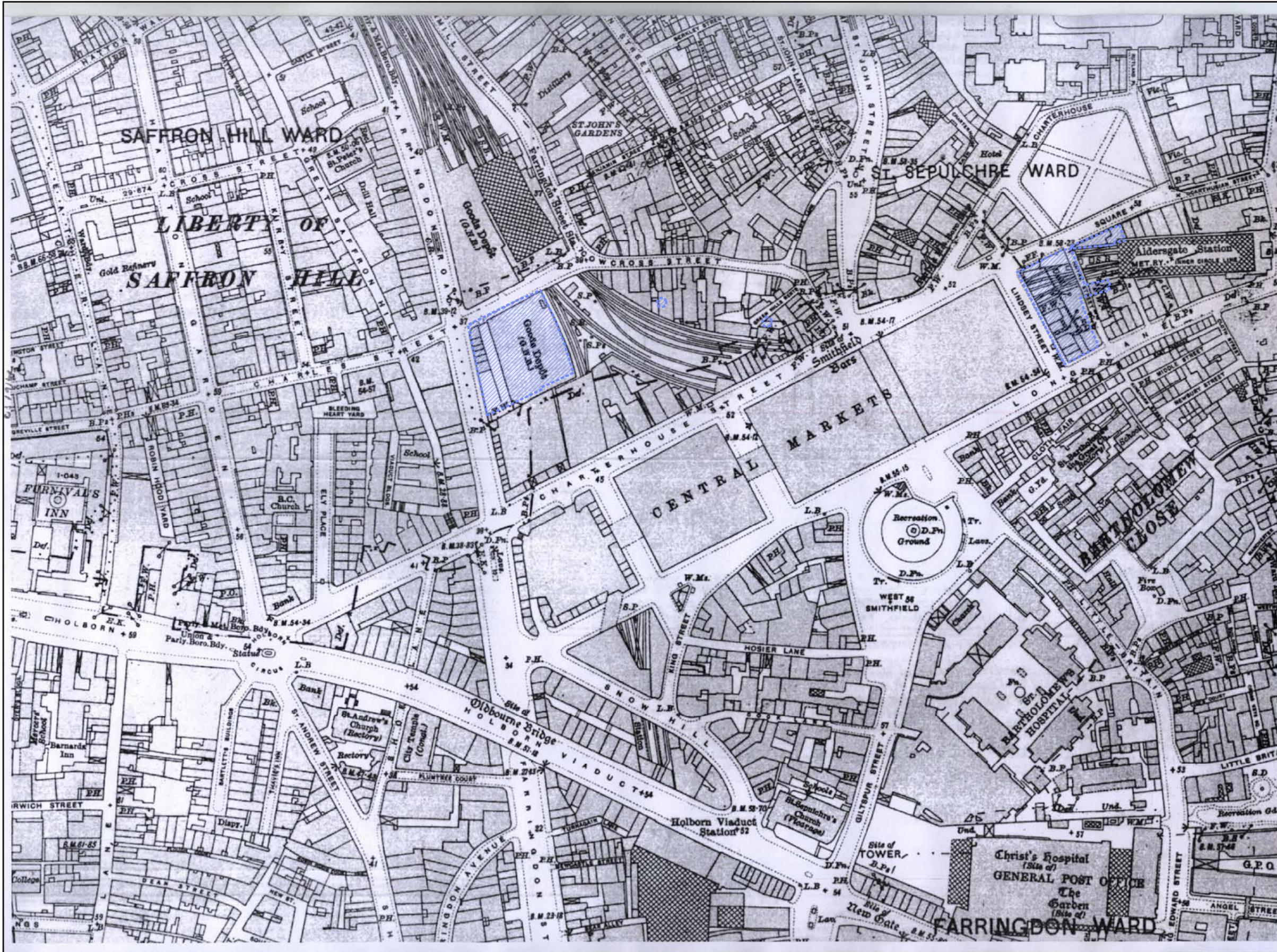
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- Crossrail Worksite
- Grout Shaft Locations to be confirmed

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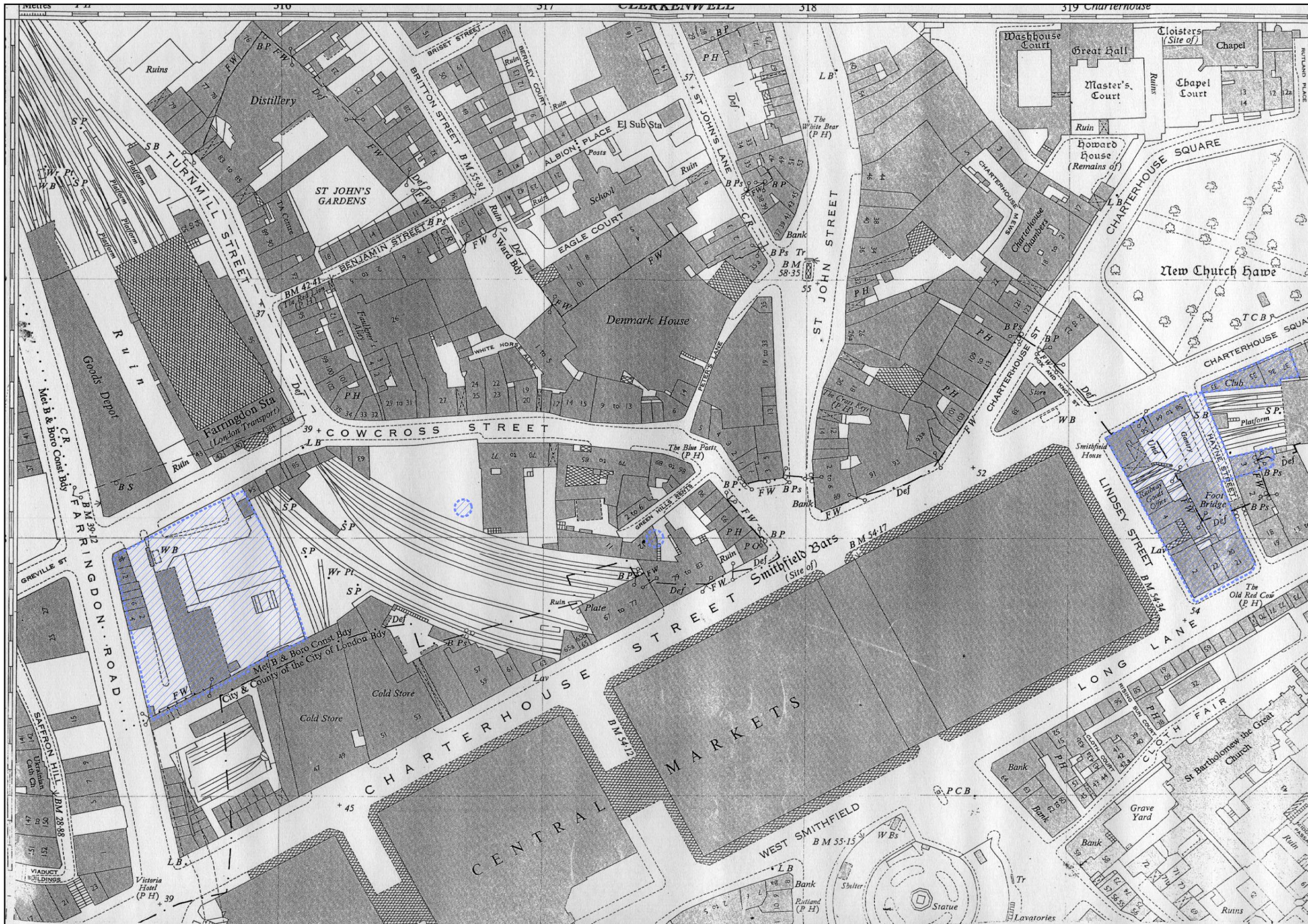
CONTRACT No. / CONSULTANT:  
 1199 / MOTT MACDONALD

TITLE:  
**FARRINGDON STATION  
 HISTORICAL MAPPING  
 ORDINANCE SURVEY 1914**

SCALE: NTS @ A1      DRAWING AND CAD FILE No: P30103-C1M10-E00-D-50112      REV: A02

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REV	DATE	DESCRIPTION	BY	CHKD	APP	CAD	ACC
A02	05/12/2008	SCHEME DESIGN 3 ISSUE	PWC	MC	DSW		

**LEGEND**

- Crossrail Worksite
- Grout Shaft Locations to be confirmed

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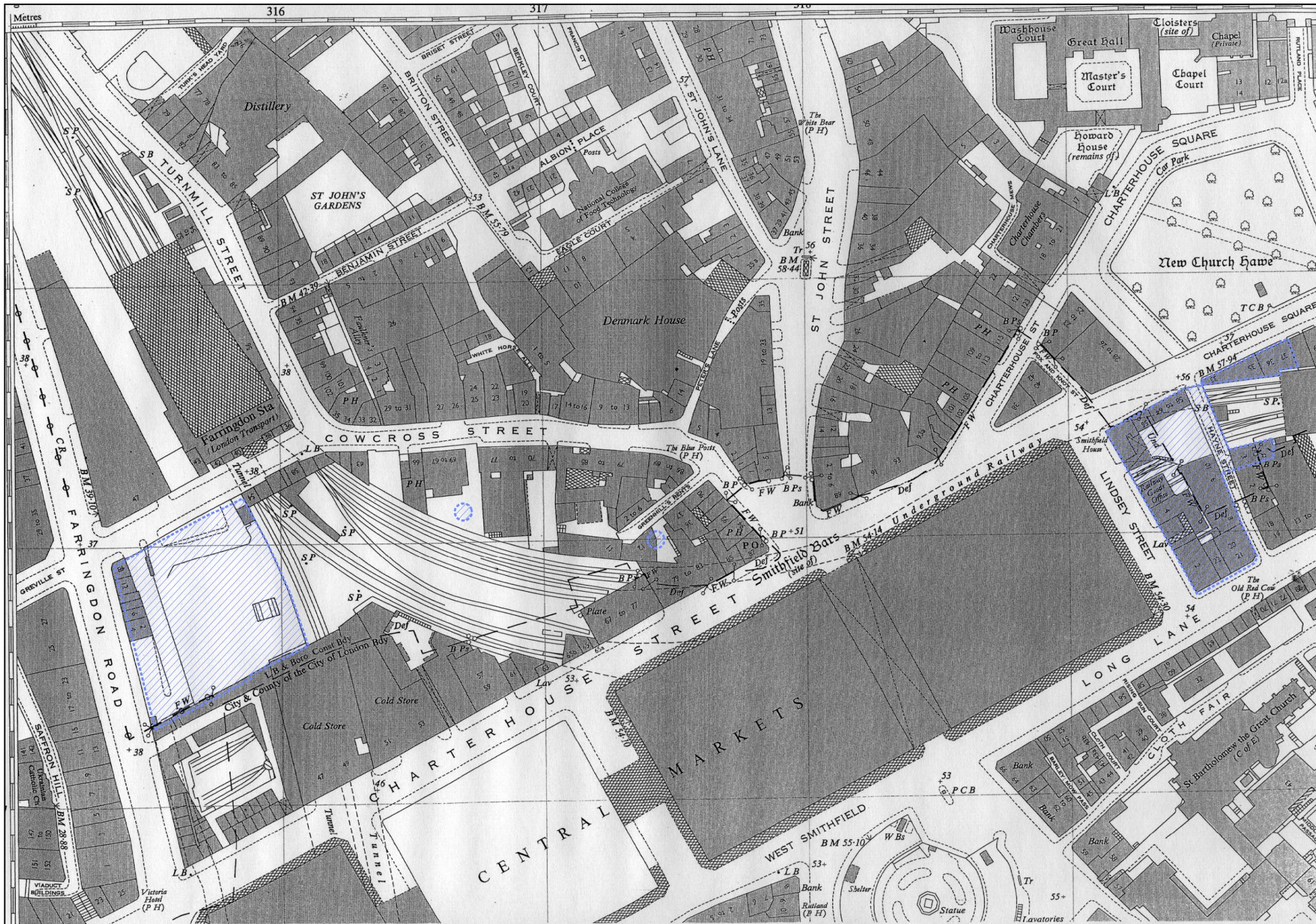
**CONTRACT No. / CONSULTANT:**  
 1199 / MOTT MACDONALD

**TITLE:**  
 FARRINGDON STATION  
 HISTORICAL MAPPING  
 ORDNAV SURVEY 1953

**SCALE:** NTS @ A1  
**DRAWING AND CAD FILE No:** P30103-C1M10-E00-D-50114  
**REV:** A02

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REV	DATE	DESCRIPTION	PWC	MC	DSW	ACC
A02	05/12/2008	SCHEME DESIGN 3 ISSUE				

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**TITLE:**  
 FARRINGDON STATION  
 HISTORICAL MAPPING  
 ORDNANCE SURVEY 1961

**SCALE:** NTS @ A1

**DRAWING AND CAD FILE No:** P30103-C1M10-E00-D-50115

**REV:** A02

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A02	05/12/2008	SCHEME DESIGN 3 ISSUE								

**LEGEND**

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- Grout Shaft Locations to be confirmed

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**TITLE:**  
FARRINGDON STATION  
HISTORICAL MAPPING  
ORDNANCE SURVEY 1970

**SCALE:** NTS @ A1

**DRAWING AND CAD FILE No.:** P30103-C1M10-E00-D-50116

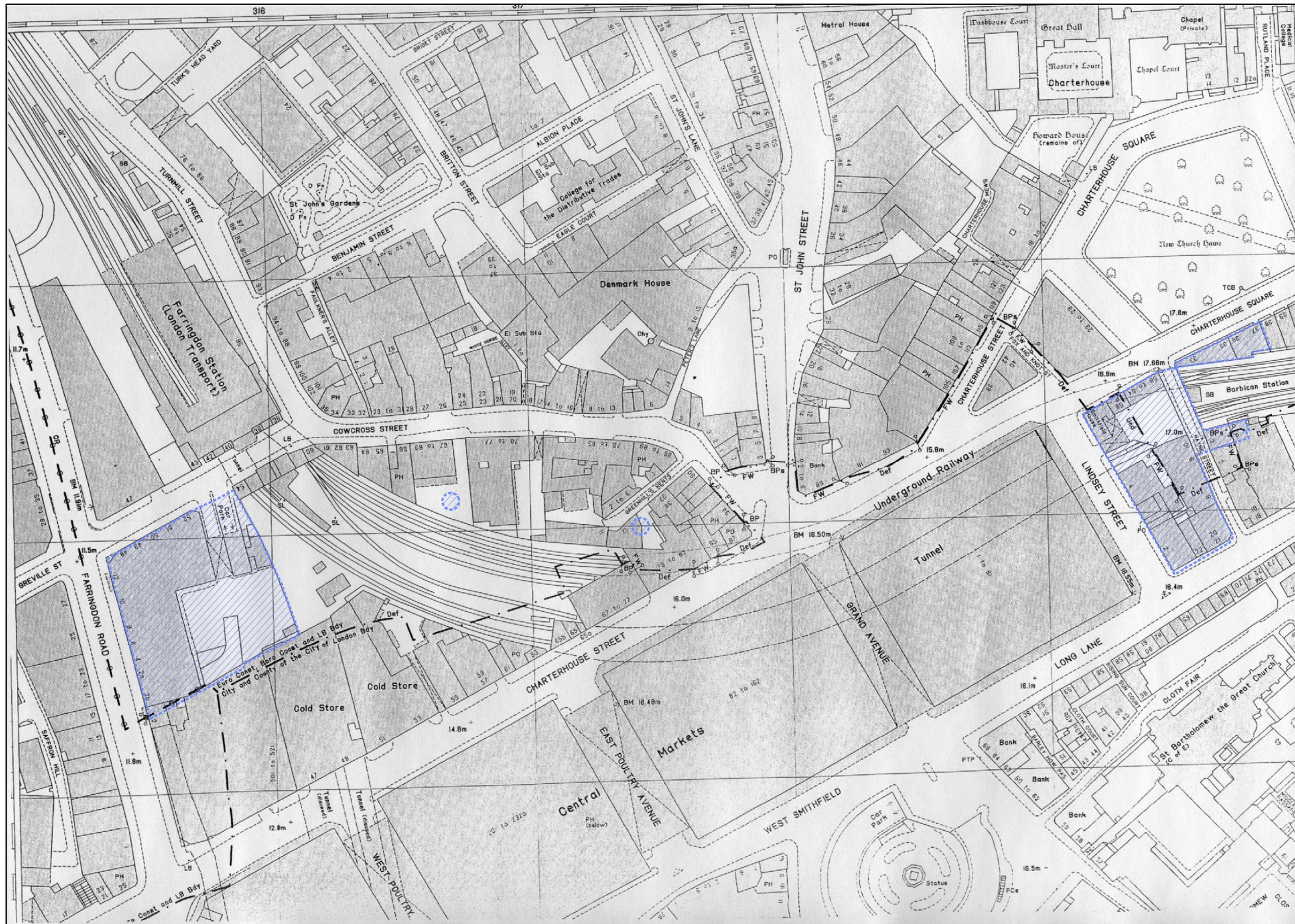
**REV:** A02

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REV	DATE	DESCRIPTION	BY	CHKD	APP	CAD	ACC
A02	05/12/2008	SCHEME DESIGN 3 ISSUE	PWC	MC	DSW		

**LEGEND**

- Crossrail Worksite
- Grout Shaft Locations to be confirmed

CONTRACT No. / CONSULTANT: 1199 / MOTT MACDONALD	
TITLE: FARRINGDON STATION HISTORICAL MAPPING ORDNANCE SURVEY 1983	
SCALE: NTS @ A1	DRAWING AND CAD FILE No: P30103-C1M10-E00-D-50117
REV: A02	

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A02	05/12/2008	SCHEME DESIGN 3 ISSUE								

**LEGEND**

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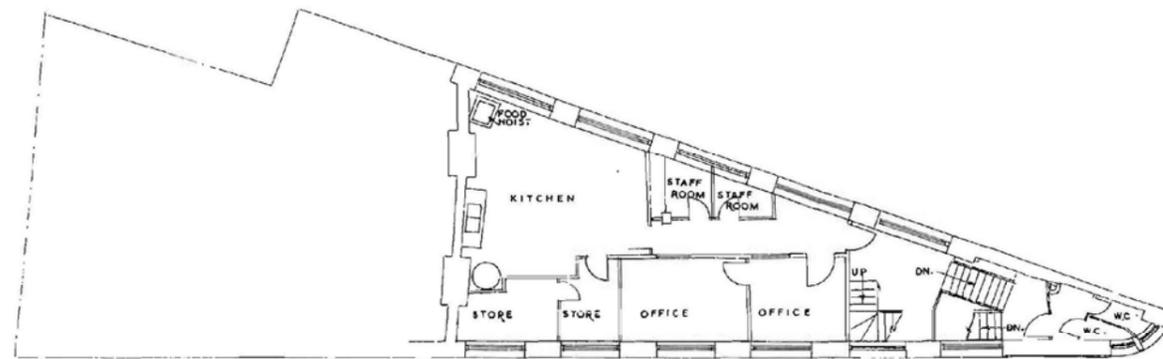
CONTRACT No. / CONSULTANT:  
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TITLE:  
**FARRINGDON STATION  
 HISTORICAL MAPPING  
 ORDNANCE SURVEY 1988**

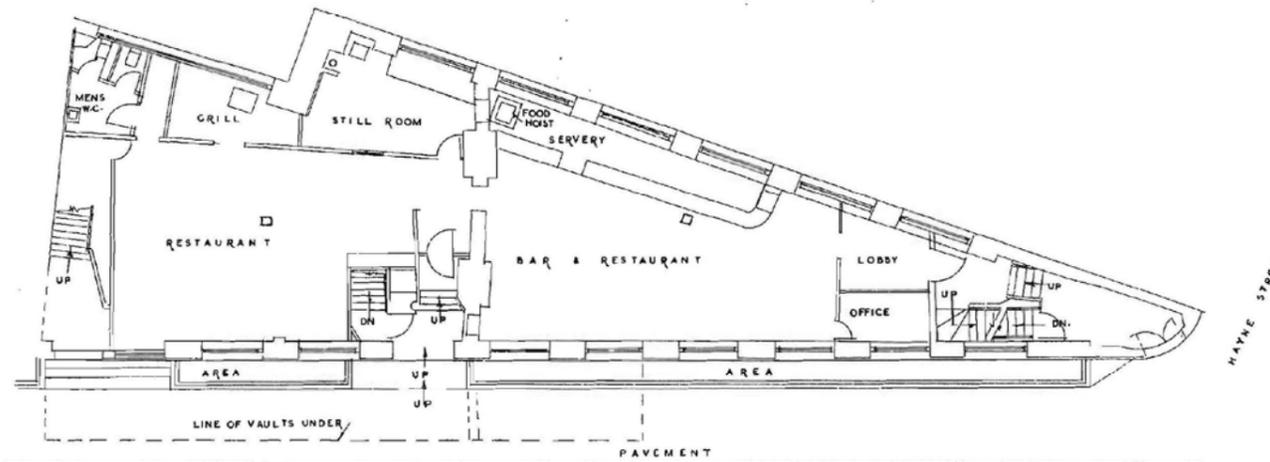
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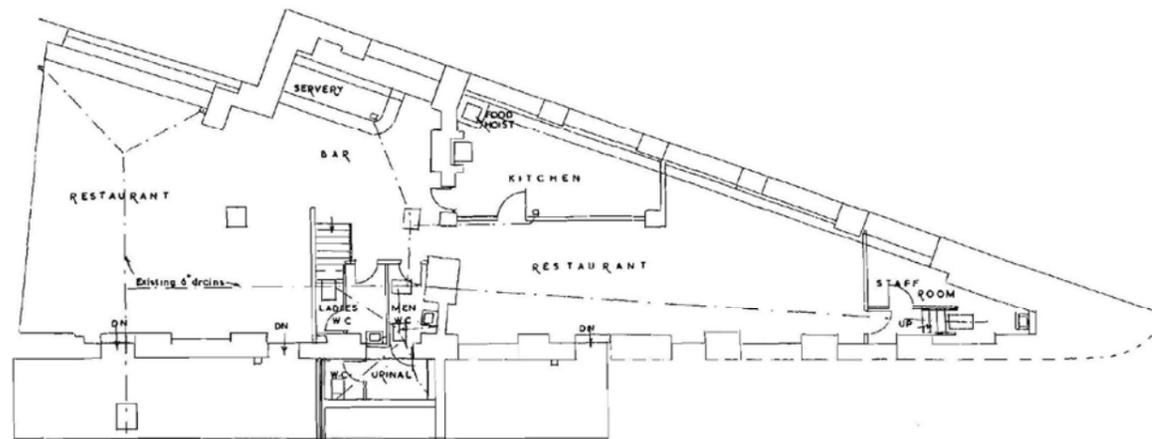




FIRST FLOOR



GROUND FLOOR



BASEMENT



**N558-6**

33-37 CHARTERHOUSE SQUARE - LONDON. E.C.1.

Scale 8 Feet to 1 Inch. N. 558/6.  
L.T.E. Estates-Baker Street N.W.1. P.188E/6.

W.Rowen - November 1975.

REV	DATE	DESCRIPTION	BY	CHKD	APP	CAD	ACC
A02	05/12/2008	SCHEME DESIGN 3 ISSUE	PWC	MC	DSW		

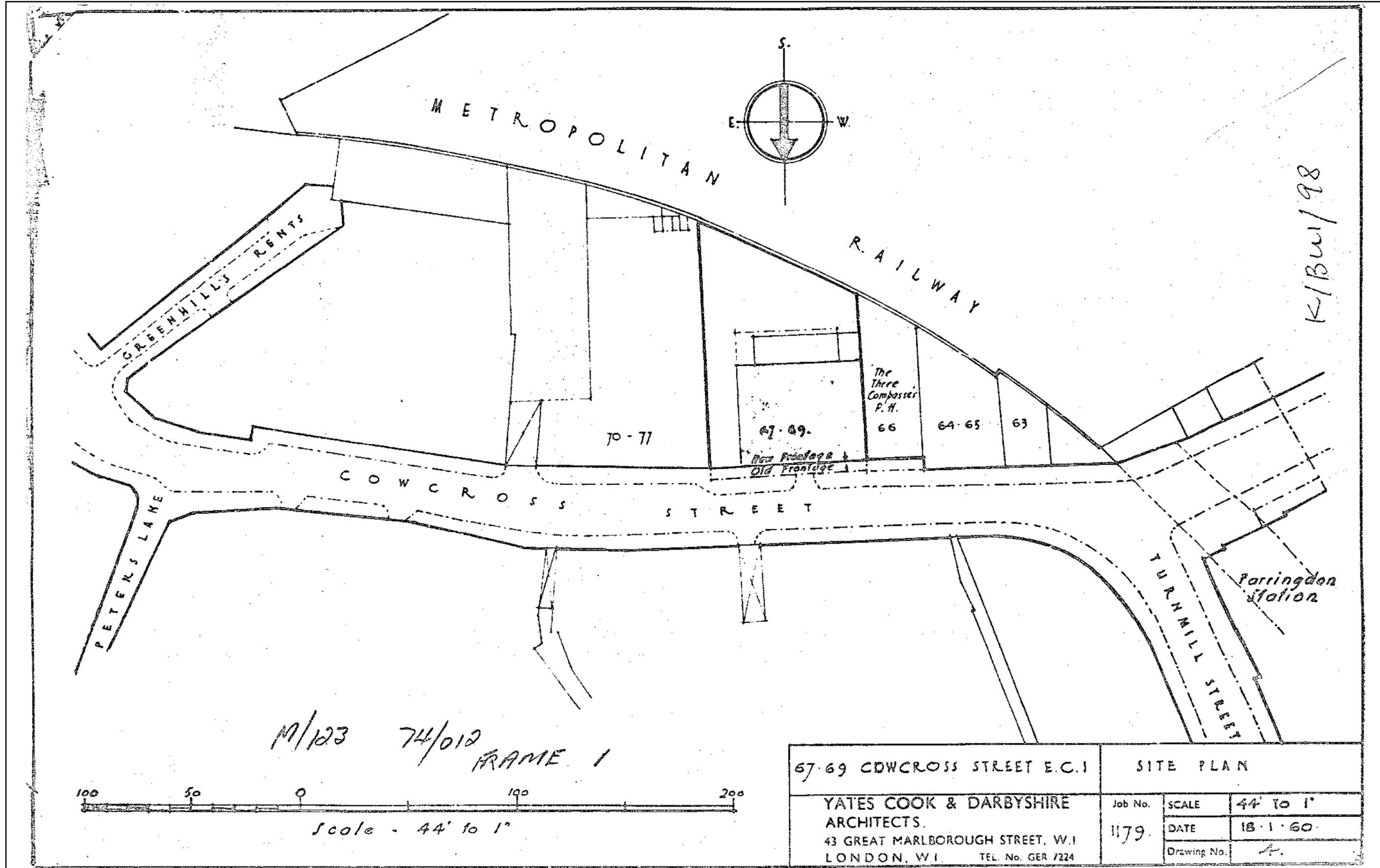
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CONTRACT No. / CONSULTANT:  
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TITLE:  
 FARRINGDON STATION  
 33 - 37 CHARTERHOUSE SQUARE  
 PLANS OF EXISTING BUILDING

SCALE: NTS @ A1  
 DRAWING AND CAD FILE No: P30103-C1M10-E00-D-50142  
 REV: A02

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67-69 COWCROSS STREET E.C.1		SITE PLAN	
YATES COOK & DARBYSHIRE ARCHITECTS. 43 GREAT MARLBOROUGH STREET, W.1 LONDON, W.1 TEL. No. GER 7224		Job No.	1179
		SCALE	44' to 1"
		DATE	18.1.60
		Drawing No.	A.

M/123 74/012 FRAME 1



Scale - 44' to 1"

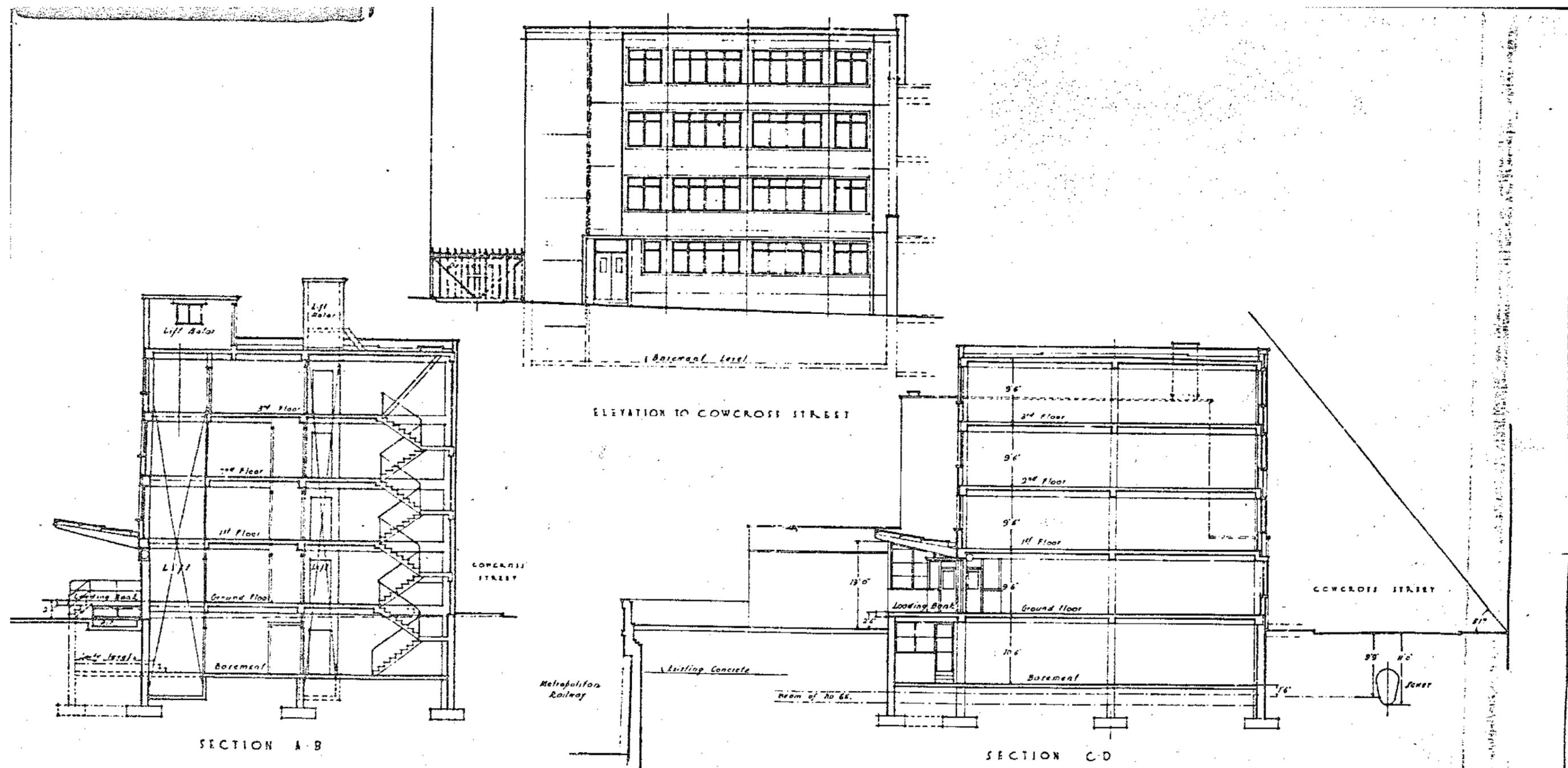
Draw 332 Z3

REV	DATE	DESCRIPTION	BY	CHKD	APP	CAD	ACC
A01	05/12/2008	SCHEME DESIGN 3 ISSUE	VRM	MC	DSW		



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CONTRACT No. / CONSULTANT:		1199 / MOTT MACDONALD	
TITLE:		FARRINGTON STATION 67-69 COWCROSS STREET 1960	
SCALE:	NTS @ A1	DRAWING AND CAD FILE No.:	P30103-C1M10-E00-D-50160
REV:			A01



K/BW/99

M/23 74/012 FRAME 2

67-69 COWCROSS STREET E.C.1.

NAME OF JOB

SKETCH PLANS

TITLE OF DRAWING *Revised P.1-69*

YATES COOK & DARBYSHIRE ARCHITECTS  
43 GREAT MARLBOROUGH STREET, LONDON, W.1. TEL No. 629 7324

SCALE 1/2" TO 1' 0"

1179 23-12-53

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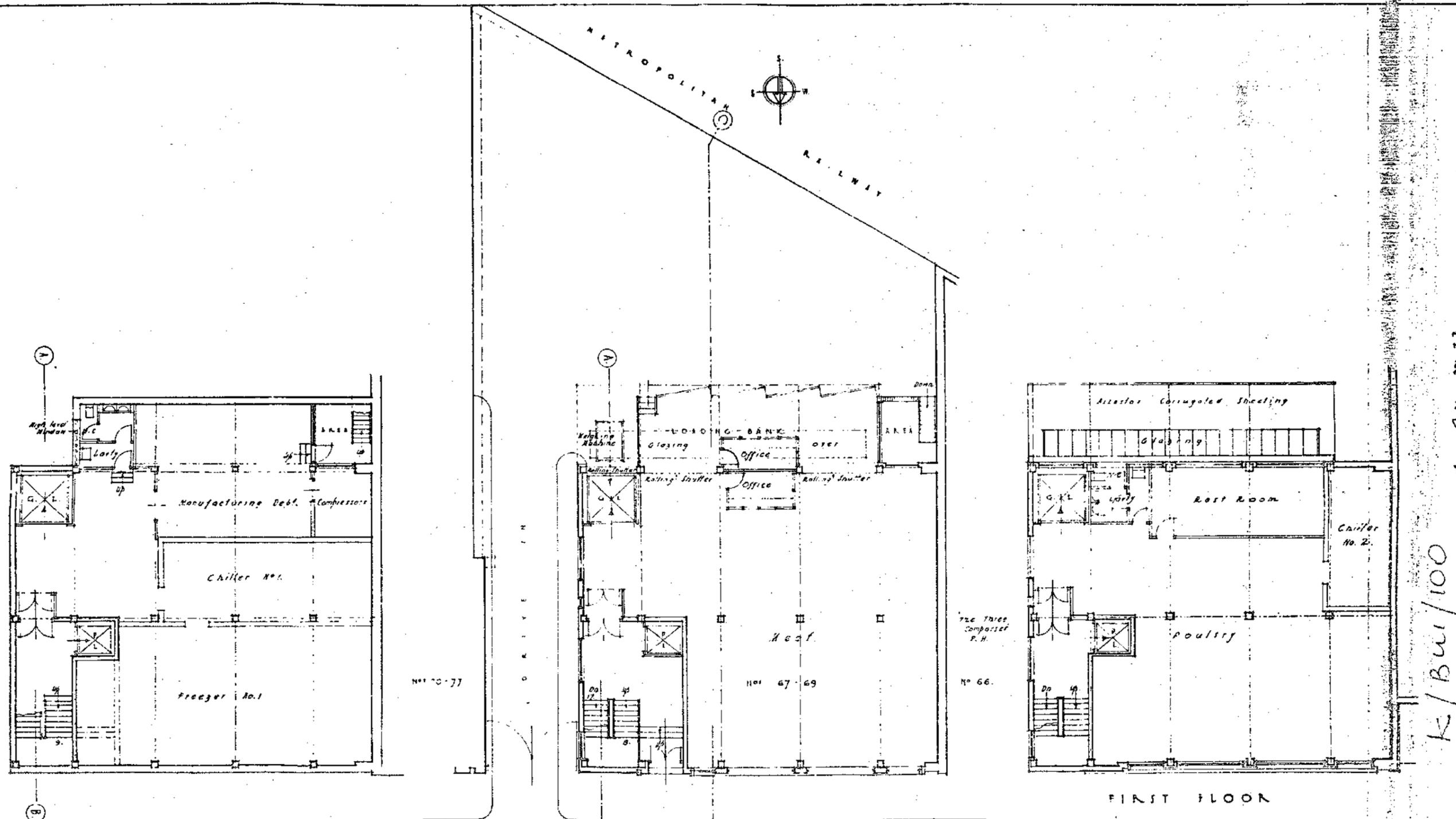
REV	DATE	DESCRIPTION	BY	CHKD	APP	CAD	ACC
A01	05/12/2008	SCHEME DESIGN 3 ISSUE					

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CONTRACT No. / CONSULTANT: 1199 / MOTT MACDONALD

TITLE: FARRINGTON STATION  
67-69 COWCROSS STREET 1960  
ELEVATIONS AND BASEMENT

SCALE: NTS @ A1 DRAWING AND CAD FILE No: P30103-C1M10-E00-D-50161 REV: A01



BASEMENT

GROUND FLOOR

FIRST FLOOR

COWCROSS STREET

M/123 74/012 FRAME 3

67-69 COWCROSS STREET E.C.1.

SKETCH PLANS

YATES COOK & DARBYSHIRE ARCHITECTS.  
43 GREAT MARLBOROUGH STREET, LONDON, W.1

SCALE	1/6" TO 1/8"
DATE	29.12.59
DRAWING No.	1.



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1. Confirmation of all survey data must be obtained from the Crossrail survey team.  
2. Coordinates to the London Survey Grid, heights to the London height datum which is 100 metres below Ordnance Datum Newlyn. See Crossrail standard CR-STD-010.

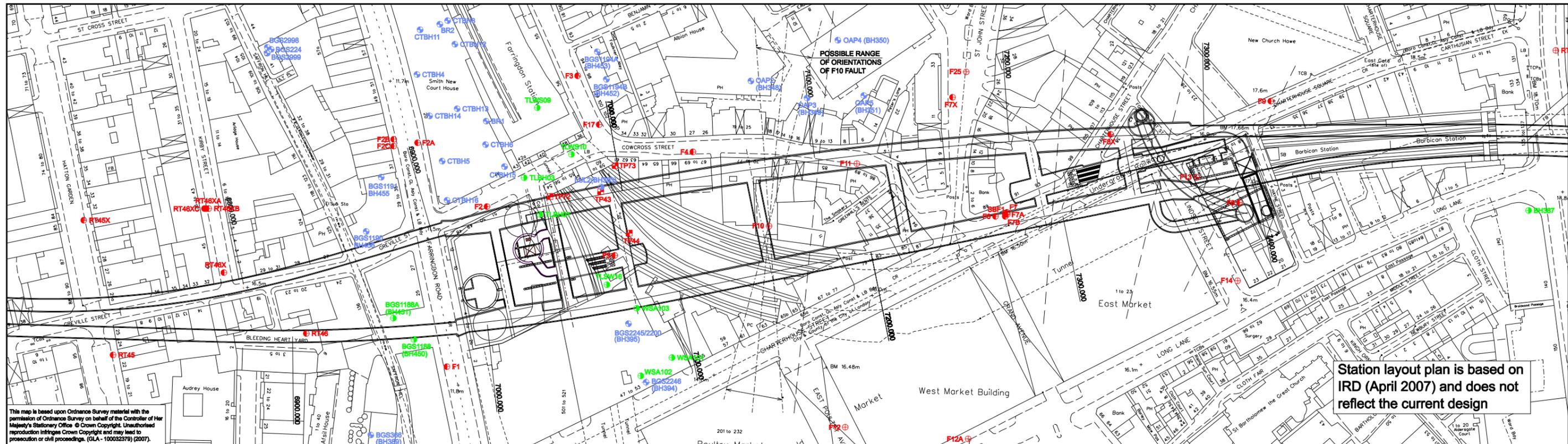
CONTRACT No. / CONSULTANT:  
1199 / MOTT MACDONALD  
TITLE:  
FARRINGTON STATION  
67-69 COWCROSS STREET 1959  
BASEMENT PLAN  
SCALE: NTS @ A1  
DRAWING AND CAD FILE No.: P30103-C1M10-E00-D-50162  
REV: A01

REV	DATE	DESCRIPTION	BY	CHKD	APP	CAD	ACC
A01	05/12/2008	SCHEME DESIGN 3 ISSUE	VRM	MC	DSW		

Iron Jaws 332 Z3

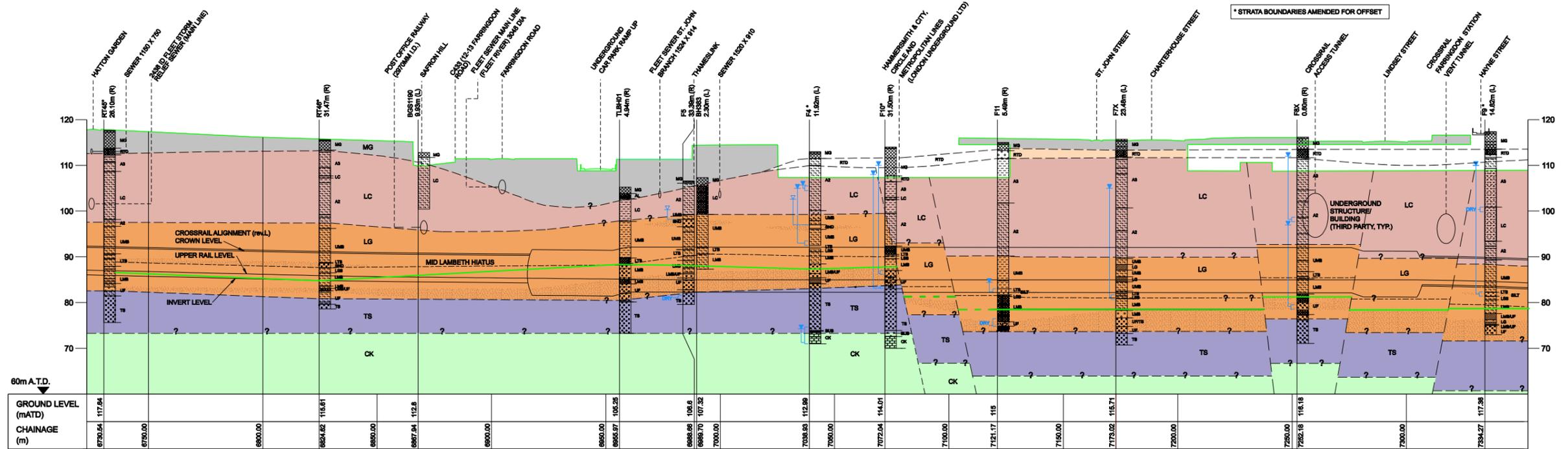
K/Bui/100

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Station layout plan is based on IRD (April 2007) and does not reflect the current design



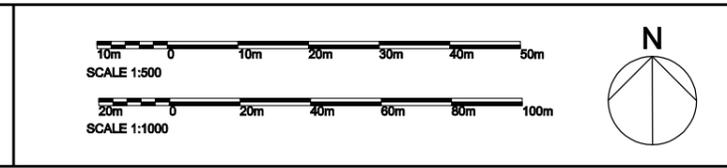
LONGITUDINAL SECTION (EASTBOUND)  
SCALE H=1:1000, V=1:500

- KEY**
- CROSSRAIL BOREHOLES PACKAGE C (FES) (1992)
  - ⊕ CROSSRAIL ADDITIONAL BOREHOLES (SM) (1994-1996)
  - ⊕ CROSSRAIL TRIALPITS
  - THIRD PARTY BOREHOLES (USED FOR 2002 REVIEW)
  - THIRD PARTY BOREHOLES OBTAINED IN 2006
  - 18.32m (L) OFFSET FROM CENTRE LINE (LEFT OR RIGHT)
  - - - INTERPRETED GEOLOGICAL BOUNDARY
  - EXISTING GROUND LEVEL
  - COHESIONLESS LAYERS POTENTIALLY WATER BEARING (PRINCIPLE PARTICLE SIZE SILT, SAND OR GRAVEL) WITHIN LC AND LG
  - RECORDED WATER LEVEL DURING WATER STRIKE
  - WATER STRIKE LEVEL
  - MAXIMUM RECORDED GROUNDWATER LEVEL (PIEZOMETER)
  - PIEZOMETER TIP LEVEL AND SAND FILTER ZONE
  - ? INDICATES UNCERTAINTY IN STRATUM BOUNDARY LEVEL AND/OR EXTENT
  - BASE OF LOWEST IDENTIFIED AQUITARD IN LG (interpolated)
  - BASE OF LOWEST IDENTIFIED AQUITARD IN LG (extrapolated)
  - POSSIBLE MINOR FAULTS
  - F10 FAULT

- NOTES**
- The scheme plan and vertical alignment is revision 'L' alignment. The survey grid detailed on the plan layout is in Ordnance Survey grid.
  - This drawing presents the existing geotechnical information provided by GCG and third party information gained from other sources. Where required Mott MacDonald have re-interpreted the existing data for the purposes of the ground model construction.
  - The geotechnical long sections have been interpreted principally from the boreholes closest to the section line. However, the overall geological structure has been interpreted from all the data available. Where exploratory holes are offset from the section line, strata boundaries shown on the long section may not coincide with the strata boundaries within individual exploratory holes.
  - For detailed information regarding material type, reference should be made to the factual exploratory hole records.
  - The generalised dip (within approx 250m of the alignment) of the deposits is assumed to be three degrees towards the south for the purpose of identification of potential anomalies as determined from contours of the top of Lambeth Group.
  - The quality of the logging of the CTBH boreholes is poor, the ground levels for these boreholes are also assumed. Therefore, low reliance has been put on these boreholes.
  - Chainages shown on plan and sections are indicative only, and subject to change. Both sections chainages increase running West to East.
  - Most reliance has been placed on the Arup Farringdon ground investigation boreholes (F prefix). Third party boreholes have been used generally where they are within close proximity of the alignment only, although the reliability of the boreholes is less than the Arup Farringdon boreholes, and alternative interpreting may be possible. Shallow boreholes have generally not been included unless they have informed the interpretation of the geological structure.
  - A detailed review of the piezometric profile within the Farringdon station area has been carried out. Within the Farringdon area the groundwater monitoring data is limited to 1992-3 readings.
  - The alignment of the possible minor faults is indicative only. Insufficient data is available to determine precise alignments, although a north south trend is anticipated.
  - Drawings based on available information up to April 2007.

REV	DATE	DESCRIPTION	BY	CHKD	APP	CAD	ACC
A01	17/12/2007	FIRST ISSUE - INTERMEDIATE REFERENCE DESIGN	DJC	BUL	DSW		

Stratigraphic Units		A2, A3, B		LMB	
MG	Made Ground	LC	London Clay Formation	LMB	Lower Mottled Beds
AL	Alluvium	LS	Unclassified London Clay	LG	Unclassified
LS	Langley Silt	HF	Harwich Formation	UF	Lambeth Group
RTD	River Terrace Deposits	USB	Upper Shelly Beds	TS	Upnor Formation
WR	Weathered London Clay	UMB	Upper Mottled Beds	UBB	Thames Sand Formation
		LTB	Laminated Beds	BUB	Bullhead Beds
		LSB	Lower Shelly Beds	CK	Chalk



**DRAFT**

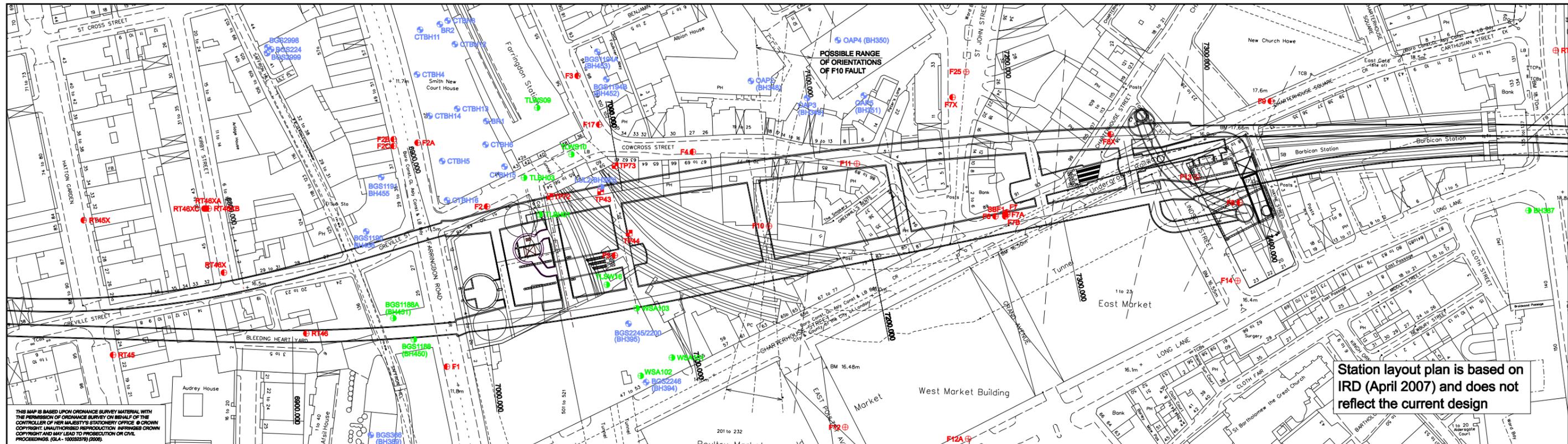
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CONTRACT No. / CONSULTANT:  
1199 / MOTT MACDONALD

TITLE:  
**FARRINGDON STATION  
GEOLOGICAL SECTION  
EASTBOUND TUNNEL**

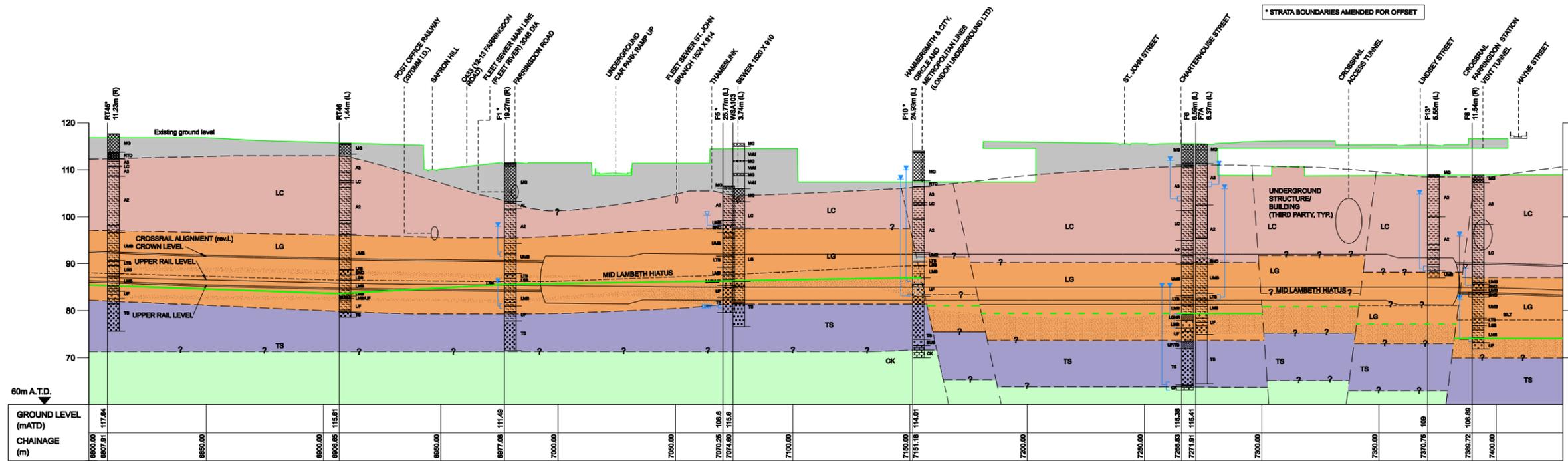
SCALE: 1:1000 @ A1  
DRAWING AND CAD FILE No: P30101-C1M10-G00-D50101  
REV: A01

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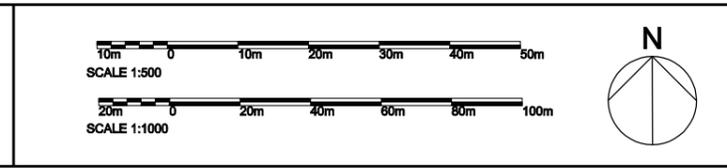
LONGITUDINAL SECTION (WESTBOUND)  
SCALE H=1:1000, V=1:500

- KEY**
- CROSSRAIL BOREHOLES PACKAGE C (FES) (1992)
  - ⊕ CROSSRAIL ADDITIONAL BOREHOLES (SM) (1994-1996)
  - ⊕ CROSSRAIL TRIAL PITS
  - ⊕ THIRD PARTY BOREHOLES (USED FOR 2002 REVIEW)
  - ⊕ THIRD PARTY BOREHOLES OBTAINED IN 2006
  - 18.32m (L) OFFSET FROM CENTRE LINE (LEFT OR RIGHT)
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  - EXISTING GROUND LEVEL
  - COHESIONLESS LAYERS POTENTIALLY WATER BEARING (PRINCIPLE PARTICLE SIZE SILT, SAND OR GRAVEL) WITHIN LC AND LG
  - RECORDED WATER LEVEL DURING WATER STRIKE
  - WATER STRIKE LEVEL
  - MAXIMUM RECORDED GROUNDWATER LEVEL (PIEZOMETER)
  - PIEZOMETER TIP LEVEL AND SAND FILTER ZONE
  - ? INDICATES UNCERTAINTY IN STRATUM BOUNDARY LEVEL AND/OR EXTENT
  - BASE OF LOWEST IDENTIFIED AQUITARD IN LG (interpolated)
  - BASE OF LOWEST IDENTIFIED AQUITARD IN LG (extrapolated)
  - POSSIBLE MINOR FAULTS
  - F10 FAULT

- NOTES**
- The scheme plan and vertical alignment is revision 'L' alignment. The survey grid detailed on the plan layout is in Ordnance Survey grid.
  - This drawing presents the existing geotechnical information provided by GCG and third party information gained from other sources. Where required Mott MacDonald have re-interpreted the existing data for the purposes of the ground model construction.
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  - The generalised dip (within approx 250m of the alignment) of the deposits is assumed to be three degrees towards the south for the purpose of identification of potential anomalies as determined from contours of the top of Lambeth Group.
  - The quality of the logging of the CTBH boreholes is poor, the ground levels for these boreholes are also assumed. Therefore, low reliance has been put on these boreholes.
  - Chainages shown on plan and sections are indicative only, and subject to change. Both sections chainages increase running West to East.
  - Most reliance has been placed on the Arup Farringdon ground investigation boreholes (F prefix). Third party boreholes have been used generally where they are within close proximity of the alignment only, although the reliability of the boreholes is less than the Arup Farringdon boreholes, and alternative interpreting may be possible. Shallow boreholes have generally not been included unless they have informed the interpretation of the geological structure.
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  - The alignment of the possible minor faults is indicative only. Insufficient data is available to determine precise alignments, although a north south trend is anticipated.
  - Drawings based on available information up to April 2007.

REV	DATE	DESCRIPTION	BY	CHKD	APP	CAD	ACC
A01	17/11/2007	FIRST ISSUE - INTERMEDIATE REFERENCE DESIGN	DJC	BUL	DSW		

Stratigraphic Units		A2, A3, B		LMB	
MG	Made Ground	LC	London Clay Formation	LMB	Lower Mottled Beds
AL	Alluvium	LG	Unclassified London Clay	LG	Unclassified
LS	Langley Silt	HF	Harwich Formation	UF	Upper Formation
RTD	River Terrace Deposits	USB	Upper Shelly Beds	TS	Thanet Sand Formation
WR	Weathered London Clay	UMB	Upper Mottled Beds	BUB	Bullhead Beds
		LTB	Laminated Beds	CK	Chalk
		LSB	Lower Shelly Beds		



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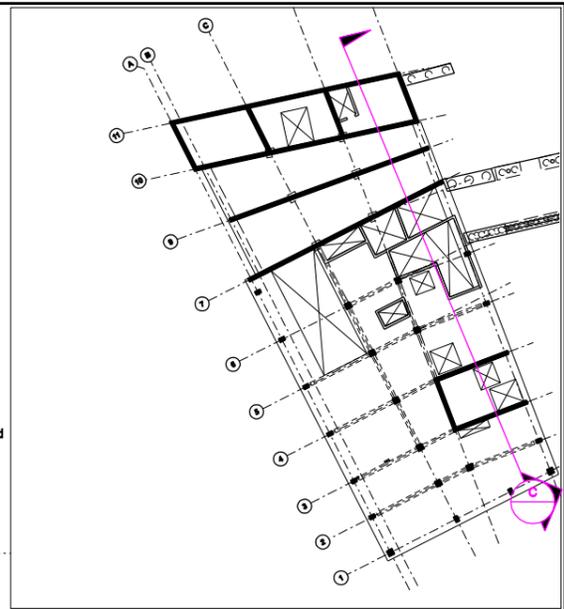
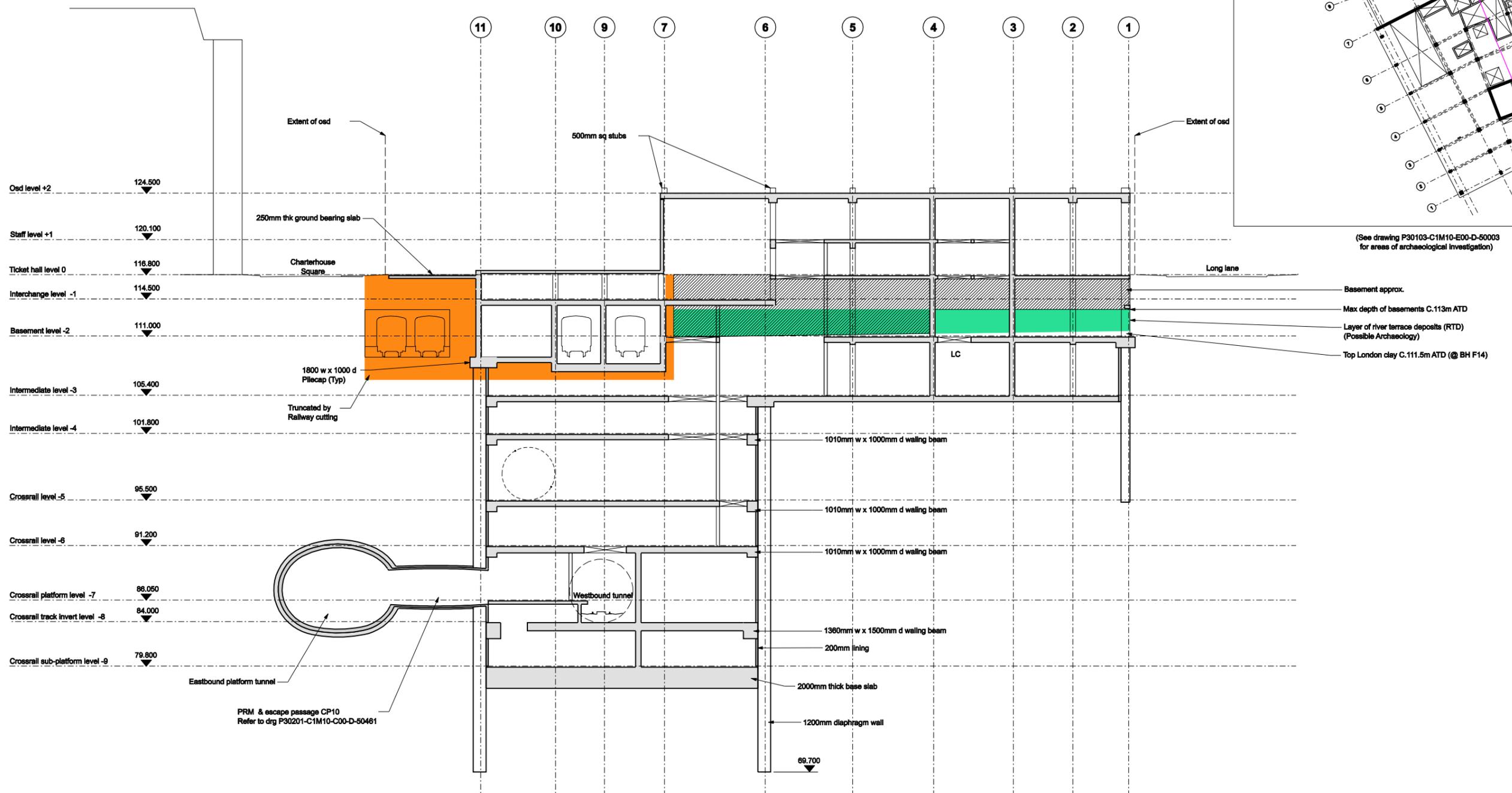
CONTRACT No. / CONSULTANT:  
1199 / MOTT MACDONALD

TITLE:  
**FARRINGDON STATION  
GEOLOGICAL SECTION  
WESTBOUND TUNNEL**

SCALE: 1:1000 @ A1  
DRAWING AND CAD FILE No: P30101-C1M10-G00-D-50102  
REV: A01

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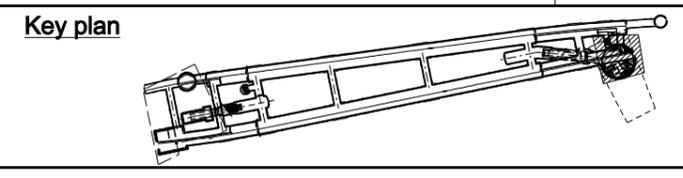
## 9.2 Site Deposit Model



(See drawing P30103-C1M10-E00-D-50003 for areas of archaeological investigation)

- Notes**
- The Scheme design drawing shall not be used for construction.
  - For standard notes, refer to drg P30201-C1M10-C00-D-50100.
  - Construction tolerances as specified in C.E.D.M. Rev 3.0, not shown for clarity.
  - For grid setting out see drg no. P30201-C1M10-C00-D-00311.
  - All external columns to be 800 x 800 R.C. unless noted otherwise.
  - All internal columns to be 800 x 800 R.C. unless noted otherwise.
  - All walls to be 500 R.C. unless noted otherwise.
  - All wall around lifts to be 300 thk R.C.

REV	DATE	DESCRIPTION	BY	CHKD	APP	CAD	ACC
A01	05/12/2008	SCHEME DESIGN 3 ISSUE					



**Legend**

- Truncated by railway cutting (assumes 1m of truncation by track side retaining wall)
- Layer of river terrace deposits thought to survive beneath basements
- Behind retaining wall level of truncation + level of london clay unknown
- Basements

Scale 1:200

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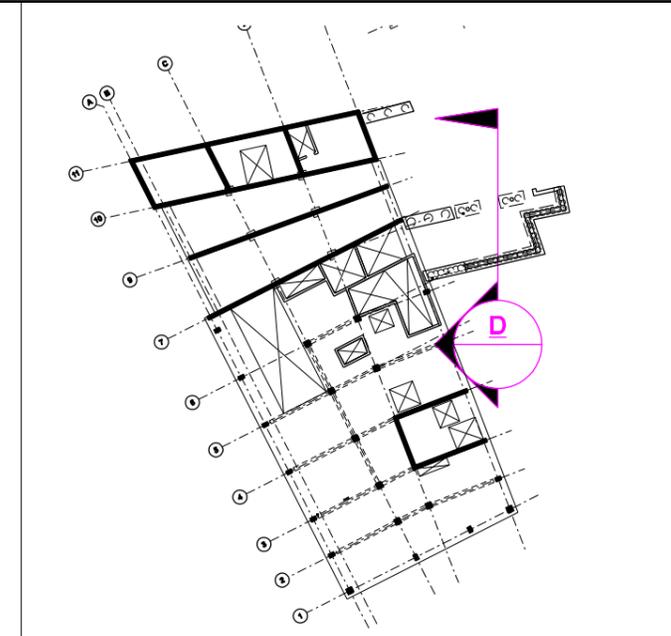
CONTRACT No. / CONSULTANT:  
 1199 / MOTT MACDONALD

TITLE:  
**FARRINGTON STATION EAST TICKET HALL  
 POTENTIAL SURVIVAL OF ARCHAEOLOGICAL  
 DEPOSITS THROUGH SECTION C - C**

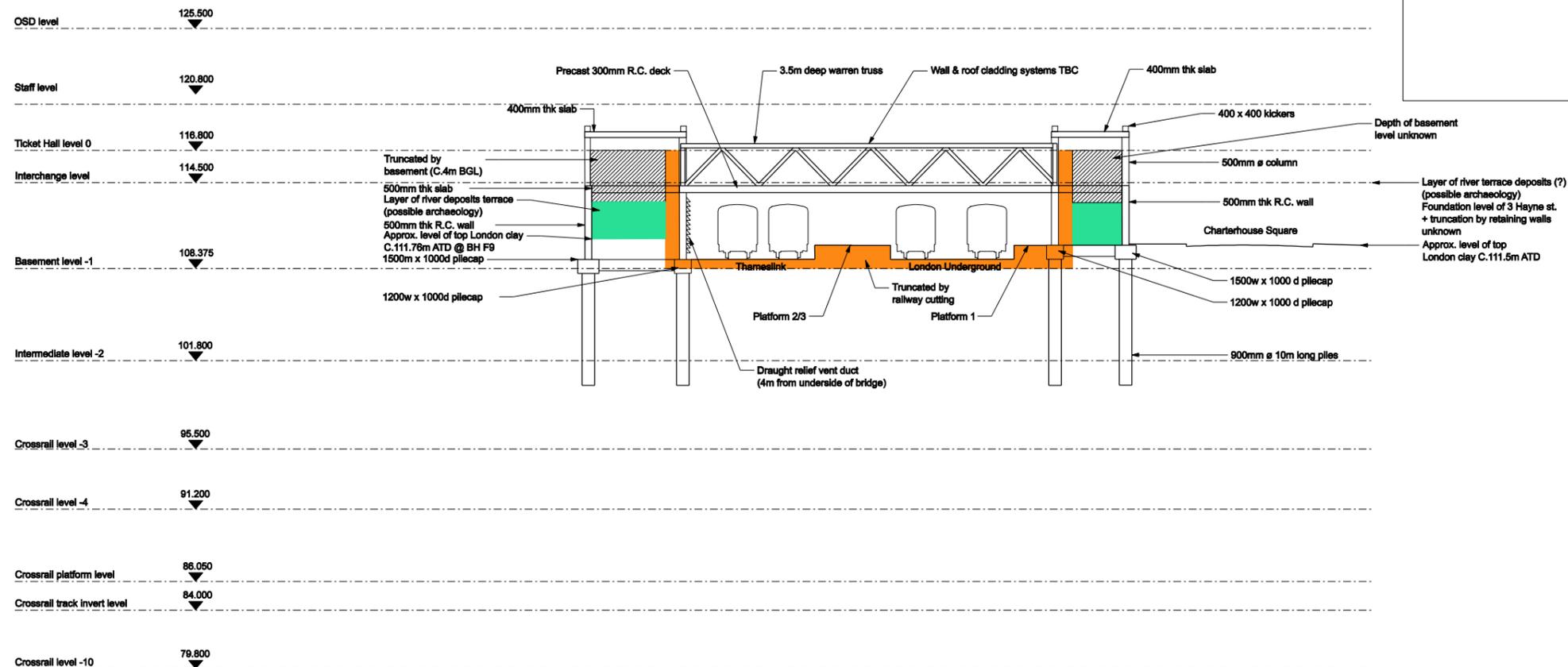
SCALE: 1:200 @ A1 DRAWING AND CAD FILE No: P30103-C1M10-E00-D-50150 REV: A01

1. Confirmation of all survey data must be obtained from the Crossrail survey team.  
 2. Coordinates to the London Survey Grid, heights to the London height datum which is 100 metres below Ordnance Datum Newlyn. See Crossrail standard CR-STD-010.

RESTRICTED



(See drawing P30103-C1M10-E00-D-50003 for areas of archaeological investigation)

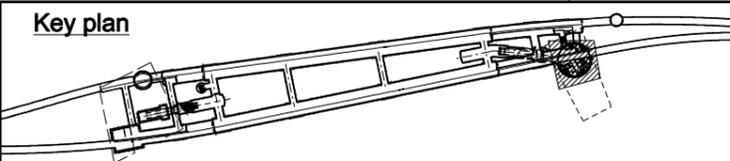


**Section D-D**  
(See drgs 50305, 50307 & 50308)

**Notes**

1. The Scheme design drawing shall not be used for construction.
2. For standard notes, refer to drg P30201-C1M10-C00-D-50100.
3. Construction tolerances as specified in C.E.D.M. Rev 3.0, not shown for clarity.
4. For grid setting out see drg no. P30201-C1M10-C00-D-00311.
5. All external columns to be 800 x 800 R.C. unless noted otherwise.
6. All internal columns to be 800 x 800 R.C. unless noted otherwise.
7. All walls to be 500 R.C. unless noted otherwise.
8. All wall around lifts to be 300 thk R.C.

**Key plan**



**Legend**

- Truncated by railway cutting (assumes 1m of truncation by track side retaining wall)
- Layer of river terrace deposits thought to survive beneath basements
- Behind retaining wall level of truncation + level of london clay unknown
- Basements

Scale 1:200



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TITLE:  
**FARRINGTON STATION EAST TICKET HALL  
POTENTIAL SURVIVAL OF ARCHAEOLOGICAL  
DEPOSITS THROUGH SECTION D - D**

SCALE: 1:200 @ A1 DRAWING AND CAD FILE No: P30201-C1M10-E00-D-50151 REV: A01

REV	DATE	DESCRIPTION	DC	MC	DSW	ACC
A01	05/12/2008	SCHEME DESIGN 3 ISSUE				

### **9.3 Previous Archaeological Interventions in the Area**

The list below comprises a gazetteer of archaeological excavations and observations within the vicinity of the site.

#### **FNG02**

##### **Farringdon Station: Thameslink 2000**

**Relevant sub-sites: 67-69 Cowcross Street shaft**

**Archaeological periods: 19<sup>th</sup> Century**

NGR 531854 181846

Watching brief carried out by MoLAS in 2002.

London Clay between c 5.4m OD and c 3.8m OD. Truncated natural gravel recorded at c 5.5m OD. Localised alluvial deposits c 0.5m depth, within the cutting.

#### **CAA00**

##### **18-21A Charterhouse Square**

**Relevant sub-sites: Eastern Ticket Hall and Hayne Street shaft**

**Archaeological periods: Undefined**

NGR 531890 181910

Evaluation carried out by MoLAS in 2000.

In the basement of 17 to 21 Charterhouse Square c 100m to the north the Lindsey Street.. The natural gravel was found to have been truncated by construction of the basements of the standing building. Natural terrace gravels encountered at c 13.2 to 13.8m OD, archaeological deposits to c 0.5 to 0.75m deep and modern deposits to c 13.7 to 14.5m OD.

#### **XRC02**

##### **Crossrail Project (Package C), Farringdon Station**

**Relevant sub-sites: 67-69 Cowcross Street shaft and Greenhill's Rents shaft**

**Archaeological periods: Undefined**

NGR 531620 181800

Evaluation carried out by MoLAS in 1992.

Level within railway cutting c 7.3 to 7.4m OD. Alluvial material laid down by the River Fleet was recorded at 4.3 to 6.6m OD, deriving from a cut feature or possible stream channel.

#### **CSQ98**

##### **Charterhouse Square, EC1**

**Relevant sub-sites: Eastern Ticket Hall and Hayne Street shaft**

**Archaeological periods: Medieval**

NGR 531950 181940

Evaluation carried out by MoLAS in 1998.

## Archaeology Detailed Desk Based Assessment – Farringdon Station

The location of a chapel (b 1481) of the Carthusian monastery, the Charterhouse (f 1371), was indicated by a geophysical survey and tested during this evaluation. No evidence of the chapel was located but a single burial of a child, probably dating to the period of the Black Death cemetery (1348-9), was found (LAARC).

Archaeological deposits encountered at c 16.6m to 17.7m.

**CLO83****24-37 Cloth Fair, 62-67 Long Lane, EC1**

**Relevant sub-sites: Eastern Ticket Hall and Hayne Street shaft**

**Archaeological periods: Roman, Medieval and Post-medieval**

NGR 531950 181750

Watching Brief carried out by DUA in 1983 immediately north of St Bartholomew the Great church and within the precinct of the 12<sup>th</sup> century priory. The earliest recorded features were a ditch system perhaps of the Roman period, which fell into disuse. This was overlaid by a large number of east-west aligned adult male burials of Medieval date confirming that this was part of the site of the monastic cemetery. From the 14th century a succession of extensive but well-maintained gravelled yard surfaces covered the site, sealing the burials. A group of 15 very worn Penn floor tiles, dating to 1330-1400, were incorporated in the early part of the yard sequence. The surfaces correspond with the suggested site of the Medieval Bartholomew Fair. The first structural evidence observed was a row of houses built in the late 16th century. The cellars of several of these houses were constructed of Reigate stone and brick with timbered floors; they cut through the latest gravelled surfaces, and fronted onto a metalled road (the origin of Cloth Fair) which was laid out across the south part of the site adjacent to the ex-priory church. This development was part of a larger scheme involving all the land to the north and east of the church. It remained partially intact into the 20th century (LAARC).

**CIN91****2-5 Carthusian Street, EC1**

**Relevant sub-sites: Eastern Ticket Hall and Hayne Street shaft**

**Archaeological periods: Medieval, Post-medieval and 18th century**

NGR 532050 181920

Excavation carried out by DGLAS (N) in July 1991.

A large medieval quarry pit, probably contemporary with the Carthusian Monastery, was excavated. Post-medieval features were found including cess pits and brick walls from the 17th century and two brick cess pits from the 18th century (LAARC).

**LOG82****84-85 Long Lane, EC1**

**Relevant sub-sites: Eastern Ticket Hall and Hayne Street shaft**

**Archaeological periods: Medieval and Post-medieval**

NGR 532030 181800

## Archaeology Detailed Desk Based Assessment – Farringdon Station

Watching Brief carried out by DUA in 1982 toward the northeast corner of the precinct of St Bartholomew's Priory. Victorian basements had truncated the site but two rectilinear stone structures survived, cutting into the natural gravels. At least one was a cesspit, both of chalk and ragstone and aligned with Long Lane. Evidence from sections around the edge of the site revealed, on the north side, 2.5m of successive road-metallings and tread of Medieval and Post-medieval Long Lane, and on the south side horizontal deposits of garden soil disturbed only by north-south foundations of a 16th or 17th century brick wall under East Passage. Two north-south aligned adult skeletons were noted by contractors at a depth of 8ft (2.4m). In sections around the perimeter of the site the gravel street surfaces of Long Lane were recorded. The stone lining of a late Medieval or Post-medieval pit, probably a cesspit, was also recorded (LAARC).

**EGC04****8, 10–11a Eagle Court, EC1**

**Relevant sub-sites: 67-69 Cowcross Street grout shaft and Greenhill's Rents grout shaft**

**Archaeological periods: Post-medieval**

NGR 531720 181900

Watching Brief in which the surface of archaeological deposits were recorded at c 16.0m OD. The site was located within the outer precinct of the Medieval priory of St John of Jerusalem adjacent to known sites of Medieval activity. The watching brief recorded between 1 to 2m of modern and 19th century made ground and demolition debris overlying earlier post-medieval garden type soils. A thin possibly late medieval soil horizon was identified beneath 1m of the garden soil deposit. There was no evidence of medieval structures. Natural sandy gravels were present at between 15m to 14.5m OD.

**CFI06****39–40 Cloth Fair**

**Relevant sub-sites: Eastern Ticket Hall and 3 Hayne Street**

**Archaeological periods: Post-medieval**

NGR 531924 181723

A watching brief carried out by MoLAS in 2006 at 39/40 Cloth Fair, EC1, showed that the existing basement had removed the majority of archaeological deposits, but two parallel north-south aligned walls of late 19th-early 20th century date were recorded. Natural gravel was observed at 13.50m OD in the north of the site, sloping to 13.30m OD in the south (Crossrail 2007b).

**CQC07****Carthusian Street and Charterhouse Square junction**

**Relevant sub-sites: Eastern Ticket Hall and 3 Hayne Street**

**Archaeological periods: Post-medieval**

NGR 532021 181896

A watching brief carried out by MoLAS on the junction of Carthusian Street and Charterhouse Square, EC1, showed brick walls and a floor surface believed to be part of an 18th-century

## Archaeology Detailed Desk Based Assessment – Farringdon Station

building, as well as a sequence of horizontal deposits. Natural sand and gravel was observed at 15.92m OD. The highest survival of archaeological deposits occurred at 17.62m OD, 0.3m beneath the road surface (Crossrail 2007b).

**COW89**

**20-26 Cowcross Street, 9-13 Peter's Lane, 35a St John's Street, 1-4 St John's Lane, 8-10 Eagle Court, 37-39 Britton Street, EC1**

**Relevant sub-sites: 67-69 Cowcross Street grout shaft and Greenhill's Rents grout shaft**

**Archaeological periods: Medieval**

NGR 531630 181840

Excavation in 1989 following revealed some 150m south of the gatehouse of St John Clerkenwell, substantial chalk footings and clay floor surfaces of between four and ten buildings of Medieval date and several post-Dissolution Tudor structures. Three phases of chalk-founded Medieval buildings were identified and traces of earlier timber constructions. Structures to the west included a chalk-lined well and several cesspits. There was also evidence of milling and baking in the form of Rhineland quernstone fragments associated with a crushed chalk floor and in the adjoining room, a tiled oven complex. A few Medieval burials were also excavated to the west of the chalk buildings (LAARC).

Cowcross redevelopment covers large area north of Cowcross Street, ground levels recorded relevant to 1980s street level not necessarily the same as today (the area within the development has been significantly landscaped).

## 9.4 Gazetteer of the Known Archaeological Resource

Record ID	Description	Subject(a)	Period(a)	Relevant Sub-sites
MLO1493	Long Lane EC1, TQ 3197 8178, unspecified Roman pavement found in the area of Long Lane in 1806 by T Fisher.	Settlement evidence	Roman	Eastern Ticket Hall, 3 Hayne Street
MLO1516	Charterhouse Square, TQ 3185 8190, Location of medieval plague cemetery by Sir Walter de Manny. The cemetery had an associated Chapel and later a Hermitage which became the nucleus for Charterhouse.	Cemetery Plague Pit	Medieval Medieval	Eastern Ticket Hall
MLO5732	Charterhouse Square, TQ 3196 8191, post-medieval road surface of Charterhouse Square (Bounding Points; TQ 31892 81888, TQ 31935 81865, TQ 31988 81994, TQ 32010 81901). Listed grade 2 on 29/9/1972, ref 77+78/1087. De-listed on the revised list dated 30/9/1994.	Road	Post-medieval	Eastern Ticket Hall, 3 Hayne Street
MLO5824	6 Cowcross Street, TQ 3175 8185, Post-medieval terraced house, not recorded as being Listed.	House	Post-medieval	Greenhills Rents Grout Shaft
MLO11082	81 Cowcross Street, TQ 3165 8185, medieval well, said to be located between the medieval garden of the Hospitallers and Smithfield Bar. This may be fed or drained by the stream identified at 81 Cowcross Street (See MLO11090).	Well	Medieval	Cowcross Street Grout Shaft
MLO11090	70-77 Cowcross Street, TQ 3168 8183, undated watercourse, possible draining from the 'Faggess' well to the Fleet River.	Watercourse	Unknown	Cowcross Street Grout Shaft, Greenhills Rents Grout Shaft
MLO13879	7 Cowcross Street, TQ 3175 8185, post-medieval terraced house; not recorded as being Listed	House	Post-medieval	Greenhills Rents Grout Shaft
MLO18059	Holborn, TQ 3170 8180, excavation by HADAS 1975 near the east end of the church revealed an 18 <sup>th</sup> century vault and finely engraved 18 <sup>th</sup> century brass and lead coffin plates. The GLSMR also records a medieval ditch.	Settlement Evidence Graveyard structure	Medieval Post-medieval	Greenhills Rents Shaft
MLO19690	Charterhouse Square, TQ 3180 8180, Part of the Great Cloister of Charterhouse Priory, which was used by the Bassano family Italian Entertainers at Court. The buildings in use included the Priors Cell, the Priors Private Chapel, and a number of cells (c. 1485 AD to 1600 AD). Henry VIII granted use of the area to the Bassano family following the Dissolution of the Monastery.	House	Medieval – Post-medieval	Eastern Ticket Hall
MLO22990	St John Street, TQ 3163 8251, road from West Smithfield to Islington (Bounding Points; TQ 31450 83150, TQ 31800 81870).	Road Road	Medieval Post-medieval	Eastern Ticket Hall
MLO24151	18 Cowcross Street, TQ 3175 8185, Post-medieval terraced house, not recorded as being Listed.	House	Post-medieval	Cowcross Street Grout Shaft, Greenhills Rents Grout Shaft
MLO25707	St John Street, TQ 3180 8190, site of Hicks Hall, the first Sessions House, in Clerkenwell built by Sir Baptisthicks, JP and Mercer. The name continued to be used by its replacement, the Old Middlesex Sessions House.	Sessions House	Post-medieval	Eastern Ticket Hall
MLO25713	67-77 Rear of Charterhouse Street, TQ 3172 8178, burial ground of St Sepulchres (possibly workhouse),. Holmes's study of London burial grounds notes that there were two burial grounds one for the church and a larger one for the workhouse. Both were lost to the Great Northern Goods Depot, now railway lines north of Charterhouse Street.	Cemetery	Medieval	Greenhills Rents Shaft

## Archaeology Detailed Desk Based Assessment – Farringdon Station

Record ID	Description	Subject(a)	Period(a)	Relevant Sub-sites
MLO30266	6-7 St Johns Lane, TQ 3176 8194, St Johns Priory, an archaeological excavation by the Department of Greater London Archaeology in 1990 (Site Code SJL90) recorded fragments of robbed out medieval wall footings, within the outer precinct of the priory. A large number of medieval and post-medieval (C14th-C17th) were recorded filled with domestic rubbish. Finds included tile, pottery, two dog skeletons and a 15 <sup>th</sup> century gold ring.	Structural Remains Occupation activity	Medieval Medieval & Post-medieval	Eastern Ticket Hall
MLO43571	St John Street, TQ 3167 8200, precinct wall of the medieval priory of St John of Jerusalem. The precinct would have been roughly rectangular starting at St John's gatehouse, running east to St John Street, then north almost to the corner of Aylesbury Street where it turned west to Clerkenwell Green. The walls consist of an inner and outer precinct, grid references for the corners of the outer precinct are TQ 31500 82055, TQ 31705 82260 TQ 31720 81850 and TQ 31750 81845.	Wall	Medieval	Greenhills Rents Grout Shaft
MLO46412	Ely Place, Camden, TQ 316 819, location of stable buildings relating to Ely House, noted as being located 'some distance north of the Cloister'.	Stable Stable	Medieval Post-medieval	Cowcross Street Grout Shaft
MLO53375	Cowcross Street, TQ 3174 8188, medieval priory of St John of Jerusalem, an evaluation and subsequent excavation work by the Department of Greater London Archaeology in 1989 (Site Code COW88 and COW89) recorded many features associated with the priory including early medieval gravel quarrying, a range of chalk walled buildings one of which was possibly the tower base of the gateway into the outer precinct; with associated rubbish pits, lined cess pits and wells. Four or five inhumation burials were recorded in probable gardens behind the buildings.	Priory buildings Gatehouse tower Occupation activity Burials	Medieval	Greenhills Rents Grout Shaft
MLO55698	South of Cowcross Street, TQ 3164 8177, burial ground of St Sepulchres workhouse. Now railway line.	Cemetery	Post-Medieval	Cowcross Street Grout Shaft
MLO61079	78-85 Cowcross Street, TQ 3173 8183, observation of a trial pit by the Department of Greater London Archaeology in 1986 revealed a medieval dump deposit comprising two layers of waterlogged clay, containing a large amount of medieval building material, which appeared to have filled an old watercourse, pond or gravel pit.	Dump deposit	Medieval	Greenhills Rents Grout Shaft
MLO61157	167-179 Queen Victoria Street, TQ 3168 8191, post-medieval cellar constructed on reclaimed land was recorded during excavation for the DUA between March and December 1985 (Site Code QVS 85). Reclamation dumps and cellars continued to be in use until modern development took place.	Dump deposits Cellar	Medieval and Post-medieval Post-medieval	Cowcross Street Grout Shaft
MLO63383	Cowcross Street, TQ 3162 8180, undefined and undated watercourse.	Watercourse	Unknown	Cowcross Street Grout Shaft
MLO65649	43-44 Cloth Fair, TQ 3191 8179, archaeological watching brief undertaken in June 1986 (Site Code CFA86) during the refurbishment of a pair of 18 <sup>th</sup> century houses. This revealed that the internal timber structure supported and external brick wall, no evidence for the re-use of materials or decorative features were in situ. Finely chamfered limestone fragments were observed in one basement fireplace and an unusually decorated block of Caen stone (attributed on stylistic grounds to the 17th century) retrieved from the basement floor make-up must have come from a grander structure nearby.	House	Post-medieval	Eastern Ticket Hall, 3 Hayne Street
MLO65913	109-113 Charterhouse Street, TQ 3187 8187, negative archaeological watching brief revealed that modern building works had truncated the site to a point where no archaeological remains survived.	Negative evidence	Unknown	Eastern Ticket Hall, 3 Hayne Street

## Archaeology Detailed Desk Based Assessment – Farringdon Station

Record ID	Description	Subject(a)	Period(a)	Relevant Sub-sites
MLO67032	Farringdon British Rail Station, TQ 3161 8181, undated watercourse identified during monitoring of test pits by Museum of London Archaeology Service in 1992 (Site code XRB92). Two test pits identified slightly organic alluvial deposits laid down by the River Fleet. The deposits contained plant debris, charcoal and occasional peaty lenses; tile, decayed greensand, potsherds and flint nodules were also found.	Watercourse	Unknown	Cowcross Street Grout Shaft
MLO70872	Charterhouse Square, TQ 3199 8190, Part of the site of the medieval plague cemetery, dating to 1349, when Sir Walter de Manny purchased 13 acres of land known as Spittle Croft from St Bartholomew's Hospital. In 20years 50,000 bodies were interred there. In 1371 the Cartusian Monastery was built upon it. The Pardon Churchyard comprised three acres acquired c.1348 survived longer, being used for suicides and executed people. Charterhouse square covers 1.25 acres.	Cemetery	Medieval	Eastern Ticket Hall
MLO72219	52-53 Britton Street EC1, TQ 3166 8182, Negative archaeological evaluation carried out by JSAC in February 1998. 19 <sup>th</sup> century cellaring had truncated deposits to approximately 2m below existing ground level (14.80m AOD).	Negative evidence	Unknown	Cowcross Street Grout Shaft
MLO73771	6-9 Benjamin Street EC1, TQ 3165 8191, internal walls with 19 <sup>th</sup> and 20 <sup>th</sup> century backfills were recoded during a watching brief carried out by the Museum of London Archaeology Service, during March - October 1998; (Site Code BEJ98).	Negative evidence	Unknown	Cowcross Street Grout Shaft
MLO73901	Charterhouse Square, TQ 3195 8190 Resistivity survey undertaken by D. Shiel for Geophysical Surveys of Bradford, May 1997 on the assumed location of the former chapel. No clear building plan was identified. One anomaly was identified which may represent a fragment of surviving wall. Other anomalies were thought to be cellars, backfilled air-raid shelters or were due to recent vegetation, garden features or landscaping.	Location of Former Chapel, Wall	Medieval	Eastern Ticket Hall, 3 Hayne Street
MLO76194	18-21A Charterhouse Square, EC1, TQ 31890 81916, an archaeological watching brief revealed construction make-up associated with the standing building.	Made ground	Modern	Eastern Ticket Hall, 3 Hayne Street
MLO86463	16 St. John Street EC1M 4NT, TQ 31817 81851, Grade II Listed Building; Late C19 industrial or commercial building. In brick (now painted) set in Flemish bond with stucco dressings. Four storeys over basement, five-window range. Ground floor of four bays, altered, including a slightly broader works entry to right; fascia and cornice.	Listed Building	Modern	Eastern Ticket Hall
MLO97899	Eagle Court (No. 8, 10-11a), Clerkenwell EC1, TQ 31720 81907, the site is located within the precinct of the medieval priory of St John of Jerusalem, adjacent to sites of known medieval activity. A watching brief carried out on behalf of the Museum of London Archaeology Service (12 <sup>th</sup> October to 7 <sup>th</sup> Dec 2004) recorded 1-2m of 19 <sup>th</sup> century made ground and demolition layers overlying post-medieval garden soils. A thin probable late medieval soil horizon was identified sealed beneath 1m of the garden soil deposit. There was no evidence of medieval structures. Natural sandy gravels were encountered between 14.5m and 15mOD.	Soil Horizon Building Garden Soil	Medieval Post-medieval Post-medieval	Cowcross Street Grout Shaft

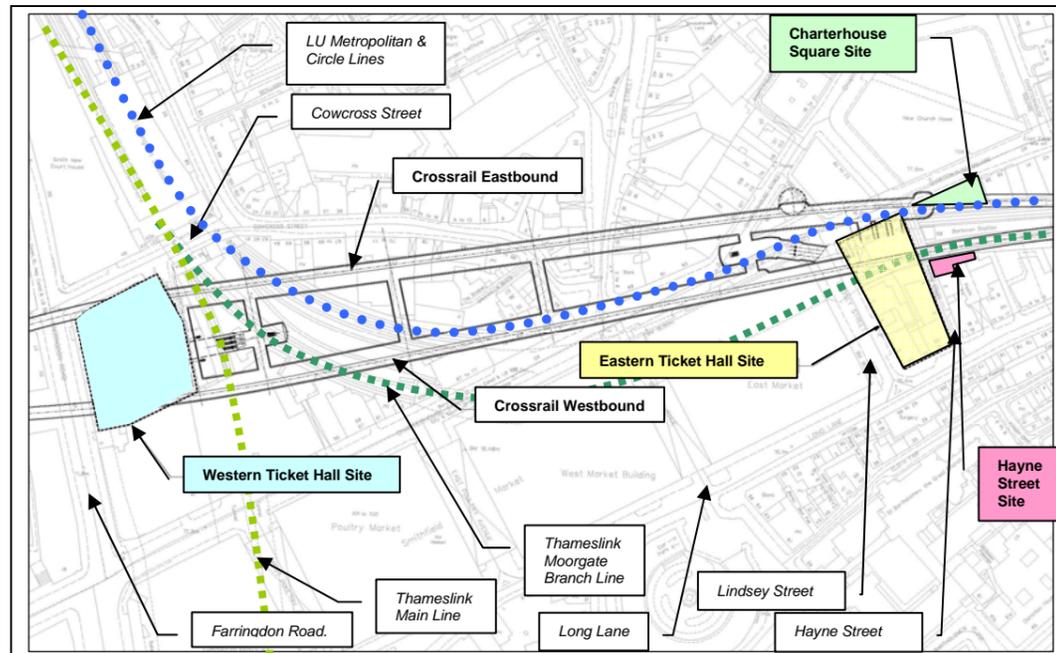
## **9.5 Construction and Construction Process Report**

## 12 Construction and Construction Process Report

### 12.1 Introduction

This report draws together the information relating to the construction of Farringdon Station covering the Methodology and Sequence, Advanced Works, Enabling Works and Contractors worksites.

Each of these sections is divided into the two geographic work areas that make up Farringdon Station namely the Western Ticket Hall adjacent to Cowcross Street and the Eastern Ticket Hall adjacent to Lindsey Street which also includes the site areas adjacent to Charterhouse Square and Hayne Street. The sections include the subsurface tunnel works which are predominantly constructed from the Western Ticket Hall work site.



**Figure 12 Site Plan showing site area and street names relevant to the text**

The construction methods and sequencing for this station are determined by; the site geology, access and site area constraints, limitations on the location and capacity craneage, proximity to LU and Thameslink infrastructure and the relationship of the site works to the overall Crossrail and Thameslink Project programmes. The construction sequence reflects the overall programme priorities which are:

- 1) Completion of the platform tunnels to permit system-wide installations and commissioning for the railway.
- 2) Completion of the station tunnels and the Western Ticket Hall to provide interchange facilities with Thameslink upon commencement of Crossrail Services
- 3) Completion of the Eastern Ticket Hall for interchange facilities with LU lines at Barbican Station which augment those available at Farringdon from the Western Ticket Hall.
- 4) Minimise adverse effects arising from the concurrent construction of the Farringdon Thameslink Station upgrade works at the Western Ticket Hall which forms an integrated station design.

Details of construction risks, demolition, lorry histograms, environmental impacts, plant schedules and construction programming are addressed in separate sections of the Scheme Design Submission.

A subsidiary consideration in devising the programming of the station works has been to minimise the duration of occupation of the former Thameslink Moorgate track-bed where it passes through the Eastern Ticket Hall site.

## 12.2 Methodology and Sequence

### 12.2.1 Western Ticket Hall.

The construction sequence of the Western Ticket Hall is more complicated than in past submissions by its interface with the Thameslink Project works. This aspect has not been addressed in past Crossrail Design submissions where simplifying assumptions had assumed the projects were constructed in isolation.

As explained elsewhere in the text the design is now integrated with that for the Thameslink station extension. The construction planning must similarly allow for the influences arising from overlap of the construction programmes which lead to concurrent construction activities..

SD3 is based upon Thameslink programming from March 2008 although an update is scheduled for October 2008.

The sequencing of works reflects the site commencement dates of the PCS01 programme and the intention for the accelerated acquisition of the Cardinal House site which is based upon the recommendations of the report "Study of Options Concerning the Acquisition of the Cardinal House Site, CR-SD-FAR-TP-SR-00001" which identified significant mutual benefits for both projects.

The risk of delay, changes in the Thameslink construction works programme and the resulting impact upon Crossrail is a major project risk and will be potentially exacerbated by slippage of Thameslink into the period of the Olympics which will cause a suspension of Thameslink works with attendant de-mobilisation and re-mobilisation.

The contractual, design and programme interface with the Thameslink are subject to continuing revision and refinement.

A further factor that complicates the Western ticket hall construction works since the past submission has arisen from the requirement to incorporate the over site development (OSD) foundations into the site and the construction activities.

### **The Thameslink Project at Farringdon Station.**

In outline the Thameslink Project at Farringdon aims to allow the station to accommodate the running of longer 12 carriage trains, this involves the following:

- The provision of a new LU ticket hall accessed off Turnmill Street to maintain LU operations both during and after the project work.
- The extension of the Network rail platforms to the north as far as the site restraints permit; the station is situated in a cutting that narrows to the North preventing significant platform extension in that direction.
- The provision of a new EdF local area sub-station beneath Turnmill Street which is vital to Thameslink works at the southern end of the platforms described below, where an existing sub-station must be removed prior to bridge demolition. This sub-station relocation is also vital to Crossrail as it prevents the full demolition of Cardinal House Tower.
- The staged demolition and replacement of the Western arch of Cowcross Street Bridge, changing the bridge from an arched structure to a portal frame to provide headroom for passengers to make the platform extension to the South feasible.
- The demolition of all properties along the southern side of Cowcross Street bridge to permit the construction of the new combined Thameslink and Crossrail station concourse and gate line.
- The closure of the Moorgate branch line to permit platform 3 to be extended to the South of the station.
- The demolition of trackside infrastructure to permit construction of Thameslink platform 3 to the South of the station and foundations for the train shed and street level concourse.
- The decommissioning of an existing EdF sub-station abutting Cowcross street bridge sited on the Cardinal House site, referred to above.
- The construction of a new station "train shed" South of Cowcross Street with an over-track street level concourse and flat "green" roof with skylights which will eventually be integrated with the Crossrail Western Ticket Hall when it is subsequently completed.

These activities are all planned to be undertaken whilst maintaining full Network Rail and LU operations, including the uninterrupted operation of the existing Farringdon Station maintaining public access along Cowcross Street.

To accommodate Crossrail construction the following additional activities have been introduced to the scope of the Thameslink works;

- The construction of a lift shaft linking Thameslink Platform 3 to the Crossrail underground station concourse adjacent to the access tunnel for the Western Escalator.
- The incorporation of settlement mitigation measures into the design of the station structure in the form of structural jacking points in the column supports and railway infrastructure of the new southern “train shed” which will have been completed prior to Crossrail tunnelling activities.
- The inclusion of the design and execution of mitigation works to the St John’s branch of the Fleet sewer which currently runs beneath the Thameslink Platform 4 southern extension site and must withstand or reduce the impact of settlement arising from the Crossrail piles, tunnels, shafts and escalator the latter having a potentially significant impact. This is an ongoing work activity as it is subject to the approval of Thames Water who own the affected asset. It is a mutual project risk to both Thameslink and Crossrail.

To accommodate the Thameslink project Crossrail has undertaken the following:.

- The date of procurement and demolition of the Cardinal House Site has been advanced to provide benefits to Thameslink in the form of improved access and logistics. This benefit is ultimately mutual as it removes significant programme risks from Thameslink.
- The station design has been modified to integrate with the Thameslink scheme
- The interface line between the two projects has been rationalised.
- The programming of the Crossrail works continues to be revised to accommodate The Thameslink works.

#### **The Western Ticket Hall construction work sequence: Relevant Thameslink activities and early Crossrail works.**

On the basis of the above programme constraints the works undertaken by the Thameslink Project relevant to the Crossrail Western Ticket Hall are :-

- Thameslink site activities in the northern Farringdon Station area including Turnmill Street and Cowcross Street Bridge works and the EdF sub-station reprovision activities.
- Crossrail acquire Cardinal House in June 2009 disconnect all utilities, undertake Asbestos surveys and the necessary clearances.
- The Cardinal House structures are then demolished as described previously in the sequence given in Figure 13 This gives a site working area and access that is independent of the ongoing Thameslink Project works affecting Cowcross Street Bridge. The timing of the tower demolition is controlled by the relocation date of the

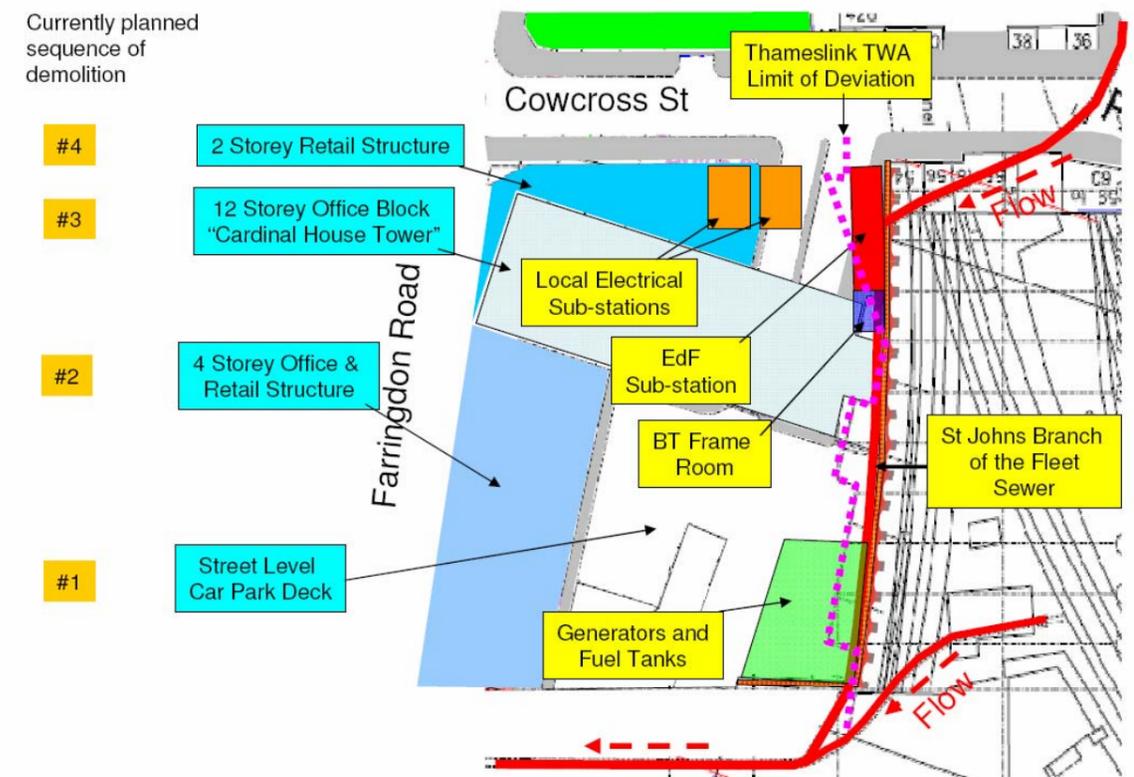
EdF sub-station but it is intended to protect the sub-station location whilst the upper floors of the tower are sequentially removed. The leaves only the street level structure to be demolished once the sub-station is decommissioned.

- During Demolition of Cardinal House the Thameslink rail operations will be unchanged, until better information is forthcoming from negotiations with the operator, programming assumes that crash deck provisions are necessary and can be installed without impact on programme.
- Concurrent with the above, the demolition of the car park deck will allow Thameslink access to the disused generators and fuel tanks currently located beneath the deck which must be removed to give access to both the party wall with Thameslink trackside and the St John’s branch of the Fleet Sewer.
- At this time the Moorgate Branch line will be taken out of service, “blockaded”, there is a one year period of time whilst the track and infrastructure remain in place for use in exceptional events.
- In the current absence of a definitive sewer mitigation scheme for the project the current programming and designs are based upon an online sewer replacement activity whereby the existing egg-shaped brick sewer is replaced by larger capacity pre-cast sewer pipes. This work requires over-pumping of the sewer and protection of the site from inundation arising from any surcharge event during these works. This work will be phased to be concurrent with Thameslink works below and the tower demolition activities above.
- Using the Cardinal House site and access, once the sewer works permit, Thameslink will demolish the party wall and access the trackside for Platform 4, to undertake low headroom piling for the train-shed foundations, casting of the pile caps, including the settlement jacking provisions required for Crossrail mitigation and once progress on platform 3 permits, the site will then be used to construct the train shed and concourse superstructure being used for steelwork deliveries and fabrication and craneage. Based on current programming, these structural works should be effectively complete before the Crossrail contractor mobilises to the site. The Thameslink station should be undergoing finishes and fit-out processes when the Crossrail activities below are instigated.
- To access Thameslink Platform 3, Thameslink will demolish 65b Charterhouse Street which lies above the portal of the tunnel for the Moorgate Branch line where it passes beneath Charterhouse Street and Smithfield Market.
- Once the Moorgate track-bed is permanently blockaded, the track side structures have been demolished and OHLE amendments undertaken, the track-bed will be used as the access route for plant and materials for Platform 3 lifted down from Charterhouse Street. This includes the plant and materials necessary to form the lift shaft that links to Crossrail.
- Install commission and obtain background readings for settlement, track, train clearance and structural monitoring on LU and Thameslink assets and lines.
- The crane capacity will dictate the methods of construction by limiting the plant available to low weight, low headroom piling and drilling rigs, teleporter units, compact tracked telescopic cranes, limited capacity concrete mixer (Ultranazz units) or

concrete pumps, and dumpers for spoil movement. There is an obvious opportunity to use the rest of the disused track-bed for site area and storage subject to the usual restrictions arising from proximity to the LU and Thameslink railways.

- The sinking of the lift shaft will be undertaken and entail the following sequence:
  - Mobilise drilling equipment to undertake SI, and install dewatering and depressurising measures including passive wells, ejector wells and deep abstraction wells to target the perched aquifers of the Lambeth Group and Lower aquifer of the Thanet Sand / Upnor formation and the necessary piezometers for groundwater monitoring.
  - Mobilise multiple piling rigs to place the train shed foundation piles and secant piles for the lift shaft to form a cut-off the upper aquifer and provide settlement protection to the LU siding lines.
  - Erect a gantry crane over the shaft site.
  - Commence shaft sinking using segmentally lined underpinning techniques.
  - Once full depth is attained cast the base plug to the shaft and then install the propping and opening provisions necessary for subsequent Crossrail activities.
  - Place a temporary cap to the shaft including the lift base for the Thameslink lift.
- Concurrent with the later activities above sewer mitigation activities will be undertaken for the City Sewer and Moorgate track drain and the foundations of the train shed, include jacking provisions for Crossrail settlement mitigation will be constructed.
- The train shed superstructure will then be erected, largely undertaken from the Cardinal House site but with lighter steelwork erected by the plant on the Platform 3 site.

### Farringdon Station Western Ticket Hall Site – Existing Structures and Utilities



**Figure 13 WTH Site Existing Structures and Utilities**

There is a significant opportunity in the above works for Crossrail to undertake SI works in advance of the main contract activities as these have proven difficult to achieve to date due to the difficulties in gaining track access. In addition the shaft sinking, drilling and piling records from the Thameslink works will provide valuable supportive SI data for Crossrail providing active measures are undertaken to ensure the necessary observations are made and recorded for the duration of the Thameslink works.

There are further opportunities for Crossrail in the above works from;

1. Installing dewatering measures in the Western Ticket Hall site and Moorgate track-bed in advance of the main Crossrail work mobilisation, giving them greater time to become effective before shaft sinking and tunnelling.
2. Utilising the Thameslink piling contractor to install Crossrail piles in the Cardinal House site once the Thameslink activities are complete.

These actions could accelerate the Crossrail programme and mitigate against groundwater risks but would require appropriate commercial agreement and early funding.

The above opportunities have not been assumed in SD3 programming.

### **The Western Ticket Hall construction work sequence: Crossrail Activities.**

This will comprise of the following sequence of activities:

- The mobilisation to site of the main contractor and supervisory team and ensuing site setup including site hoarding between Thameslink and Crossrail work sites.
- The preparatory ground dewatering works and concurrent piling works for the shafts, escalator box, and Over Site Development (OSD) foundations;
- The works relating to shaft sinking for the rectangular and circular shafts;
- The delivery, fabrication, staged launch, tunnel drive and decommissioning of the , Earth Pressure Balance pilot tunnelling machine which will be driven East to West twice; first along the eastbound platform tunnel, dismantled, rebuilt in the westbound shaft and driven along the westbound platform tunnel. It will be removed at the East Ticket Hall main shaft and the site logistic supports at the western site will be dismantled.
- Concurrent with the above ground investigation and treatment works will be undertaken from the pilot tunnels as they become free. These are largely supported from the eastern end of each drive but aspects such as the insertion of drilling plant and subsidiary logistic support elements will be provided from the Western Ticket Hall site.
- The site will be revised to support Sprayed Concrete Lining (SCL) tunnel works that will be undertaken to enlarge the pilot tunnels and form the underground station platform tunnels and cross-passages including the escalator lower machine chambers, these SCL works will be concurrent with the maintenance of the pilot tunnel ground treatments installed previously which will be maintained from the eastern shafts;
- The timing of the SCL works is critical for the excavation of an SCL tunnel East of the circular Eastbound shaft within the footprint of the Cardinal House site to intercept and cut off the toes of the piles from the former Cardinal House Tower and form a reception adit for the Eastbound running tunnel TBM arriving from Royal Oak.
- On completion of the platform SCL tunnels they will be cleaned out in preparation for the secondary lining works for the SCL station tunnels, these are supported from the Eastern Ticket Hall site;
- The secondary lining works within the shafts will be undertaken “bottom-up” and for the rectangular westbound shaft will commence once underground access to the tunnels has been established from the Eastern Ticket Hall. The Eastbound shaft works will commence once all major spoil removals from the tunnels have been completed ;
- The Spoil handling and SCL logistics will be cleared from the site permitting excavation of the Escalator box.

- On completion of the box excavation, jet grouting equipment and logistic support will be established on site and jet grouting undertaken in preparation for escalator tunnelling beneath the St John’s branch of the fleet sewer and the new Thameslink station and trackbed.
- On completion of the jet grouting the logistic provisions will be demobilised and limited SCL support provisions re-established to permit escalator excavation.
- The construction of the Escalator shaft from ticket hall to Crossrail platform level will be undertaken by pilot tunnel and enlargement using SCL techniques with pipe arch provision;
- The construction of the OSD foundations will be undertaken as site area permits and will include installation of pile caps, ground beams and the construction of hand dug caisson piles, which will be undertaken concurrently with the escalator works;
- On completion of the escalator tunnelling the site SCL support provisions will be cleared and secondary lining works for the escalator shaft will commence;
- With the foundations complete the construction of the Ticket Hall basement structure will commence followed by the road level superstructure including the Thameslink interfaces, corridors, escalators, stairs and lifts, this will be initially concurrent with the escalator secondary lining;
- The mechanical and electrical fit-out and commissioning of the station will commence on completion of the civil works;
- The final activity will be the staged removal of the temporary party wall to link the new facilities with those of the active Thameslink station.

This sequencing makes no allowance for any adverse impact arising from the arrival of the running tunnel TBMs, from the West, launched from the Royal Oak Portal site; these are assumed to be dismantled in place and removed back to the Royal Oak Portal or dismantled in-situ without impact on the above works.

It is known that the Caxton House site, located to the south of the Western Ticket Hall site, is planned to be redeveloped and will be concurrent with part of the above works. In the absence of any programme for this activity its impact cannot be assessed and is not addressed, it is a project risk item.

### **Western Ticket Hall, Ground treatment and Piling Works**

Key to the understanding of these works is the geology of the site, which is covered in Section 10.2 of the Scheme Design submission.

The foundations of Cardinal House will locally form an obstacle to the ground-works requiring their removal or ad-hoc in-situ demolition. Where piles occur in the shafts these will be excavated in stages as each shaft progresses.

All work during these activities will be undertaken during the normal site working hours, no nightshift or weekend working is anticipated but some late working may occur during placement of concrete for the deeper and larger piles.

Following the completion of demolition drilling equipment will be mobilised to drill and install piezometer “observation wells” around the site periphery, these will be followed by a series of ejector well installations to remove water from any perched aquifers beneath the site and deeper abstraction wells to protect the shafts from the influence of the lower aquifer. This will assist the subsequent piling by helping to maintain the bore stability prior to pile placement and will also ensure that water pressures are controlled during shaft sinking.

Concurrent with the water control measures, pile guide walls will be constructed and obstruction removals will be undertaken.

Settlement monitoring provisions for the site and adjacent areas will be set up at this time and commence in advance of active dewatering to ensure any dewatering induced settlement effects can be identified and mitigated.

Piling plant will be mobilised and access the site using the existing ramps in the north-eastern corner, off Cowcross Street. Site welfare and storage will be sited in the basement car park beneath Caxton House. All concrete for the piling will be obtained from ready-mix suppliers, there will be no on-site concrete batching provision. Due to the constrained site area the pile cages will be delivered as pre-fabricated units delivered in lengths of up to 12m.

The piling works for the shaft and box structures will comprise of a “hard” / “soft” secant wall for all the Crossrail structures. The piles will be sunk using bentonite or polymer mud flush to maintain stability in the Lambeth Group and Thanet Sands.

The piling work will commence with the rectangular “Westbound” shaft and progress Southwest to Northeast across the site, culminating in the removal of the access ramp to place piles for the circular Eastbound shaft. The escalator box structure will have to link in to the pile wall stubs placed by Thameslink at the site boundary unless Thameslink install all the piles for this structure as a continuation of this aspect of their works activity.

The main deep load-bearing piles for the subsequent Over Site Development (OSD) will be placed at this time using full sized piling plant. These will be capped and in specific locations the structural pile cap or raft slab placed before being protected and buried beneath the temporary site working layer for the duration of main tunnelling activities.

Any temporary works piles relating to heavy lifting requirements for the TBM deliveries will be placed at this time; it should be noted that such temporary piles have not been shown in the drawings of the Design Submission and there is an opportunity to utilise the redundant piles of the former Cardinal House structures.

Concurrent with piling, a structural capping slab will be placed over the rectangular Westbound shaft and a high capacity, single lane temporary works access ramp will be constructed across the southern part of it, this is to provide longer term construction access from Farringdon Road for the duration of underground works. The timing of

construction of this ramp should ensure that this access is open before the existing access has been removed to complete the piling. The ramp load capacity and dimension is to be determined by the crane required for heavy lifting during the TBM delivery and fabrication.

Upon completion of piling the equipment will be demobilised and the site area capped with a reinforced concrete temporary working platform with the necessary integral drainage, foundations and service ducts required for the subsequent tunnelling activities.

A second temporary single lane access ramp will be constructed across the eastern side of the Eastbound circular shaft abutting the Thameslink party wall to provide the point of egress for heavy goods vehicles from the site during construction of the underground works. The two ramps will form the one way system for lorries through the site during the main tunnelling and shaft sinking work. With access off Farringdon Road onto site and egress from site back to Farringdon Road via Cowcross Street.

### **Western Ticket Hall, Westbound Rectangular Shaft Construction**

Owing to the slow rate of progress in rectangular shafts the shaft construction of the Westbound shaft will commence whilst piling activities are still in progress, starting with excavation to install the pile capping beam, and structural temporary covering slab referred to above. The slab will be constructed with “glory hole” openings for access and ventilation for the duration of underground works.

Once piling has been completed the shaft will be sunk as a series of excavations as detailed in the table below using backhoe excavators loading spoil into skips for removal by crane to surface for disposal. At each propping level the excavations will cease and the shaft working surface will be temporarily sealed with a blinding layer to prevent deterioration of the exposed ground and to give a stable working level for prop and whaling installation.

Westbound, Rectangular, Shaft		
Excavation No.	Excavation level	Propping level
1	105.50 – 104.00	104.75
2	104.00 – 101.20	102.52
3	101.20 – 96.00	97.22
4	96.00 – 91.15	92.55
5	91.15 – 84.00	85.20
6	84.00 – 82.00	83.25
7	82.00 – 79.10	80.76-79.26m base slab.

**Table 27 Excavation and Propping levels in WTH, Westbound Shaft**

The whaling and propping will be installed mounted on temporary brackets installed into the piles with the structural elements sized to be lifted down the shaft through the slab openings and lifted into position by plant working on the blinding layer then grouted to bond with the pile walls. The propping plan layout will reflect the openings in the capping slab to ensure that the props are protected against lifting impacts and are of adequate dimension for the subsequent TBM erection works. The propping levels are determined by the different openings that will be made in the shaft.

With one exception the propping for this shaft will be temporary and will be replaced by permanent support from the reinforced concrete floor slabs placed during the “bottom up” secondary lining and civil fit-out of the shaft undertaken upon completion of the tunnelling works from this shaft. The exception is the propping installed at 83.25mOD which is initially placed to permit casting of the base slab but is subsequently required for the tunnel opening support, this prop cannot be removed and will be encased in concrete as part of the permanent works.

The shaft excavation sequence will be interrupted after excavation 5 to 84.0mOD to permit tunnelling works for the pilot tunnel to be undertaken at the earliest opportunity. The propping at this level will be buried and covered with a robust temporary reinforced concrete working deck which will be removed after the pilot tunnel drive is completed.

Once the tunnelling equipment has been removed a level of whaling beams will be installed at 88.0mOD which will span across the pilot tunnel opening and the upper ring beam for the SCL opening will be installed.

The shaft sinking will then be continued by excavating the two remaining levels and installing the propping at 83.25mOD and base slab.

The working level will then be raised in preparation for the SCL tunnelling works by burying the lowest props and casting another robust temporary concrete working level slab with recesses for a sump and a spoil skips.

The prop installed at 85.2mOD will obstruct access for the SCL works and will have to be removed. To permit this, props will be installed in the walings at 88.0mOD and the props and walings at 85.2mOD will then be removed giving 4m clearance for SCL plant. The lower section of the SCL opening ring beam will then be installed.

The shaft will then be available for SCL tunnelling activities until the programme permits the installation of the final lining and permanent support as described in section 12.2.1.12 below.

#### **Western Ticket Hall, Eastbound Circular Shaft Construction**

The circular shaft will commence after piling activities have ceased and the plant has been demobilised and commence with the emplacement of a capping beam and the installation of a protective deck and an access ramp across the eastern side of the shaft.

As with the rectangular shaft, it will be sunk as a series of excavations, as detailed in the table below, using backhoe excavators loading spoil into skips for removal by crane to surface for disposal. At each ring-beam level the excavation will cease and the shaft working surface be temporarily sealed with a blinding layer to prevent deterioration of the exposed ground and give a stable working level for the circular whaling beam installation. There will be no internal bracing props.

Eastbound, Circular, Shaft		
Excavation No.	Excavation level	Ring-beam level
1	105.50 – 104.20	104.75
2	104.20 – 100.90	101.22

3	100.90 – 94.00	94.62
4	94.00 – 90.35	90.85
5	90.35 – 84.40	84.70
6	84.40 - 82.11	1.50m Base slab.

**Table 28 Excavation and Ring-beam support levels in WTH, Eastbound Shaft**

The smaller cross-sectional area, simpler support arrangements and clearer crane access to the circular Eastbound shaft will result in this shaft being sunk more quickly than the rectangular Westbound shaft and installation of tunnelling plant & logistics will commence in and around this shaft whilst the Westbound shaft is still being excavated.

The steel ring-beams of the Eastbound shaft are designed to be ultimately incorporated into the permanent works of the secondary lining and installation details will reflect this requirement by incorporating the necessary waterproofing and reinforcement provisions.

The use of steel ring-beams is justified by programme and durability as it gives access to the tunnelling horizon quickest, by avoiding the need for curing time before recommencing excavation, and can be readily monitored, repaired, augmented or replaced in the event of any damage or disturbance during the tunnel construction works.

Using the excavation intervals and temporary propping described the Eastbound shaft will be sunk to its full depth and the basal plug will be cast. The lowermost support level at 84.7mOD will be removed and the working level will then be raised with compacted backfill before placing of a temporary concrete slab for the working level for the pilot tunnel TBM.

On completion of the pilot tunnel work, described below, the upper section of the ring beam for the SCL opening will be placed, then the working slab will be broken out and the level reduced to suit the SCL phase of tunnelling. The lower section of the ring beam for the SCL opening will then be placed and a new temporary working level concrete slab placed complete with recessed for sumps and skips.

The shaft will then be available for SCL tunnelling activities until the programme permits the installation of the final lining and permanent support.

### **Western Ticket Hall, Platform Pilot Tunnel Works**

The platform pilot tunnels are to be formed using 5.1m external diameter, Earth Pressure Balance (EPB) Tunnel Boring Machine (TBM) using fibre reinforced segmental tunnel lining giving a 4.5m internal diameter finished pilot tunnel. These will be operated 24hours per day 7 days per week during their brief tunnelling operations.

The constrained site area gives very limited storage for segments and spoil. Frequent lorry movements will occur to remove spoil and deliver segments. The tunnelling production rate will be dictated by these constraints.

Logistically only one tunnel drive can be supported at a time by this site, this suits the programming of the shaft construction on the site with the Eastbound pilot tunnel being driven whilst the westbound shaft is still being excavated and prepared for pilot tunnel works.

The size and weight of the TBM parts delivered to site require the provision of a high capacity (800 tonne) mobile crane to offload from the Farringdon Road onto the site and lower the parts into the respective shafts.

The pilot tunnel TBM will be designed to undertake a “staged” launch from the shafts. To achieve this staged launching sequence requires the TBM to be specifically designed for the purpose and this will form a major early work procurement activity.

A staged TBM launch is minimises the perceived ground risks of inundation, face instability and settlement.

The segmental lining elements will need to have been designed, cast, cured and stored at an off site location ready to be delivered “just in time” when required by production.

Spoil handling from both pilot drives is assumed to be by conveyor underground into skips at the shafts which are then lifted and emptied into a small spoil store on surface where it is then by handled by excavator and conveyor into lorry loading hoppers on site. This assumption is based on the safety benefits from minimised vehicle movements and to ensuring the spoil can be removed efficiently. Alternative provisions for spoil removal by construction trains may also be appropriate to this situation but would require the construction of an SCL “back-shunt” tunnel on the Eastbound alignment and this has not been allowed for in the current scheme design. The construction of this tunnel will be undertaken once the site is set up for SCL operations to permit removal of the piles left from Cardinal House which intersect the running tunnel alignment and could not be mined through by the running tunnel TBM.

The spoil from the EPB machines will have high fluid content, due either to added conditioning agents, bentonite or water added during TBM operation, it may also arise from any encountered groundwater pockets.

There is no area on the site to permit the materials to stand and drain or to be separated by separation (hydrocyclone) plant or be mechanically dried by belt presses so the lorries removing spoil from site will have to be sealed units to avoid leakages in transit and may have to be taken to remote specialist facilities where any ‘contamination’ such as bentonite can be processed. During the TBM pilot drives the site will still have significant surface mud from handling operations and wheel-washing and road-sweeping facilities will be required for the duration of the pilot tunnel drives.

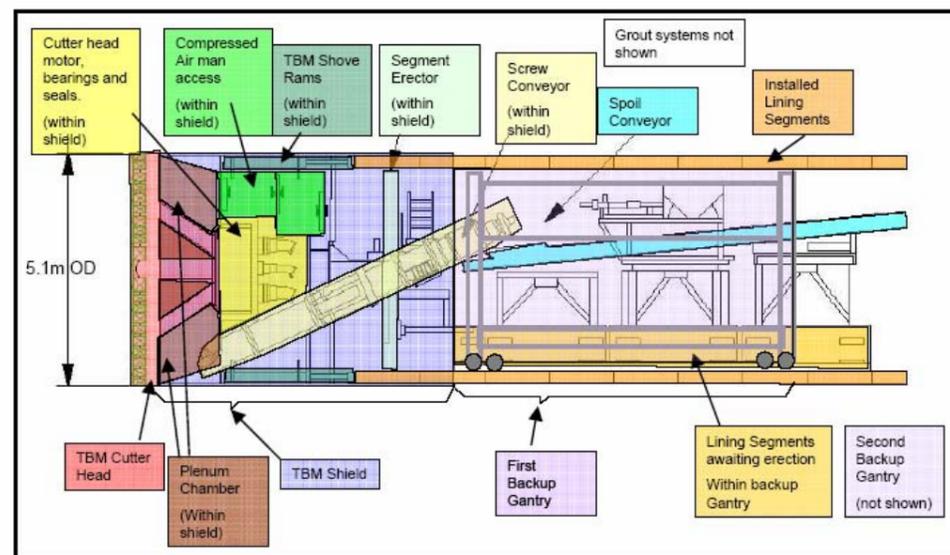
The complexity of the TBM and the need for its staged re-assembly and disassembly will require that these planned operations are tested in the factory during the commissioning stage prior to delivery to site.

The TBM will be designed to have a “sacrificial skin” around the machine shield, this is left in place when the drive is complete to support the ground whilst the internal working parts of the machine are removed, a second sacrificial skin will be delivered for the Westbound pilot tunnel drive at the same time as the result of the TBM and stored until required for TBM reconstruction prior to the second pilot drive.

Due to the high clay content expected in some of the lithologies to be encountered during the tunnel drives the head will be fitted with lubricating foam injection ports and high pressure water jets to avoid the machine cutter head and plenum chamber becoming “choked” by clay and silt materials.

The pilot tunnel drives do not have significant curves so it is assumed that the machines will not be designed with the shield segmental articulation that such curves require, this will make the machines less complex.

The TBM specification will be developed during the Detailed Design stage. Procurement period is recorded as a risk.



**Figure 14** Cross-section illustrating EPB TBM elements referred to in the text

The construction planning for scheme design assumes that rubber tyred logistic support will be used such as Teleporter or flatbed units to deliver segments, grout tanks etc.

The details of the delivery route to site for the TBM elements has not been investigated but owing to their weight and size the selected route will require checking and preparation such as the application for and co-ordination of the temporary removal of street furniture.

#### Western Ticket Hall, Eastbound Pilot

Shaft preparatory works will be necessary ahead of the TBM delivery and launch which will involve:

- The treatment or investigative probing of the ground around the breakout eye of the tunnel potentially formed of a staggered wall of secant un-reinforced weak concrete piles emplaced from surface during piling.
- The formation of a structural circumferential ring-beam around the tunnel eye.
- The staged cutting and removal of the piles in front of the machine and formation of a temporary sprayed concrete headwall using external ready mixed supplies.
- The placing of a fixed launching cradle for the TBM in the Eastbound shaft base into which the TBM will be lowered.
- The casting or fabrication of a confinement collar for the machine head complete with an embedded exit eye seal, necessary to permit the TBM to be operated at pressure from the outset.
- The emplacement of a temporary reaction frame for the TBM to shove against during the staged launch, anchored into the basal slab.

Due to the area required for the 800 tonne crane, the surface around the shaft top will be kept clear until after the TBM parts have been lifted. Work on the sinking of the Westbound shaft may have to be curtailed during these heavy lifting operations.

In a carefully pre-planned operation the TBM parts will then be delivered to site during off-peak hours and off-loaded from the street onto the site. The parts delivered will comprise of the following elements:

1. The cutter head of the Eastbound TBM.
2. The shield of the Eastbound TBM already installed in its sacrificial skin.
3. The screw conveyor.
4. The first backup sled.
5. The second backup sled.
6. The emergency backup generator equipment.

The first 3 items will be subsequently placed into the shaft for re-assembly, the latter 3 items will be placed on surface in prepared positions in readiness for the staged launch. The 800t crane will then be de-mobilised.

In the same operation the following elements of the Westbound Pilot tunnel machine will also be delivered and unloaded for storage on site until required:

- The sacrificial shield skin of the Westbound TBM.

Depending upon the final TBM design, the Westbound TBM may also require a dedicated cutter head but for programming it has been assumed that the single EB machine cutter head is designed to be dismantled and reassembled for re-use on the Westbound drive. This is based upon the short distance and low production rate required from the machine which will imply the head will not receive significant wear and can be operated to minimise risk of damage.

The surface logistical support equipment will then be installed comprising of:

- 35t gantry crane and shaft spanning rails.
- Spoil lorry loading hoppers and travelling conveyor.
- Ventilation fans.
- Compressors & air reservoirs.
- Electrical supply facilities, protected transformers, armoured cabling and distribution boxes.
- Fixed surface conveyors.
- Lorry wheel-washing unit.
- Water treatment and discharge facilities.
- The tunnel conveyor "cassette".
- Segment storage and handling area.
- Shaft personnel access, e.g. Alimak lift.
- Grout storage, batching and loading facility.

Concurrent with these surface installations, the TBM will be fabricated and tested with umbilical feeds from the backup gantries on the surface supplying electrical and hydraulic power, water and air to the TBM shield.

The first stage of the TBM launch will then be undertaken, driving the TBM head and shield into the ground thereby clearing space in the shaft base for the first of the backup gantry units to be lowered into position. This will require the removal of some of the umbilical supply cables to the TBM head and shield but provision will be made to ensure that the key supplies to the TBM head are maintained and that the machine head remains pressurised and free to move. This provision will enable the ground stability at the face to be maintained and avoids the machine becoming trapped by the ground between launch stages.

Due to the weight of the backup gantry, a 200 tonne mobile crane will be mobilised to site to lower the gantry into place and then demobilised, this may interrupt other activities on the site for the lift duration.

The second backup gantry will be installed in a repeat of the operation undertaken for the first gantry. The third stage of the TBM launch will then be undertaken driving the tunnel incrementally further to draw the second gantry into the tunnel to a point where reaction forces are no longer exerted on the reaction frame, detected by monitoring, thereby allowing the clearance of the base of the shaft for the next stage of works. The shaft bottom will then be fitted out for the main pilot tunnel drive, this will involve:

- The removal of the launch reaction frame and the segments used to undertake the initial stages of the launch. The reaction frame being stored for re-use with the Westbound pilot launch.
- The removal of the confinement collar used to pressurise the head upon initial launching. The eye exit seals remaining in situ to maintain the seal around the tunnel annulus
- The installation of the longer term cabling, pipe-work and ducting for the services required for TBM operations.
- The installation and commissioning of the tunnel conveyor system.
- The installation and commissioning of the skip loading, lifting and unloading arrangements.

The Eastbound pilot tunnel drive will then be recommenced and the TBM driven continuously for the full required length of the tunnel, as described in the report "Farringdon Station, review of tunnelling options, Vol 1. Version 2." Dated May 2007 (Ref CR-DV-FAR-CE-RT-00003).

Preparation for the completion of the tunnel drive at the temporary construction shaft beneath the site of 37 Charterhouse Square will involve the following activities:

- A breakthrough eye being formed in the shaft wall with propping from the opposite wall as required by the temporary works design. With high frequency monitoring for load and deformation effects during breakthrough.
- The installation of a reception cradle to receive the TBM head and assist with its subsequent dismantling.
- The provision for access, craning and ventilation required during TBM dismantling.
- The provision of monitoring and emergency preparedness plans for LU infrastructure and operations.

On completion of the pilot tunnel drive the following activities will occur;

- The tunnels will be cleared of the redundant conveyors, cables, pipework and ducting which will be stored for re-use on the Westbound pilot tunnel drive.
- The backup gantries will be detached from the TBM shield and drawn back to the shaft for removal by 200t mobile crane to surface where they will be stored for re-use on the WB pilot tunnel drive.
- The TBM screw conveyor and internal workings: segment erector, shove rams, cutter head motors, compressed airlock, will be removed from within the sacrificial skin and

hauled back to the shaft for removal to surface where they will be reconditioned for re-use in the Westbound machine drive.

- The TBM head and main bearing will be detached from the shield and dismantled in the base of the shaft either being lifted from the shaft by a crane sited on Charterhouse Square, removed in elements through the shaft by a smaller crane or drawn back along the pilot tunnel once the shield has been stripped out.

It should be noted that the TBM elements that are salvaged for re-used for the Westbound pilot TBM are recovered in the reverse order to that required for their fabrication, this has an impact upon the programme time required for this work and it may ultimately prove more economic for the Westbound TBM to be an entirely separate machine but this will only become apparent after detailed design and once the programming for the scheme has become more certain.

The Eastbound pilot tunnel will then be available for the ground treatment activities described below.

### **Western Ticket Hall, Westbound Pilot Tunnel**

The Westbound pilot tunnel construction operations are rendered more complicated than those of the Eastbound tunnel by the absence of cranage directly over the tunnel alignment and the resultant need to fabricate and then move major TBM elements into position at the base of the rectangular shaft.

Once the Westbound shaft has attained the depth required for the pilot tunnel works the following preparations will be undertaken:

- The treatment or checking of the ground around the breakout eye of the tunnel. (Potentially formed of a staggered wall of secant un-reinforced weak concrete piles emplaced from surface during piling)
- The formation of a structural ring-beam around the tunnel eye.
- The staged cutting and removal of the piles in front of the machine and the staged formation of a temporary sprayed concrete headwall using external ready-mix Shotcrete supplies.
- The casting of a confinement collar for the machine head, necessary to permit the TBM to be operated at pressure from the outset.
- The placing of a greased steel plate slide upon which the launch cradle will be placed mounted upon air jacks.
- The creation and testing of anchorages for jacks and winches to move the TBM and cradle into the correctly aligned launch position.
- The emplacement of the temporary reaction frame for the TBM to shove against during launch, anchored into the basal slab and shaft walls.

Once these preparations are complete a 200 tonne mobile crane will be mobilised to the site and erected. This will be used to install the main bearing, fabricate the TBM head, install the screw conveyor, complete the sacrificial shield skin and remaining shield internal

workings in the launch cradle before it is jacked across the shaft base into position for the TBM launch.

During the TBM re-assembly the surface site logistics which were in place during the Eastbound Pilot drive will be re-organised to suit the Westbound drive.

The staged launch process as described for the Eastbound pilot drive will then be repeated and the pilot tunnel driven to the exterior of the East Ticket Hall Diaphragm Walled Box.

Based on current programming the East Ticket Hall main shaft will not be ready to receive the pilot tunnel TBM, consequently on completion of the drive the TBM plenum will then be in-filled with a weak cement bentonite grout to maintain face stability until the programmed removal of the TBM parts can be initiated through the East Ticket Hall site.

As with the Eastbound drive, upon completion of the pilot tunnel the following activities will be undertaken:

- The tunnels will be cleared of the redundant conveyors, cables, pipe-work and ducting which will be taken to the surface and removed from site.
- The backup gantries will be detached and drawn back to the shaft for removal by 200t mobile crane to surface where they will be dismantled and removed.
- The TBM screw conveyor and internal workings will be removed from within the sacrificial skin and hauled back to the shaft for disposal.

The tunnel will then be available for the ground treatment activities described below.

With the completion of the Westbound pilot tunnel the surface site logistics will require revision from support for TBM tunnelling to support for SCL tunnelling, this will involve:

- Removal of the grout batching plant and its replacement by the aggregate hoppers, cement silos and a batching facility to provide shotcrete sufficient for the safe shutdown of SCL works, the batching plant size will not be adequate to provide the bulk of shotcrete during the works and external shotcrete supplies will be necessary and static re-mixers will be installed in the basement of Caxton House for holding such deliveries until required.
- The removal of the tunnel conveyor cassette equipment.
- The removal of the TBM power supplies and the emergency generator equipment.
- The removal of the segment storage and handling facilities and provision of stores for shotcrete additives and lattice profile ribs.
- The provision of a materials testing facility.
- The mobilisation of SCL plant and maintenance workshop facilities.

These changes will occur in tandem with the ground treatment activities being undertaken in the two pilot tunnels.

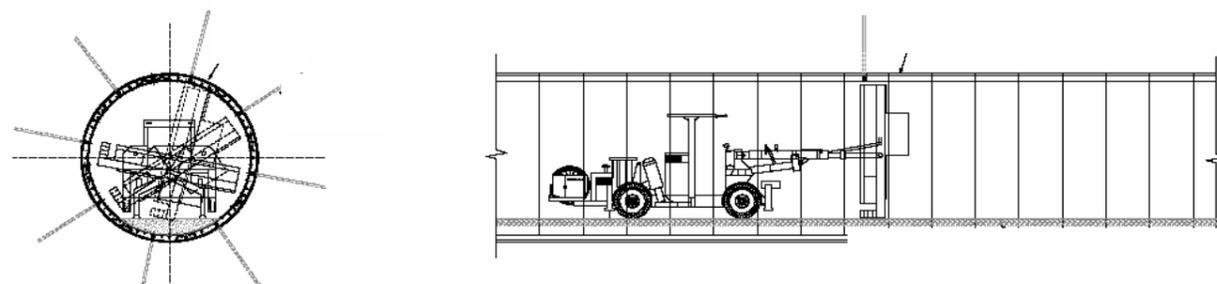
### Pilot Tunnel Ground Investigation and Treatment Works

The first activity to be undertaken upon the completion of clearance of both of the pilot tunnels will be to mobilise appropriate drilling equipment and geologically trained staff to instigate a programme of probe drilling through the tunnel lining to identify the geology and geological hazards along the platform tunnel alignments such as the location of faulting and pockets of groundwater.

With the stratigraphic information obtained the extent of the fixed pattern drilling for passive bleed wells and vacuum well point dewatering of the Lambeth Group strata along the length of each tunnel can be determined and instigated and the required staff and equipment mobilised.

The first priority for ground investigation and treatment in the Eastbound tunnel will be the location adjacent to the East Ticket Hall main shaft. This is necessary to permit the earliest possible formation of an access tunnel between the pilot tunnel and shaft along the alignment of the PRM access tunnel. This will then be used for ventilation, utility provision and access and egress for personnel, consumables and small items which will be vital if the ground treatment work is to be maintained during the SCL platform enlargement activities. Once this location has been investigated and treated the pre-enlargement drilling activities will be progressed from West to East from the shaft along the pilot tunnel, to ensure the maximum duration of these measures is gleaned prior to the SCL works.

For the Westbound Tunnel the pre-enlargement drilling activities will be progressed from West to East from the shaft along the pilot tunnel.



**Figure 15** Cross-section showing possible drill rig in 4.5m ID segmental pilot

### SCL Tunnelling Works

Platform tunnel enlargement using SCL tunnelling techniques will commence in the Eastbound tunnel from the shaft once a new ring-beam has been constructed for the larger tunnel opening in the pile wall of the shaft. The commencement of enlargement works from the western end of the Eastbound platform tunnel takes maximum advantage of the absolute period of dewatering, the easier access at this location and permits an overlap of these activities with the shaft sinking activities in the Westbound shaft as described earlier.

The SCL works will be subject to intensive management and contractual Quality Assurance and Quality Control processes including:

- Emergency Preparedness Planning; (EPP)
- Required Excavation and Support (RES) control processes;
- Inspection and Test Plans (ITPs) concerning shotcrete batching, strength development and controls on lining thicknesses;
- Geological review processes – comparison of face logging against ground models based on the results of SI and pilot probing logs;
- Certification of key operatives such as sprayed concrete nozzle men;
- Tunnel monitoring control and review processes;
- Dewatering & groundwater monitoring control and review processes;
- Surface settlement monitoring control and review processes; (including controls on monitoring of LU and Thameslink tracks and structures, utilities and surface structures)
- Environmental control and review processes; (Dust, Gases (H<sub>2</sub>S, CO, NO<sub>x</sub>, Oxygen depletion aka. Anoxia)
- Operative welfare review processes; (e.g. Vibration exposure HAVS)
- Design Change Control Procedures;

The EPP provisions are not limited to the SCL works but will be in place for the full duration of construction and adapt to the different construction phases and activities to ensure resources and plans to react to the “worst case” scenarios are in place. The planning will cover items such as:

- The access and egress of emergency services to site in the event of fire, inundation, instability, collapse etc.
- The protection of active railway operations from the effects of settlement via monitoring to trigger service suspension, speed restrictions and track adjustment or “fettling”.
- Plans to cope with inundation of the site from a breached sewer or water main.

The SCL works from the Westbound shaft will commence once the management process is assured, the shaft works are complete, the ring beam for the enlarged opening has been constructed and the shaft working level has been raised and the working platform prepared.

The enlarged platform tunnel profile that will be constructed by SCL techniques is now the same as that of other Crossrail stations and has been increased from that of the previous design submission, this change is reflected in the programmed production rates as the site logistics remain the controlling factor on productivity so the increase in tunnel size is directly related to the attainable tunnelling rates. The increased size will also increase the extent of dewatering wells drilled from the pilot tunnels.

The SCL tunnelling and dewatering techniques required for this phase of construction require high levels of competency from both construction staff and supervisors and there will be an extensive period of training and certification for key staff which will be undertaken whilst the pilot tunnel drives are in progress. For a fuller discussion of techniques and competencies refer to “Farringdon Station, review of tunnelling options”,

dated May 2007, Vol. 1., Version 2. (Ref CR-DV-FAR-CE-RT-00003). The related risks are elaborated in Volume 5 of the same report.

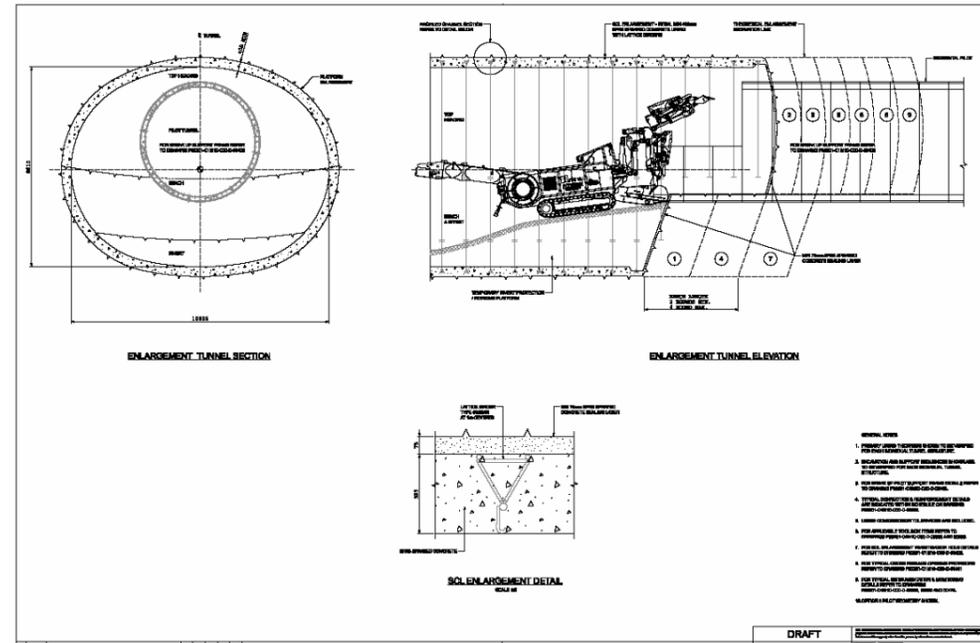


Figure 16 Platform Tunnel Enlargement Construction Sequence

To assure the stability of the pilot tunnel lining during the enlargement excavation a support frame will be placed within the pilot tunnel and moved at a fixed point in the construction sequence, or incrementally dismantled and re-assembled during the excavation sequence as shown in the figure below:

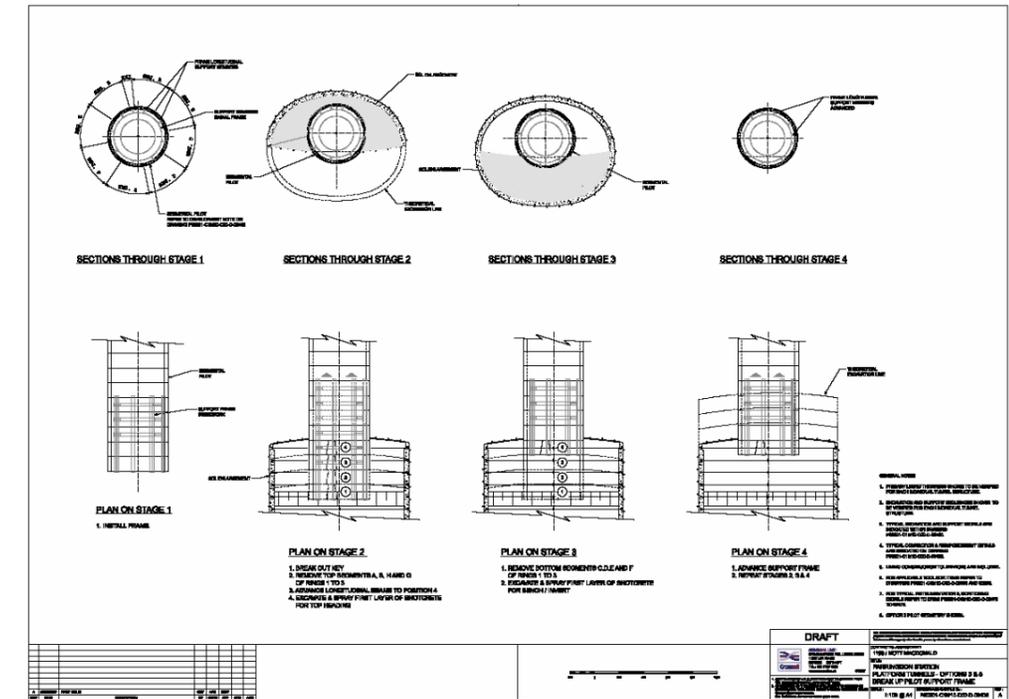


Figure 17 Platform Tunnel Enlargement Pilot tunnel support Construction Sequence

The basic platform tunnel excavation and support sequence will be as follows, based upon an abstract from “Farringdon Station, review of tunnelling options”, dated May 2007 (Ref CR-DV-FAR-CE-RT-00003).

- Step 1E. Installation of Groundwater Control Measures**
- Sequentially activate/re-activate pilot tunnel vacuum wells, as appropriate.
  - Undertake monitoring of piezometers outside enlargement profile.
  - Advance the zone of drainage or depressurization of the ground ahead of the face using vacuum wells
  - Verify that the pore pressure in the ground around the area to be excavated does not exceed 3kPa.
- Step 2E. Excavation and Support of Top Heading**
- Ensure propping of pilot tunnel is installed for the required length of tunnel ahead of the excavation.
  - Locate the tunnelling plant on one side of the pilot tunnel and break through face support and excavate top heading increment for one advance up to a maximum length of 1m.
  - Immediately after excavation undertake face logging and then install minimum 75mm SFR sealing shotcrete on all exposed ground surfaces.
  - Erect the lattice girder.
  - Install splice bars at the top heading – bench interface
  - Install SFR sprayed concrete to the required lining thickness (minimum 400mm including the 75mm sealing shotcrete thickness)
  - Transfer plant and equipment to the opposite side of the pilot tunnel and excavate the top heading a matching increment up to 1m in length.
  - Immediately after excavation undertake face logging, install minimum 75mm SFR sealing shotcrete

<p>on all exposed ground surfaces including the tunnel face</p> <ul style="list-style-type: none"> <li>i) Erect lattice girder.</li> <li>j) Install splice bars at the top heading – bench interface</li> <li>k) Install SFR sprayed concrete to the required lining thickness (minimum 400mm including the 75mm sealing shotcrete thickness)</li> <li>l) Dismantle and remove the exposed pilot tunnel segments and the length of redundant internal propping. And move/relocate the pilot tunnel support frame.</li> </ul>
<p><b>Step 3E. Excavation and Support of Bench</b></p> <ul style="list-style-type: none"> <li>a) Excavate the enlargement bench for a double heading advance increment (up to 2m maximum length).</li> <li>b) Immediately after excavation, undertake face logging and install minimum 75mm SFR sealing shotcrete on all exposed ground surfaces including the inclined tunnel face</li> <li>c) Erect lattice girders.</li> <li>d) Bend down splice bars previously installed during the top heading construction to fully embed them in the shotcrete lining</li> <li>e) Install SFR sprayed concrete to the required lining thickness (minimum 400mm (including the 75mm sealing shotcrete thickness)</li> </ul>
<p><b>Step 4E. Excavation and Support of Invert</b></p> <ul style="list-style-type: none"> <li>a.) Excavate enlargement invert increment of maximum 2m length</li> <li>b.) Immediately after excavation and face logging, install minimum 75mm SFR sealing shotcrete on all exposed ground surfaces including the inclined tunnel face</li> <li>c.) Erect lattice girders.</li> <li>d.) Bend down splice bars previously installed during the bench construction to fully embed them in the shotcrete lining</li> <li>e.) Install SFR sprayed concrete to the full lining thickness of minimum 400mm (including 75mm sealing shotcrete thickness)</li> </ul>
<p><b>Step 5E. Repeat Steps 1E to 4E until completion of the enlargement.</b></p>

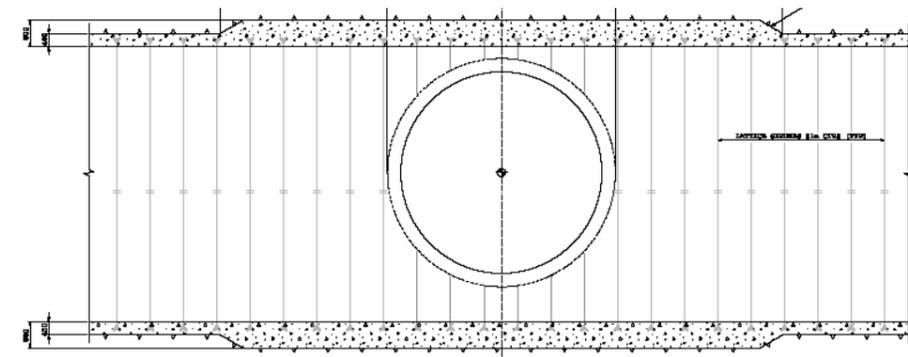
**Table 29 The SCL Excavation Sequence**

During construction of the platform tunnel, local thickening of the tunnel lining will be required at the junction breakout locations for cross-passages and vent tunnels. At these locations the lining will be thickened by 400mm to 800mm over a distance equivalent to half the opening diameter either side of the opening location, subject to design verification. This thickening is created by locally enlarging the excavated profile and spraying two layers of shotcrete.

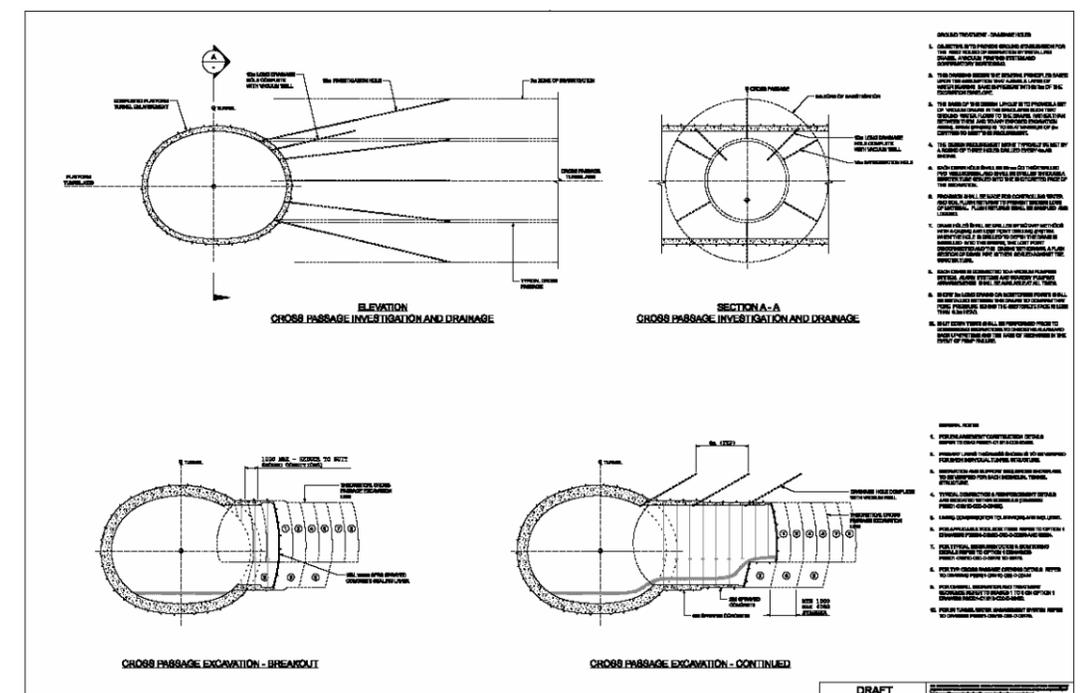
At locations where cross passage are to “break in” to a platform tunnel an external ring beam will be formed on the extrados of the platform lining from the cross passage prior to breakthrough.

Prior to construction of the opening a pattern of drainage holes will be drilled between the two platform tunnels as shown on Drawing C00-D-00412. Should water bearing sand layers be detected, these holes would be connected to vacuum groundwater control equipment.

The cross passage junction arrangements described are illustrated in the following figures. Cross passage design, development and space-proofing during Scheme Design stage is discussed in section 10.3.6 of this report.



**Figure 18** Section through the Platform Tunnel Enlargement at a Cross-passage junction



**Figure 19** Platform Tunnel Enlargement groundwater mitigation measures for cross-passage construction

The flexibility of SCL construction allows for the use of various specific tunnelling tools to be defined in the contract documents in a ‘non-systematic’ way which compliment and

augment the basic design to mitigate changes in the assessed construction risks. The application of these tools will follow pre-defined processes which are included in the contract documents to cater for anticipated conditions that will only occur along limited lengths of the tunnels.

These measures are colloquially termed '*toolbox measures*'. Good practice ensures that the content of the '*toolbox*' is assessed prior to tunnelling and continually reviewed during tunnelling and their use agreed with the supervisory team. The resources, equipment and materials must be readily available to allow them to be implemented immediately they are required.

A key to the success of toolbox measures is to have widely understood criteria as to when to implement them. Toolbox measures have been included in the systematic design to be used in a non-systematic way to account for variations in ground behaviour which will have been identified in advance by pilot tunnel probing and verified by the routine face logging procedures.

The toolbox items are shown on example drawings C00-D-00407, 00560 and 00564 for the pilot and C00-D-00430 and C00-D-00470 to C00-D-00473 for the enlargement as presented in "Farringdon Station, review of tunnelling options", dated May 2007, (Ref CR-DV-FAR-CE-RT-00003), abstracts of which are included in the later figures in this section for ease of reference.

The toolbox items assessed to be available for the construction of the pilot, platform and ancillary tunnels include:

- grouted pipe arch; (pipes drilled above and around the profile for the next advance and grouted in place prior to excavation)
- grouted pipe spiles; (solid metal bars drilled above and around the profile for the next advance)
- pocket excavation; (further partitioning of the face into localised excavations further reducing face area exposed at any one time in order to incrementally emplace the tunnel primary lining)
- face "dumpling"; (a mound or bench of spoil left in place against the face for passive support)
- face dowels; (sacrificial glass or carbon fibre rods placed into the face to bind the ground akin to soil nails which will be subsequently removed by subsequent stages of excavation)
- reduced advance length and increased shotcrete thicknesses
- the provision of additional drainage and de-pressurisation wells

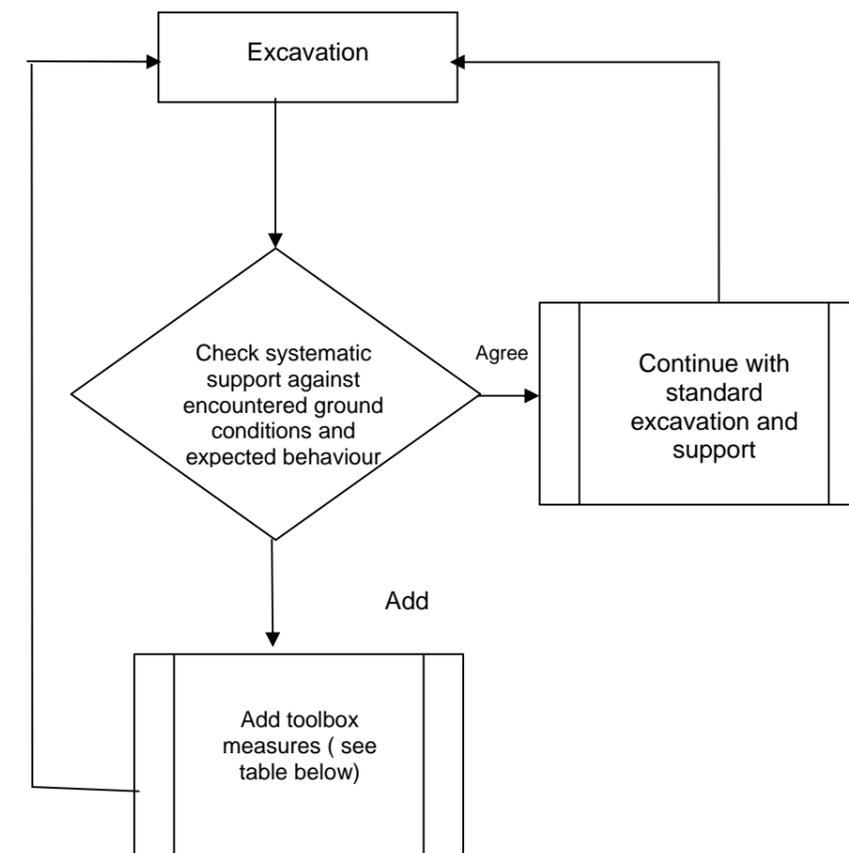
Appropriate tool box items have been selected based on past experience and effectiveness on comparable projects.

As a general requirement, the ground conditions revealed at each tunnel face shall be logged and evaluated against the expected conditions that formed the basis of the design

which were initially confirmed by probe drilling from the pilot tunnel. The visual inspections, monitoring results from the surface, subsurface and in-tunnel instrumentation will be reviewed to assess if the standard ground support is sufficient or whether the implementation of toolbox items is required. In recent UK projects this procedure has been termed the "Required Excavation Support" (RES) Procedure.

Toolbox items specified by the RES Procedures are documented and are then applied until the tunnel progresses beyond the area of concern and the toolbox measures are discontinued as a result of a decision taken under the RES process.

The flowchart below outlines the decision making RES process that will be implemented on site and will form part of the daily routine carried out by the Contractor's and Client's supervisory personnel.



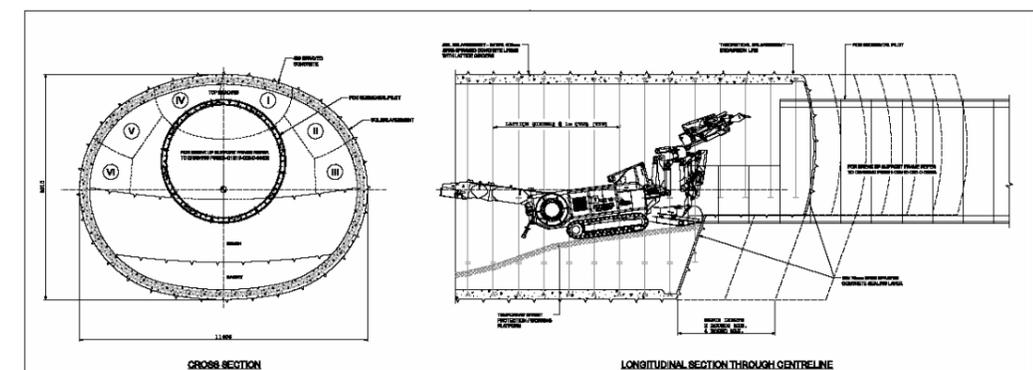
**Figure 20 Flow diagram for the Required Excavation and Support (RES) decision making process**

Observation	Proposed Toolbox Item
Sand layer appears in the tunnel face	<p>If layer is of small size and localized cover with SFR sprayed concrete.</p> <p>If the feature is extensive or assessed to have potential to increase during excavation, install grouted pipe spiling (4m long typically.) at the tunnel periphery in the subject area.</p> <p>If an extensive feature is encountered in face, immediately seal entire face with SFR sprayed concrete.</p> <p>If an extensive feature is expected ahead of the tunnel face, from the pilot probe drilling results, install grouted steel pipe arch of minimum. 8m length.</p> <p>If an untreated pocket of free flowing high volume water or high ground water pressure is detected, use additional well points to augment systematic groundwater control and delay excavation until assured of sufficient pore-water depressurisation.</p> <p>Undertake additional probe drilling.</p>
Highly fissured, blocky, slickensided material in face.	<p>If area is sufficient to cause significant over-break (&gt; 300mm), install grouted pipe spiling (4m long typically.) at tunnel perimeter in subject area or over the entire tunnel roof and shoulder area.</p> <p>If a highly fissured blocky zone is expected from the pilot probe drilling results that extends more than 4 m ahead of face, install grouted steel pipe arch of min. 8m length.</p> <p>If any pre-support measure is expected from probe drilling results to need to be repeated, provide sufficient overlap to minimise over-break and optimize efficiency.</p>
Highly fractured or low-strength material causes instability in the face during excavation	<p>Cease excavation and immediately apply SFR sprayed concrete for enhanced stability. If the unstable area is extensive, assess requirement for pocket excavation to complete the excavation for that round. Leave face stabilisation wedge (or "dumpling") resulting from pocket excavation in place against the face.</p> <p>Undertake additional probe drilling.</p> <p>If the unstable area extends over large areas of the face or into the roof and shoulder, install grouted pipe spiling over the entire roof and shoulder area prior to excavation for the next round in sequence and augment the lining if appropriate – consider delaying and/or shortening the depth excavation for strength gain and stability,</p> <p>If it is to be expected that conditions will extend over longer distances, a grouted steel pipe arch should be installed in lieu of grouted pipe spiling.</p> <p>If any pre-support measure is expected to be repeated based on probe drilling results, sufficient overlap will be provided to minimise over-break and optimize efficiency.</p> <p>Assess whether the deployment of face dowelling may be beneficial in lieu of the face stabilisation wedge or "dumpling".</p>
Increased over-break during	Install grouted pipe spiling (4m long typically) for the excavation rounds to follow.

excavation	<p>Consider reducing the length of the future advance.</p> <p>Consider local pocket excavation.</p>
Discontinuity planes occur in face that may encourage the dislocation of blocks or blocks dislocate from the face.	<p>With larger blocks dislocating, cease excavation, record block dimension and orientation and seal face with SFR sprayed concrete. Finish the excavation round leaving a face stabilisation wedge in place.</p> <p>Install grouted spiling in tunnel roof and shoulder area prior to commencing excavation for the next round in sequence.</p> <p>Excavate, leave face stabilisation wedge or "dumpling".</p> <p>Assess whether face dowelling may be used in lieu of a face stabilisation wedge/"dumpling".</p> <p>Consider reducing the length of the future advance.</p> <p>Consider pocketed excavation.</p>
Sand/silt lens occurs in face displaying free water and indicating insufficient drainage	<p>Immediately cease excavation and seal entire face with SFR sprayed concrete.</p> <p>Install steel set/lattice girder, if the excavation round is not fully completed remove sufficient ground to allow proper installation.</p> <p>Install full sprayed concrete support. Probe drill &amp; Install additional well points into the water discharging layer and delay future excavation until assured of drainage or sufficient pore-water depressurisation.</p>

**Table 30 Criteria for the Implementation of toolbox measures**

Examples of the above "toolbox" augmentation items are given in the following figures:



**Figure 21 Toolbox Item – "Pocketed" excavation**

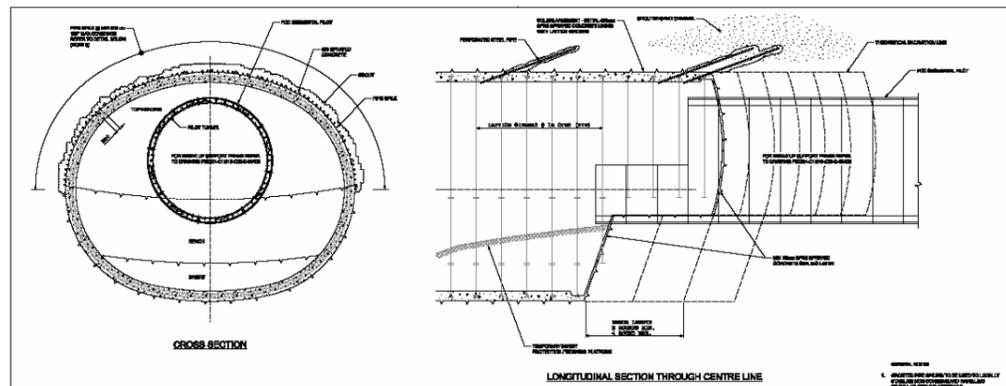


Figure 22 Toolbox Item – “Spiling”

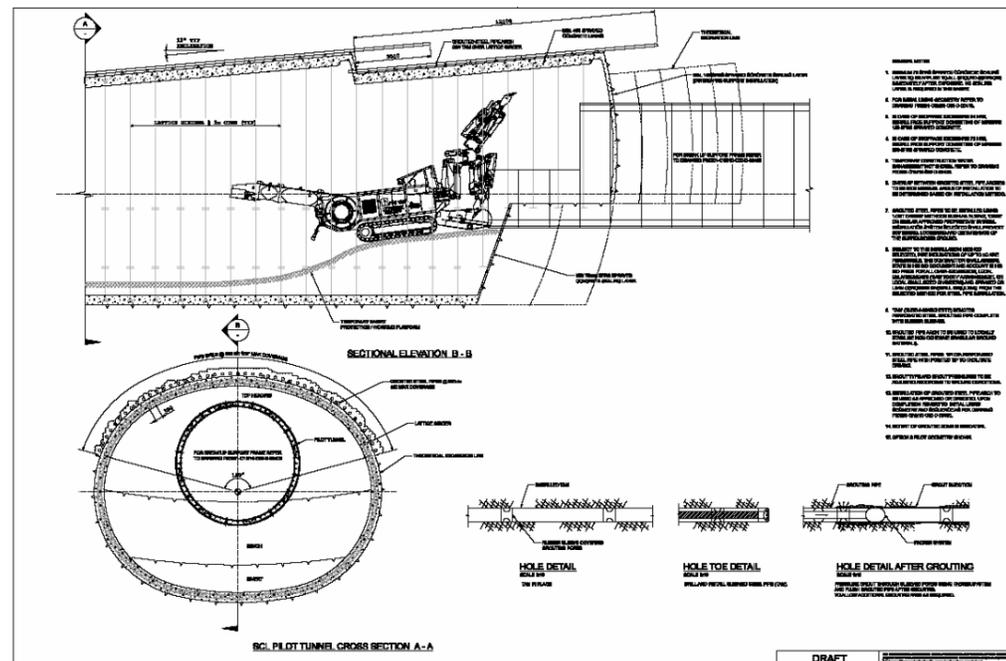


Figure 23 Toolbox Item – “Grouted Pipe Arch Canopy”

**Running Tunnel TBM Removals**

The construction planning currently does not allow for any significant demands or impact arising from the removal of the running tunnel TBMs. They are assumed to be dismantled in-situ with the internal elements removed by construction railway back to their respective portals leaving the shield skin in place which will be lined through with segments or cast in-situ reinforced concrete.

Only passive provisions for this work are anticipated such as:

- Personnel and Tool access and egress.
- Provision of power, water and ventilation.
- Welfare and access facilities for staff.

There is no provision for heavy lifting facilities, additional HGV movements, lay-down areas or on-site parking either in terms of site area or programming at either the Western or Eastern Ticket Hall sites.

The Eastbound running tunnel TBM would encounter the piles from Cardinal House prior to breakthrough into the Eastbound shaft unless these are removed in advance. This will be accommodated by the creation of an SCL reception or back-shunt tunnel driven westwards from the Eastbound circular shaft to mine through the obstructions prior to the running tunnel TBM arrival. This work is done within the footprint of the site and its long established dewatering regime once SCL works on the Eastbound Platform Tunnel enlargement are well established.

**Tunnel Secondary Lining Cleanout Works Undertaken from the Western Ticket Hall Site**

Upon completion of SCL tunnelling and Pilot tunnel TBM removal, the shotcrete batching facility on the Western Ticket Hall site will be decommissioned and removed and all future shotcrete operations, such as the escalator tunnels will wholly rely on external ready-mix supplies with on-site static re-mixer storage facilities.

The spoil placed in the invert to form the protective temporary working layer will be progressively removed in a “clean-out” process using the tunnelling back-actor excavator and spoil haulage plant. The invert surfaces will be cleaned down using a pressure-washer and all temporary fixings such as pipe and cable brackets will be removed and the surface smoothed off.

These activities will be undertaken working back towards the West Ticket Hall shafts where the spoil will be handled in the same manner as the excavated spoil during SCL works. Once these “clean-out” operations are completed, the spoil handling logistics on the Western Ticket Hall site will be decommissioned and removed. This will permit escalator box excavation, jet grouting, escalator tunnel construction and OSD caisson sinking activities to be undertaken .

The tunnel invert will have a geotextile fleece and drain installed, covered by a waterproofing membrane upon which the first layer of secondary lining invert concrete will be cast using a travelling shutter.

A scaffold, travelling on the new tunnelling invert will then be used to install a geotextile drainage fleece and waterproof membrane in the tunnel crown, shoulders and flanks which lap onto the invert layers installed in the preceding operation.

A travelling crown shutter will then be erected within the waterproofed tunnel, travelling on the invert concrete and will be used to cast the tunnel secondary lining.

All the secondary lining activities will be supported from the Eastern Ticket Hall site with access through the main shaft structure, This will then permit the lining out of the Western Ticket Hall shafts and construction of the outstanding works at the Western Ticket Hall. This switch in underground logistic support location is necessary to ensure that the Western Ticket Hall is completed at the earliest point in the programme and any delays are accommodated by the programming of the Eastern Ticket Hall where there is scope to provide emergency access and egress whilst delaying the opening of the ticket hall itself, this is in accord with the programme priorities outlined in Section 12.1.

The change in support site means that the lining out processes will generally be undertaken West to East, retreating back to the Eastern Ticket Hall access points.

The timing of placing the secondary lining in the tunnels adjacent to the caissons of the Western Ticket Hall and escalators at both ends will be delayed until the excavation works for these structures have been completed to ensure deformation and stresses arising from these activities are not hidden or imposed on the secondary lining to the detriment of its design life.

### **Western Ticket Hall; Escalator Construction**

This commences with the reorganisation of the Western Ticket Hall site, removing the bulk spoil handling facilities used during SCL works and tunnel cleanout such as the spoil storage bins, conveyors and lorry loading hoppers. This permits the site temporary base slab to be broken out to expose the escalator box piles installed at the outset of the project works which will be capped whilst local spoil handling arrangements will be installed on the site. Concurrent with these activities the caisson sinking works described subsequently will also commence and will share the spoil removal arrangements.

The escalator box will be dug out as a series of excavations staged to suit the installation of the internal whaling beams and props.

Upon completion of the box excavation, the area will be cleared and jet grouting equipment will be mobilised with supporting logistics in the form of cement silos, pumps and agitated holding tanks for the large volumes of cementitious spoil arisings from the grouting process. Sub horizontal jet grouting will then be undertaken through the headwall of the box.

On completion of the jet grouting the plant and logistics will be demobilised and a drilling rig mobilise to site to install an inclined grouted pipe arch in the treated ground to protect the St John's branch of the Fleet Sewer and the Thameslink infrastructure and operations.

During the above operations close monitoring of the Thameslink southern station structure and railway infrastructure will be undertaken with EPP provisions including structural jacking, track fettling and speed restrictions.

The escalator shaft from the ticket hall basement level to station platform level will be constructed using SCL methods

In order to receive the escalator tunnel at the headwall of the lower machine chamber the excavation will have included the provision of a ring beam eye structure in the end wall and the area will have an inclined permanent concrete support ramp cast which will protect the underlying escape adit structure from the impact of any arising ground movements. The remainder of the headwall face above the ramp will be supported by a sacrificial infill of foamed concrete through which the escalator tunnel will be mined.

Following the completion of preparatory works construction of the escalator will be carried out in the following sequence:

- Set up, excavate and primary line escalator to full depth in advance lengths of no greater than 1m.
- Clean out tunnel smooth off the primary lining and install drainage layer and waterproof membrane, bottom up;
- Set shutters and concrete invert, bottom up;
- Erect scaffold, set shutters and concrete crown of tunnel, bottom up;
- Set shutters and cast concrete bed for escalators, bottom up;
- Commence superstructure work and "fit out" in accordance with programme access constraints.
- Once ground movements due to the escalator and caisson works have ceased the secondary lining for the lower concourse will be installed.

### **Western Ticket Hall, OSD Caisson sinking.**

The caissons necessary for the OSD foundations on the Western Ticket Hall site will be sunk sequentially and commence once the site has been cleared of bulk spoil handling logistic provisions as they are located along the line of the site access ramp off Farringdon Road and cannot be accommodated earlier.

These will be sunk by traditional shaft sinking methods using a gantry crane and utilise the same spoil removal provisions as the escalator shaft.

These will be the deepest excavations undertaken on the site and will be reliant on the dewatering measures on the Thanet Sands.

On completion of each shaft the caisson reinforcement shall be installed and the caisson cast whilst the next caisson shaft is commenced.

On completion of the final caisson, the capping beam will be placed and the secondary linings of the adjacent tunnels will be cast completing the underground lining works.

The late timing of these foundation works is deliberate to ensure that they are unaffected by the effects of Crossrail tunnelling, the caisson design will ensure that the section at and above tunnel level is sleeved to ensure there is no skin friction loading on the tunnels arising from the subsequent OSD construction which will occur during Crossrail commissioning or operations when late repairs cannot be accommodated.

Whilst 3 caissons are currently planned in the south-eastern corner of the site, the OSD design is still ongoing and similar caissons may prove necessary in the north-western corner of the site and would be undertaken in tandem over the same time period.

#### **Western Ticket Hall, Eastbound Shaft Permanent Lining and Internal Walls**

This work will only commence once alternative logistical support provisions for the tunnel secondary lining works has been established from the Eastern Ticket Hall site and the shaft is no longer required for the provision of major logistical activities such as concrete and reinforcement delivery or spoil and plant handling, thereafter the shaft will be used only for the provision of ventilation, power and emergency access and egress.

The sequence for lining out the shaft will comprise of the following activities:

- Excavate the temporary working invert slab installed for the SCL works and removal of the temporary backfill to expose the permanent base-slab.
- Cast base layer with sump, drainage provisions, waterproofing and reinforcement to form the base of the secondary lining and internal walls including the track base.
- Cast lining, stairs and internal walls up to the prop at 90.85mOD, including the platform and running tunnel permanent eye structures.
- Install a false-work deck and encase the prop and cast the permanent whaling ring-beam (90.85mOD).
- Cast lining, stairs and internal walls up to the prop at 94.62mOD,
- Install a false-work deck and encase the prop and cast the permanent whaling ring-beam (94.62mOD).
- Cast lining, stairs and internal walls to the prop at 101.22mOD.
- Install a false-work deck and encase the prop and cast the permanent whaling ring-beam (101.22mOD).
- Cast lining, stairs and internal walls to the ground level prop at 105.50mOD.
- Install a false-work deck and encase the prop and cast the permanent whaling ring-beam (105.50mOD).

The Eastbound shaft can then be incorporated into the Ticket Hall basement works described in the section below.

#### **Western Ticket Hall, Ticket Hall and OSD Foundation and Construction Works**

Where possible concurrent with the shaft lining, caisson and escalator tunnel works the piles that form the foundations of the ticket hall and over site development (OSD) will be exposed, tested and capped. The Scheme Design includes a number of deep cantilevered ground beams installed during the preceding Thameslink work that must also be located and linked to additional piles placed during the Crossrail Western ticket hall construction to form the coherent foundation structure for the OSD.

These foundation works will extend beyond the shaft and tunnel activities and will result in the complete removal of the site working slab and the site road access ramps. At this stage the only site access will be through Caxton House basement car park and deliveries to the site will be offloaded from Cowcross Street.

A tower crane will be installed on the site for this purpose and to provide crane support to the future construction activities across the site. The crane will be centrally located on the OSD core foundation adjacent to the Eastbound shaft and be a jibbing crane with slew and programmed operational restrictions to ensure protection of the Thameslink railway from lifting operations.

The sequencing of these works has not been developed in detail but will be a complex sequence during which the discrete construction elements will be placed to form the basement slab, internal walls, road level deck, OSD core, ventilation ducts and “crash” deck above which the future OSD will be built.

In the works to this point the interface with the existing Thameslink structure will have been a simple exclusion barrier to separate the site and Thameslink operations. During the ticket hall construction works the boundaries with Thameslink will require planned phased revision to permit construction and installation of the interface structures and equipment; this will be a significant control on the sequencing of these work activities which is difficult to assess and represents a significant programme risk item.

During completion of the civil construction works the site will be progressively handed over to M&E fit-out and finishing work activities.

### 12.2.2 Charterhouse Square Temporary Construction shaft.

This is a short term shaft which is crucial to the station construction but which currently will form no part of the permanent works, as such, it does not fall within the scope of the permanent design.

The shaft is necessary to fulfil the following roles:

- The reception and recovery of the eastbound pilot tunnel TBM.
- The installation and support of pilot tunnel probing and dewatering measures before and during platform enlargement.
- The reception and dismantling of the Eastbound running tunnel TBM arriving from the East.
- The provision of ventilation and emergency access and egress during construction.
- Minor logistic support e.g. pumped concrete supplies during lining construction in the station tunnels.

The available site area means that the shaft axis is slightly offset from the Eastbound tunnel alignment and cannot be adjusted due to the proximity of the Barbican station platform 1. To overcome this requires the shaft profile to enlarge eccentrically to the south at tunnel level to form a TBM reception chamber. This is most readily accommodated by the adoption of SCL techniques.

As with all other shafts on this site the work will not commence until site investigation and groundwater control measures have been installed.

The close proximity of the shaft to the LU lines makes settlement control a critical factor and piling will be undertaken in advance of shaft sinking to create a contiguous pile “cut-off” wall between the shaft and surrounding structures including the LU platforms and railway. Prior to sinking the shaft beyond the London Clay level and forming the enlargement chamber, excavation will pause to permit the installation of an inclined pipe canopy, at the same time additional in shaft dewatering wells will be installed.

The shaft is similar in form to that created at Barrington Road on the CTRL project excavated in Lambeth Group and Thanet Sand materials alongside the Gospel Oak to Barking railway in the flanks of the Lea Valley but is both smaller in size and has greater settlement control mitigation due to the piling provisions described above.

The temporary shaft construction is constrained by the sequence of construction for the East Ticket Hall, in that, to build the main shaft at the East Ticket Hall, the party wall between the new ticket hall and LU lines must be constructed by infilling an opening in the cut and cover structure occupied by the LU lines. This opening is referred to as the “siding

gap” and is a disused structural opening formed to permit trains to access a siding tunnel in the past. To do this requires all LU cables at this location to be re-routed along the opposite northern side of the LU tracks and hence along Platform 1. This means that the wall at the rear of Platform 1 must be maintained during the sinking of the temporary shaft. This constrains the site area available for the shaft and dictates the shaft dimension to approximately 6m internal diameter unless an elliptical shape is considered.

The sequence of construction and usage for the shaft will be:

- Demolition of 33-37 Charterhouse Square to street level.
- Infilling of the basements beneath the road in Charterhouse Square and removal of the internal basement walls and any necessary support of the party wall with the Barbican station.
- Hoarding off the pavement and single carriageway for loading and unloading and to control noise and dust impact on Charterhouse Square.
- The LU asset and operation monitoring and management provisions which were in place during demolition will be amended to suit the changing methods of work on the site.
- Mobilisation of drilling equipment to undertake Site Investigation drilling, installation of piezometers, passive wells within the shaft footprint, ejector wells within the Lambeth Group and a deep abstraction well within the Chalk to control the lower aquifer level if required.
- Mobilisation of low headroom piling plant to install the shaft perimeter 600mm diameter contiguous piles and any piles required for the temporary works, e.g. shaft gantry crane and working deck provisions.
- After the groundworks are complete the site will be decked over at street level to give two working levels. The deck will include a 25 tonne gantry crane with 15 tonne overshot capacity for on street loading. The dewatering provisions will be at basement level as will ventilation, fixed plant ; compressors, fuel store, air reservoir and shotcrete dosage pump) and minor storage and welfare. At street level will be provision of a static concrete re-mixer to hold ready mix shotcrete, lay down area for a 5 m<sup>3</sup> skip, lattice girders and for the 3.5 tonne knuckled backhoe excavator used for shaft sinking. The crane capacity is sufficient to allow for handling drilling plant within the shaft and potential for removal of TBM parts if required. The gantry crane will need to be set up for the handling man carrying baskets for shaft access and egress.
- The shaft will then be sunk in alternating quadrants in advances of 1m or less determined by the productivity attainable within the permitted working hours of the site.

- At a level 2m from the base of the London Clay, as indicated by the SI and dewatering borehole records, the shaft sinking shall stop and a temporary blinding layer will be installed.
- Drilling equipment will be mobilised and lowered into the shaft to install a canopy of inclined pipes over the future enlargement. This will also be an opportunity to enhance dewatering measures in the Lambeth group using vacuum wells drilled in an umbrella from the shaft if the previous provisions undertaken from the surface are found to require augmentation, as shown by the canopy drilling.
- The drilling equipment will then be demobilised and shaft sinking will resume.
- The shaft will “bell out” to form the reception chamber and as the shaft sinks past the tunnel level reception eyes will be incorporated into the SCL lining.
- The shaft will bottom out in a traditional domed structure and a base plug will be cast at the level appropriate to the running tunnel track-bed. The SCL logistics will be demobilised at surface.
- The reception cradle for the EB platform pilot TBM will then be erected in preparation for its arrival along with any enhanced monitoring requirements.
- After breakthrough the EB pilot TBM will be dismantled with the backup gantries withdrawn to the shaft at the western ticket hall. The head and shield will be dismantled and either lifted to surface to be returned to the western ticket hall site by road for refabrication in the WB shaft or taken back along the tunnel. This will be determined by the TBM design specifically the piece-weights of the components and crane capacity that can be realised on the Charterhouse Square site.
- Once the TBM has been removed the shaft will be used for material and personnel access during probing and dewatering from the pilot tunnel, ventilation, power supply, water removal and provision of access for emergency services if required.
- This role will be maintained throughout the SCL enlargement works,
- A reception gantry for the EB running tunnel from Limmo will be erected in preparation for its arrival and after breakthrough the TBM will be dismantled and drawn back to Limmo.
- Once the second TBM has been removed and pilot dewatering provisions are completed the reception chamber will be waterproofed and backfilled in a series of concrete pours. A number of pipes and ducts may be provided between surface and tunnel level at this time to continue providing subsidiary power, ventilation and concrete supplies during station lining works but the requirement for access and material lifting is no longer required. The shaft will be backfilled to surface and the site cleared of decking and logistics.

- The timing of shaft backfilling is related to access to permit piling for the façade supporting OSD and pedestrian overbridge which will be undertaken once the party wall with LU Barbican station has been demolished. These are described in the next section.

### 12.2.3 Eastern Ticket Hall

In addition to the parliamentary undertakings relating to the site there are a number of key constraints and drivers behind the sequencing of the demolition and construction works on the Eastern Ticket Hall site, these are:

1. The protection and the timing of the decommissioning and removal of the LU Interlocking Machine Room (IMR) which is located at a critical location within the site.
2. The provision of abutments and subsequent craneage with sufficient reach and capacity to place the main structural spanning elements of the pedestrian over-bridge structure in the LU Barbican Station.
3. The provision of a secure party wall structure which supports Charterhouse Street above the LU Metropolitan Line tracks prior to undertaking the diaphragm wall works for the box structure, this is reliant on the IMR removal mentioned above.
4. The timing of protection and relocation of LU cables affected by the works described in items 2 & 3 above.
5. The excavation of the diaphragm walled shaft to Crossrail platform level in time to permit provision of access and logistical support for pilot and running tunnel TBM removal and the tunnel secondary lining works; thereby allowing the Western Ticket Hall site to be released for ticket hall construction activities.

This produces a complex programme sequence and this combined, with the underground works, result in the Eastern Ticket Hall completing later than the Western Ticket Hall. This is in accordance with the priorities outlined in the Introduction, Section 12.1.

The Eastern Ticket Hall construction work assumes that the Thameslink Moorgate branch lines and associated utilities have been fully decommissioned and removed. Although there is overlap between the enabling works demolition and the main works, the outline construction sequence is as follows:-

- The provision of temporary ventilation provisions for Smithfield Market Basement car park along the disused Moorgate Trackbed.
- The provision of emergency escape provisions for Smithfield Market basement car-park during the works.
- The provision of dust and noise hoardings around the site to protect Smithfield Market, Charterhouse Square and businesses in Hayne St and Long Lane.

- The demolition of retaining wall and deck and bridge structures with attendant enabling and control measures, following completion of the enabling works demolition (see section 12.4 of this report).
- The provision of staged archaeological investigations.
- The provision of dewatering monitoring and deep abstraction and ejector wells.
- The provision of monitoring and protection for the Combined Heat and Power tunnel under Long Lane.
- The mobilisation of piling plant and staged emplacement of piles across the site, with separate provision of piling equipment at the Charterhouse Square site.
- The first stage of re-routing of LU cables to permit the following work.
- The staged underpinning of the LU party wall structure and the infill of the siding gap in the party wall.
- The structural augmentation of Hayne Street Bridge to facilitate later demolition.
- The reprovision and relocation of the LU IMR to an off site position.
- The mobilisation of diaphragm walling equipment and installation of the diaphragm walls of the main shaft.
- Mobilisation of tower and high capacity crawler crane followed by the staged excavation and ring beam construction of the shaft.
- Undertake phase 2 of the LU cable relocation works.
- The emplacement of the basal slab and deck to the box and the formation of tunnel eyes and pipe arches at platform level.
- The reception and removal of the WB pilot tunnel TBM.
- The provision of dewatering support to the WB pilot tunnel.
- The provision of SCL plant and logistics.
- The construction of an SCL tunnel and mid point borehole to link to the EB pilot tunnel and provision of de-watering support.
- The provision of sacrificial support in the WB pilot tunnel.
- The commencement of SCL enlargement activity in the WB platform tunnel to a meeting point situated half way along the tunnel.
- The reception and removal of the WB running tunnel TBM arriving from the East
- Provided the ongoing access and logistic support to the platform level tunnels waterproofing and secondary lining works.
- Lining out of the shaft and formation of structural floor decks to escalator level with platform level works supported through holes in the decks subsequently used for ventilation and service risers.
- The provision of breakout eyes and pipe arch prior to breakout and construction of the escalator upper concourse & machine chamber.
- Under repeated pipe arch provisions construction of the escalator barrel in a pilot and enlargement sequence into the lower concourse, formed earlier from the platform tunnels and prepared with an inclined concrete ramp and lining breakthrough augmentations.
- The excavation and lining of the deep level vent link to the EB platform tunnel.

- Once the temporary construction shaft at Charterhouse Square has been backfilled place the piles and cast the bridge abutments for the pedestrian over-bridge spanning the LU Barbican station.
- Once the tunnelling affecting the Barbican has been completed and all settlement effects have effectively ceased form the new southern span of Hayne St Bridge and demolish the old arch.
- On completion of escalator excavation continue with the bottom up lining and internal wall works within the shaft to surface.
- Construct the LU Moorgate train-path box across the shaft.
- Provide temporary supports to the box and mobilise 500t crane to be sited on the box roof accessing the site from Lindsey St.
- Deliver and fabricate the Barbican pedestrian over-bridge elements in the southern site area and lift them into possession during LU weekend possessions.
- Demobilise crane and remove temporary works, complete over-bridge fabrication in-situ.
- Commence construction of the OSD and facade site works at Charterhouse Square and the Ventilation discharge works on the 3 Hayne Street site and fit out of the pedestrian over-bridge, fit parapets and resurface Hayne Street Bridge.
- Commence the excavation and construction of the escalator “notch” and station basement box to the south of the main shaft.
- Expose and cap the OSD piles in the southern site area.
- Amend the final ground level by placing structural fill and excavation followed by casting of ground level slab across the southern basement box and construction of basement and road level ticket hall including interface with Hayne Street Bridge structure.
- Construction of station superstructure and casting of OSD crash deck.
- Dismantling of tower crane and removal of LU protection provisions.
- Progressive hand over of ticket hall to M&E and finishing work contractors.

The sequencing makes no allowance for any impacts arising from the arrival of the running tunnel TBMs, from the East, launched from the Limmo shaft site. These are currently assumed to be dismantled in place and removed back to the Limmo shaft or lifted from the shaft without impact on the station programme or works.

#### **Eastern Ticket Hall Demolition Works and Archaeological Investigations**

Site set-up and initial demolition works will be carried out as part of the enabling works, as discussed in section 12.4. There is likely to be a certain amount of overlap between enabling works demolition and start of main works, however it is assumed that the main works demolition sequence and archaeological investigations will be as follows:

- Provisions of monitoring and Protection provisions for LU assets and operations will be in place and undergoing commissioning.
- Demolition of buildings will be undertaken generally south to north, commencing with 3 Lindsey Street.

- Due to the critical role and timing of the temporary construction shaft described in section 12.2.2 the demolition of 33-37 Charterhouse Square will be concurrent with the above and undertaken with full LU asset and operation protection measures.
- Demolition of 20-23 Long Lane,
- Formation of access ramp to basement level off Lindsey Street, establish mobile crusher and grader unit for debris handling.
- Demolition of 8-9 Hayne Street.
- Demolition of 4 Lindsey Street.
- The relocation of the ventilation outlet for Smithfield market basement car park, will be have been instigated as enabling works but the removal of the redundant vent unit is undertaken now once access has been achieved by the above demolitions.
- The Moorgate line tracks will be cut, lifted and moved to along the disused trackbed to the east for storage during the duration of construction.
- The ballast of the Thameslink track-bed will be removed.
- Concurrent with the above activities Smithfield House and 56-64 Charterhouse Street will be demolished with full monitoring and EPP provisions to protect LU assets and operations.
- The foundation for the crane required to dismantle the deck structure above the Thameslink lines and to the south of the LUL lines will then be established on the disused Thameslink track-bed.
- The demolition of the retaining wall structures adjacent to Hayne Street and decking structure spanning the Thameslink tracks will then commence. It is known from LU records that some of the column and beam structural elements of the deck and siding gap support structure have been identified as being defective, this will require investigation to confirm and assess the current condition and may result in temporary works or more intricate planning during demolition which will impact upon programme.
- Staged archaeological excavations will be undertaken following the demolition of the structures as and when the relevant site areas can be made available.
- Concurrent with demolition and archaeology there will be Investigations of the adjacent road supporting structures and installation of precautionary support measures as appropriate.
- With access established along the Thameslink track-bed the disused LU signal box abutting Hayne Street Bridge will be demolished during LU Engineering hours with materials removed during normal daytime hours.
- Precautionary investigation and reinforcement measures for the northern span of Hayne Street Bridge will be undertaken from the road level unless necessary from LU trackside which will be done during LU Engineering Hours.

### **Eastern Ticket Hall, Main Site Piling, Dewatering & Underpinning Works**

The piling works will be undertaken in a sequence that is concurrent with, and works around the sequence of demolition and archaeological investigation activities described above and will install the piles required for;

- Support of surrounding the adjacent road structures.
- Underpinning of the LU party wall.
- Station and OSD superstructure foundations.
- Main shaft tension piles.

The sequence of activities will be:

- Mobilise drilling plant to site once access to the Moorgate trackbed permits and drill SI holes including piezometers for monitoring dewatering.
- Install passive relief wells within the footprint of the main shaft,
- Install deep abstraction wells into the Chalk to control lower aquifer levels discharging into the Moorgate track-bed drain.
- Install ejector wells in the sand channel and granular deposits of the Lambeth Group focussing particularly on areas of the running tunnel and platform tunnel box openings and establish secure power supplies and disposal provisions. It is assumed these wells will be situated beneath Lindsey Street Bridge and in Hayne Street box area.
- Dewatering measures for the platform tunnel undertaken from surface along the disused Moorgate track-bed will then be installed working West to East.
- Concurrent with Si and dewatering drilling mobilise piling equipment to site once sufficient area on the site has been made available by demolition to provide separate working areas, albeit with a common point of access and egress.
- Once protective provisions are in place in the Combined Heat and Power tunnel below Long Lane and the stability of the road supporting arches beneath Lindsey St, Long Lane and Hayne St has been assured, install guide walls and commence installation of the Southern perimeter Hard – Firm secant piles to support the road pier foundations.
- During installation of the southern perimeter piles the temporary road access earth ramp will have to be removed and a longer term, temporary works, access ramp provided which has load capacity and slope angle suited to the future heavy plant requirements of the site. This may require the site working level to be raised and is an activity what will be concurrent with the establishment of the temporary working deck described subsequently.
- To install the southern perimeter piles, the point of access and egress from Smithfield Market basement car park need to be switched with appropriate protective measures to maintain this facility.
- The “over site development” OSD foundation piles will be installed concurrently with the perimeter piles working south to north up the site.
- Once access to the arches beneath Lindsey Street Bridge has been established and prior to construction of the new IMR provisions then investigative works, underpinning and internal bracing works will be undertaken in the siding tunnel adjacent to LU and below Lindsey Street to mitigate against the impact of later escalator tunnel construction. These activities will impact upon LU assets and require approvals, mitigation and planning. These works will impact upon the planned relocation of the

IMR into these un-used arches and will need to be integrated into this scheme in future planning of the detailed design.

- As the piles are installed the southern site area level will be adjusted and progressively capped with a temporary reinforced concrete working deck with drainage provisions, this will provide safe long term working conditions during the subsequent works and a stable foundation for crane operations.
- The perimeter pile caps and exterior basement walls will be installed once piling progress permits.
- Following the demolition of the Moorgate track deck structure the investigation and LU underpinning piles for the party wall can commence with the works being undertaken during LU Engineering Hours. The underpinning capping beam will form part of the guide wall for the diaphragm wall and will be required to act as a beam resisting both settlement and lateral movement.
- Following the demolition of the deck structure safe access for piling plant to the Barbican station area can be established. This permits the installation of the following piles to be undertaken in the sequence:
  - Hayne St perimeter piles.
  - Barbican Island Platform Pedestrian Over-bridge mid point fabrication piles. Installed by low headroom piling equipment during LU Engineering Hours and weekend station possessions. They will be concurrent with the other piling activities in this area. Prior to this work the structure of the Island platform will need to be investigated and the necessary enabling provisions undertaken to permit access by the piling equipment.
  - Pedestrian over-bridge southern abutment piles.
- The siding gap foundations will be emplaced as a continuation of the underpinning mentioned above. Upon this foundation a structural reinforced concrete wall will be cast with a jacking and bearing cill beneath the existing lintel beam of the opening. The beam will then be jacked to transfer the load of the jack arches to this new wall. This work is required for the following reasons:
  - The siding gap requires an impact resistant barrier between Crossrail and LU tracks to conform to standards.
  - The jacks will provide a means of settlement mitigation for the jack-arches for subsequent shaft sinking and tunnelling.

These works are on the critical path of the construction programme and are a programme risk item.
- The deep piles required to form the tension piles at the base of the box will be installed at a time to suit the piling work programme any time after the deck removal has been completed and the IMR has been relocated.

### **Eastern Ticket Hall, Charterhouse Square Site Piling Works**

The piling works at Charterhouse Square will be undertaken in 2 stages and are undertaken separately from the piling works on the main site. As explained in Section

12.2.2 both phases of the piling works are critical to the overall construction programme, the first stage piling forming the temporary construction shaft, the second stage forming the pedestrian overbridge abutment prior to its construction.

The stage 1 works will be undertaken once the demolition of the superstructure on the site has been completed including removal of the basement internal walls. The basement party wall with the back of the LU Barbican Station platform 1 will be retained and act as a physical barrier between the site and the travelling public. The basement rooms of this structure that project beneath the Charterhouse Square pavement and road will be backfilled with concrete prior to piling.

The basement area will be dug out to permit archaeological investigations and obstruction clearance and then a temporary concrete working platform will be cast including guide walls for the shaft and party wall piles with 38 Charterhouse Sq.

A drilling rig will then be mobilised to site and lowered into the basement area to undertake SI holes, install piezometers and install dewatering measures previously described.

Partially concurrent with the above, a low headroom, lightweight piling rig will be lowered into the basement site supported by a lightweight tracked telescopic crane and the 600mm diameter contiguous piles for the shaft will be placed. Due to the maintenance of a structural dividing wall and low headroom plant it is anticipated that this work will be undertaken normal working hours with close LU supervision.

The piling equipment will be demobilised and the shaft works described in section 12.2.2 will then be undertaken.

Once LU cable movements permit, the structure of LU Barbican Platform 1 will be incrementally investigated & augmented during LU Engineering Hours to ensure it is structurally sound for the second stage of piling works. It is envisaged that this will involve the sequenced lifting of the platform deck, cleanout and subsequent infilling of the under platform void with concrete.

Once the temporary construction shaft backfilling works are complete a hoarding will be installed along LU Barbican platform 1 and the party wall structure will be demolished. The wall foundations and any obstructions to piling will then be cleared and the pile guide walls will be cast.

The low headroom piling plant and crane will be remobilised and place the piles necessary for the pedestrian over-bridge abutment followed by the piles for the site OSD. These will involve working with the rig sited on the Barbican platform, hence the above mitigation works. The absence of a physical barrier between the works and LU operations means that the works will be undertaken in LU engineering hours and weekend possessions. The effective shortening of the platform during piling may require “through running” of eastbound trains. Full monitoring and EPP provisions will be in place during these works.

During both piling phases deliveries of plant and materials will be made at the roadside with access via Charterhouse Square and a lane of this road will be hoarded off for this purpose. Spoil will be taken via dumper to the main Eastern Ticket Hall site for onward disposal.

### **Eastern Ticket Hall, 3 Hayne Street Piling Works.**

This is a site constrained by adjacent structures and the Barbican station cutting to the North. The piling at this location will be undertaken in 2 phases:

Phase 1. post building demolition piling to form a retaining wall to support adjacent structures to the south whilst the lower retaining wall structure is removed.

Phase 2. Piling for the pedestrian over-bridge abutment.

The phase 1 activity will involve a light-weight low headroom rig lowered into the demolished building basement to place 600mm diameter secant piles cored into the existing abutment and natural ground behind the wall. A robust support scaffold will be required on the Moorgate track-bed to support this work.

Once the lower section of the existing retaining wall has been removed and the new retaining wall façade has been cast then low headroom plant will be mobilised again for the Phase 2 works and will access the site along the Moorgate trackbed to install the piles for the pedestrian footbridge southern abutment. The rig and crane size is determined by the issues arising from proximity to the LU station and tracks and also the access restrictions formed by Hayne Street Bridge and the need for the plant to be lifted into position by crane across the main shaft or from Hayne St.

The Phase 1 piles will additionally extend across Hayne Street to permit construction of the ventilation corridor at this location and will be incorporated into the new southern span of Hayne Street Bridge.

### **Eastern Ticket Hall, Main Site Diaphragm Wall Works**

Diaphragm walling of the box is necessary to achieve the required placement accuracy at depth on the northern wall. To achieve this under the current Crossrail design standards requires a "mill" or "hydrophraise" cutter unit to be deployed as more traditional clam shell excavators are not credited with the required accuracy, though a clam shell grab is used to start each milled panel. Discussions with machine suppliers have indicated that the accuracy of modern clam shell operations have improved and would avoid the requirement for a "mill" to be deployed. This would make reduced demands on Bentonite mud provisions and handling which currently dominate the site during this operation. To comply with design standards the following text retains references to the panel milling operations.

To perform the diaphragm walling activities 3 crane units will be required on the site: one to operate the clam shell grab, one for the mill unit and one to place the reinforcement cages,

changeover between grab and mill units on one crane is possible but takes several days during which the panel would be left open. Due to the space required for the provision and operation of 3 crane units and the Bentonite plant necessary for panel stability during excavation and casting this activity has to commence once most piling works have been completed.

The works must await the completion of the IMR relocation works, the demolition of the disused IMR structure, the emplacement of the siding gap infill wall and the satisfactory completion of the LU party wall underpinning works. It is assumed that the new LU IMR and Cabling provisions have been designed to resist the settlement and vibration arising from the diaphragm walling activities.

Due to installation of the diaphragm wall panels adjacent to the footings of road and track supporting structures settlement is a major concern. This is mitigated by placing structural guide walls that act as beams to underpin and brace the adjacent footings and limiting the length of the panels used. Limiting the panel lengths is also required due to the limited site area available for bentonite handling and storage.

By employing the minimum panel sizes the diaphragm walling activities will be at their least efficient in terms of programming and plant use and will introduce the maximum number of wall joints which must be allowed for in the support and permanent lining waterproofing provisions.

Significant inefficiency would also arise during these operations due to the need to place panels along the northern circumference of the shaft which will be restricted by the requirement to work to time restrictions imposed by LU for protection of their operations which may result in panels only being placed at weekends or other limited periods when track speed restrictions are applied for reasons of public safety.

Due to the limited site area the reinforcement cages would be delivered to site as pre-fabricated units offloaded from Lindsey Street within the perimeter hoardings.

The diaphragm wall activities will be concurrent with some of the piling activities described previously, the sequence of activities will be:

- Excavate and place reinforced concrete structural guide walls around the shaft periphery with the guide wall adjacent to western side of Lindsey Street being emplaced as a series of lapped underpinning operations. The guide walls will be placed in stages to maintain access for other site activities.
- Mobilise diaphragm walling equipment to site comprising of 3 cranes, MEWP, 2 No. 300 cu m bentonite holding tanks, bentonite silos, cleaning & mixing plant.
- Commence panel placing along the southern wall as trial panels to prove equipment and methods and assess settlement impact prior to working alongside LU assets.
- Place panels progressively around the shaft sequenced with panel placement opportunities along the northern periphery.
- Demobilise plant and equipment upon completion.

### Eastern Ticket Hall, Bridge Construction Works

There are two aspects of bridge construction involved with the Eastern Ticket Hall. These are:

1. The reconstruction of the southern span of Hayne Street Bridge changing its form from the present brick arched structure to a slender portal frame structure necessary to permit construction of the pedestrian over bridge.
2. The provision of a pedestrian over bridge spanning across Barbican Station to provide pedestrian access from the new Crossrail station to the existing Barbican station platforms.

The former of these is essentially similar to the works being undertaken by the Thameslink Project to change the form of Cowcross Street bridge at Farringdon Station to enable the platform extensions to the south.

As alluded to in the text above, the first bridge construction activity is done in order to enable the construction of the latter so they must be completed in the given sequence.

The arched structure of Hayne Street Bridge implies the presence of lateral forces and the removal of one span potentially causing distress in the other, since the northern span is above the LU active tracks the impact of such distress is unacceptable and the construction methodology is determined by this with the new span elements being emplaced prior to demolition of the existing arch, thereby maintaining the structural integrity at all times. Thus the Hayne Street Bridge southern span works are concurrent with demolition and have already been described in some detail in section 10 of this report.

The phase 1 bridge works will comprise of the following:

- Enabling Activities:
  - Precautionary diversion of LU cables located on the central pier of Hayne Street Bridge to the northern abutment.
  - Installation of catch netting, monitoring and EPP provisions to protect LU assets and operations
  - Disconnection of utilities and the closure of Hayne St Bridge.
  - The closure of the Thameslink Moorgate branch line
- Mitigation works:
  - Hayne St Bridge parapet removal

- Road deck removal to expose spandrel gaps in southern abutment and central pier.
- Inspection of internal structure followed by staged infill of spandrel gaps by grout/concrete with tension ties and propping if required following inspection.
- Installation of a working platform on the bridge deck
- Mobilise low headroom low weight piling rig.
- Install contiguous piles through reinforced central pier and southern abutment.
- Await completion of tunnelling activities affecting the structure.
- Set soffit shutter for the new southern span deck on the existing lowered brick arch.
- Install reinforcement and tie in the pier and abutment pile cages to form a monolithic structure with full moment connections.
- Cast the new structural bridge deck and allow to cure.
- Demolish the now redundant brick arch beneath the deck slab and expose pile faces in pier and abutment.
- Infill any gaps between the exposed piles and form the new abutment and pier face with brick facades
- Undertake the phase 2 bridge works.
- Erect pre-cast bridge parapets and bolt to the new bridge deck.
- Resurface Hayne Street bridge deck.

This forms a monolithic bridge structure with full moment connections at the pile caps which are necessary to achieve the required design criteria. The slender deck that results is sufficient to permit construction of the pedestrian link described below whilst maintaining the minimum headroom for the rail path along the Moorgate track bed when it is reinstated at the end of construction.

The phase 2 bridge works will comprise of the following:

Programme dependencies:

1. The phase 1 bridge works must be substantially complete to the extent that the new deck is in place and the former arch has been removed.

2. The main shaft of the Eastern Ticket Hall must be substantially complete to the extent that the Moorgate track train-path box, which spans across the shaft and abuts the Hayne Street Bridge southern span must be complete.
3. The abutment structures located on the sites of 3 Hayne Street and 33-37 Charterhouse Square must be complete including the provision of the bridge bearings.
4. The site area to the south of the East Ticket Hall main shaft must be cleared of all site logistics to provide area sufficient for the delivery and fabrication of the over-bridge elements.
5. LU weekend possessions will need to be booked for the duration of the bridge element lifts.

#### Sequence of works:

- Fabrication of a temporary works sliding trestle along the Moorgate trackbed with appropriate slab foundations for the ensuing bridge element loads and active forces during the sliding and lifting of bridge erection.
- The delivery of the bridge elements to the East Ticket Hall site and their fabrication into the main and subsidiary bridge spans.
- The installation of temporary propping within the Moorgate train path box to ensure stability of the structure during crane erection and bridge lifts.
- The formation of access ramp for crane access onto the roof of the Moorgate train path box off Lindsey Street..
- The mobilisation of a 500t mobile crane and its erection on site.
- During an LU weekend possession lift the subsidiary bridge span from the site area south of the main shaft onto the sliding trestle, slide the subsidiary bridge element into the Moorgate train path box to clear the site area for the main span.
- During the same LU possession or a subsequent sequential one, lift the main bridge span from the site area south of the main shaft onto the bridge bearings on the abutments. During the same period lift into position the island platform access stairs
- Demobilise the 500t crane.
- The finishing stages of the phase 1 bridge works may now be recommenced and completed.

- Position and jack up the subsidiary bridge span off the sliding trestle and bolt on to the main bridge span.
- Within the Moorgate train path box connect the subsidiary bridge span to the suspension elements cast into the box roof.
- Release the bridge from the supporting trestle and dismantle the trestle and its temporary foundations along with the removal of the temporary box bracing installed for the crane and lifting operations.
- The pedestrian overbridge can now be fitted out and reinstatement of the Moorgate train path track-bed and rails may commence.

#### Eastern Ticket Hall, Shaft Excavation

The shaft excavation will be undertaken in stages dictated by the levels of the internal temporary ring beams. The ring beams are temporary and replaced by the floor decks when the box is lined and fitted out bottom-up later in the sequence of construction. This arrangement allows rapid shaft excavation necessary to fit the overall programme and the resolution of later spatial conflicts between the ring beams and the PRM lift shaft and escape stairs during lining out of the shaft.

After each stage of excavation a sacrificial blinding concrete layer will be placed across the base of the shaft to prevent deterioration of materials and give a safe working surface layer for plant operations.

The shaft excavation can only be effectively accessed from the southern area of the site and this constrains cranning, particularly in terms of lifting capacity along the northern wall of the shaft. The shaft excavation also cuts off the access route to the Barbican Station area where the Hayne Street Bridge and Pedestrian Over-bridge works will be in progress and constrains the methods and sequence of works accordingly.

To support the site works within the shaft and Barbican area a tower crane will be installed for lifting and delivery of moderate loads. This will not have the capacity to handle the heavy plant, steel prop and spoil skips during shaft excavation and a high load capacity crawler crane will be mobilised to site to service these requirements. The planning and co-ordination of lifting operations will be a significant safety constraint during the shaft sinking works and the height of the tower crane will be sufficient to avoid conflict with the crawler crane.

Due to the limited access and site area on the southern site spoil loading will be undertaken via conveyor and covered hoppers sited on Lindsey Street which would be fed

by conveyor from a spoil storage and handling compound on the lower southern site level. Similarly, concrete deliveries would be undertaken when possible from Lindsey and Hayne Street via mobile concrete boom pumps or by concrete skip lifts using the tower crane with all concrete being sourced from external ready-mix suppliers.

The sequencing of activities will be:

- Ensuring all LU monitoring and EPP provisions are in place to protect their assets and operations.
- Ensure all dewatering measures are in place, actively monitored and functioning as required by the design.
- Ensure all ground movement, structural and environmental monitoring provisions are in place.
- Mobilise, install and commission the site tower crane.
- Mobilise fabricate and commission the site crawler crane.
- Concurrent with the activities above, excavate within the shaft, including the removal of the surplus tension piles to approximately 107.4mATD and blind the temporary shaft floor T
- Drill and place the ring beam reinforcement, erect shutters and cast the ring beam around the shaft periphery at 107.4mATD and allow to cure.
- Install the spoil handling provisions on the site & mobilise skips and excavators.
- Recommence excavation to the second ring beam level, approximately 94.5mATD beneath the escalator opening. Long reach excavators may be employed during this stage to assist with spoil removal by skip with the excavators fixed at predefined "lift points" where spoil can be pushed by tracked excavators in the base of the shaft.
- Seal the base of the shaft and cast the ring beam in a repetition of the previous operation.
- Due to the anticipated change in geology below this level probe drilling will be undertaken whilst the ring beam is placed, it will be done in a defined pattern across the box floor to locate and relieve any pockets of trapped pressurised groundwater within the shaft. The excavation on these stages may be phased to limit the potential for base heave and avoid local stability issued from groundwater pockets.
- Allow to cure then recommence excavation to approximately 83mATD below the platform level opening with spoil removal by inclined conveyor and 10 cu m quick release skips lifted by the site crawler crane.
- Seal the base of the shaft and cast the ring beam in a repetition of the previous operation.
- Cast a temporary working level, form portal openings for the WB pilot tunnel TBM and the access tunnel to the Eastbound pilot driven along the PRM access tunnel alignment.
- Drive the EB pilot access tunnel.
- Fabricate the TBM reception cradle and slide path.
- Receive the WB TBM, dismantle and remove.
- Clear the shaft base and breakout the temporary working level.

- Recommence excavation to the final shaft level approximately 75mATD in stages to maintain access to the tunnels to maintain pilot tunnel probing and dewatering activities.
- For each stage of excavation Install a blinding layer, sump and pump,
- Expose the tension pile cages and tie in to the base plug reinforcement as it is placed.
- Cast the basal plug in stages.
- Commence lining out work as described below.

The above sequence reflects what is shown on the drawings which show a deepened main shaft to change the ventilation arrangements, this is not reflected in the programming given in Appendix B which related to a different arrangement.

### **Eastern Ticket Hall, Shaft Internal Construction, Tunnel Junctions and Station Tunnel Logistical Support.**

The internal lining and construction works within the shaft must be concurrent with the formation of tunnel openings and the support of tunnelling activities in the station tunnels.

The sequence of works will be:

- Following the casting of the box base slab, install temporary formwork on the basal slab and cast the track level decking at approximately 77.7mTD. in stages whilst maintaining access to the tunnels for the pilot tunnel dewatering works.
- Install deck protection to be maintained for the duration of platform level tunnel civil works.
- Install temporary supporting formwork beneath the deck. The formwork beneath this deck will be in place for a considerable time and will need to be maintained and sized to accommodate the temporary loads during construction.
- Working off the protected permanent decking, the frame/eye structures for the tunnel enlargement openings for the Westbound Platform Tunnel, Westbound running tunnel and PRM access tunnel cross-passages will then be formed prior to stitch drilling the diaphragm wall panels to create the openings.
- The Site will be set up for SCL tunnelling support and the WB platform tunnel enlargement will be undertaken along with the SCL works for the Eastern Escape Cross Passage and PRM passage.
- Concurrent with the creation of the above tunnels and tunnel openings the secondary lining, internal walls and columns will be being progressed as far as the future works permit.
- From the construction programme CICP and DPS01, at this time the running tunnels from Limmo will be approaching Farringdon and preparations for the TBM reception will be undertaken concurrent with the SCL works above. These will involve the formation of the breakthrough eye in the shaft wall, the fabrication of the TBM reception cradle and the logistic arrangements for the subsequent TBM removal either

by lifting of major components or the dismantling of the TBM and removal in smaller elements.

- The running tunnel TBM reception will occur during the final stages of SCL tunnelling and during tunnel cleanout operations and preparations for tunnel lining.
- The above lining works will commence once the two points of access have been formed between the shaft and the station platform tunnels starting with the works to place the deck slab at 91.20 mOD with the installation of formwork, shuttering and reinforcement followed by the casting of the deck. The ongoing platform level tunnel operations will be supported through the ventilation shaft and service riser openings in this and subsequent decks.
- The casting of the lining walls columns etc. up to the next deck level at 95.50mOD will then be undertaken.
- The deck level at 95.50mOD will be cast in a repeat of the operations for the preceding deck.
- The internal works for the box will be suspended at this point whilst the opening frames and eyes for the Escalator tunnel are created and the upper concourse and machine chamber tunnel driven working from this deck level.
- To achieve this, tunnelling plant will be mobilised to site and lifted onto the deck and undertake the tunnelling of the Escalator tunnels described in the following section.
- Once the escalator tunnelling activities permit, the lining walls, columns etc., will be constructed up to 101.80mOD.
- The deck and permanent internal propping will then be cast in the same manner as before maintaining access to platform tunnel level at all times and removing the temporary propping once the curing of the permanent deck and props permit.
- The internal walls and columns will then be constructed up to the underside of the deck at 105.40mOD.
- The deck and permanent internal propping will then be cast in the same manner as before maintaining access to platform and escalator tunnel levels at all times and removing the temporary propping once the permanent deck and props permit.
- The internal walls and columns will then be constructed to the effective ground surface level, 108.375mOD.
- The ground level deck level, including the future track bed provisions, can then be constructed in the manner previously described and the final temporary props can be removed, completing the civil fit out of the box. Many of the non-structural internal walls will be missing at this point but will be installed during the subsequent ticket hall super-structure construction works once platform tunnel fit-out logistical support has ceased.
- The Moorgate trackbed train path Box will be progressed as a priority in the latter stages of the works to provide the access the bridge works previously detailed.
- During the later stages of fitting out of the box, sections of the ring beams will be cut out using stitchdrilling, diamond sawing and wire cutting methods to permit construction of the PRM Lift and Emergency stairs. At this time the structural role of the decks and internal lining will be activated.

- The works to break out the escalator notch to the south of the shaft will not be undertaken until the train path box and bridge works are completed.

### **Eastern Ticket Hall, Eastbound Ventilation Tunnel**

This tunnel will be built from the shaft base slab level using SCL techniques as described previously. Prior to driving the tunnel a shaft will be constructed in the invert of the EB platform tunnel with a “bell out” chamber to form the necessary junction with this tunnel.

This work cannot commence until the WB running tunnel TBM removal has been completed as it will cause conflicting access difficulties.

The settlement impact of the tunnel on the LU assets and Hayne St Bridge will be a control on construction via the EPP provisions particularly in relation to track monitoring and control with provision for emergency responses and track fettling during Engineering hours and the activation of the jacking provisions incorporated into the LU party wall if required.

It is anticipated that the LU control provisions will limit the hours of excavation to nightshifts only giving a slow rate of progress.

The excavation and shotcrete spraying plant for this tunnelling will be lifted into the base slab level by the site crawler crane, broken down into lighter elements and reassembled if required by access limitations. The spoil, lattice girders etc will be similarly be supplied by crane after delivery to the southern site area.

The logistical support for these SCL works, such as the spoil storage and handling facility for removal from site, compressors, shotcrete additives store, air reservoirs, and static re-mixer required to hold supplies of shotcrete in readiness, will be sited in the main southern area of the East Ticket Hall site.

This work will be concurrent with that of the escalator tunnel described below.

Despite being the deepest tunnel constructed the faulting of the site means that it will be undertaken in the same geological horizon as the majority of the platform tunnels.

### **Eastern Ticket Hall, Escalator Upper Machine Chamber and Inclined Escalator Barrel**

This tunnel will be built from the main shaft deck level at 95.5mOD using SCL techniques as described previously. The upper machine chamber tunnel and upper section of the inclined escalator will be driven wholly within the London Clay strata.

The settlement impact of the tunnelling will impact upon the foundations of Lindsey St Bridge and LU operations and assets in the running tunnels and these will be a major control on construction via the EPP provisions particularly in relation to track monitoring and control with provision for emergency responses and track fettling during Engineering

hours. Mitigation measures to reinforce and brace the Lindsey St Bridge arches and foundation were installed earlier in the construction sequence.

The breakout of the tunnel will be constructed beneath a grouted pipe arch canopy installed from the shaft. This provision will be subject to confirmation during the Detailed Design Stage. For the purposes of costing and programming it is assumed that the tunnel will be progressed under overlapping grouted pipe arch canopies as illustrated in figure Figure above.

In order to receive the inclined escalator barrel tunnel the headwall of the lower machine chamber the excavation will have included the provision of a ring beam eye structures in the crown and end wall and the area will have an inclined permanent concrete support ramp cast. The remainder of the headwall face above the ramp will be supported by a sacrificial infill of foamed concrete through which the escalator tunnel will be mined.

Following the completion of preparatory works construction of the escalator will be carried out in the following sequence:

- Set up, excavate and primary line the escalator shaft to full depth in advance lengths of no greater than 1m.
- Clean out tunnel smooth off the primary lining and install drainage layer and waterproof membrane.
- Set shutters and concrete invert done from bottom upwards;
- Set the crown and flank shutter and concrete the crown and flanks of the tunnel tunnel from bottom up.;
- Set shutters and cast concrete bed for escalator;
- Commence Builders Work and Fit Out in accordance with programme access constraints.

### **Eastern Ticket Hall, Escalator Notch and Southern Basement Excavation and Superstructure Construction**

With the completion of the structural fit-out of the shaft and placement of the Hayne St bridgeworks the southern area of the ticket hall site will be free to undertake these activities with any logistic support to the tunnel lining activities being undertaken from the street level area above the shaft the decks at this level being reinforced by temporary works as necessary.

A tower crane will be installed within one of the Main Service Riser shafts of the box. Once this tower crane has been commissioned the original tower crane in the southern site area will be decommissioned, dismantled and removed.

The site crawler crane will also be dismantled and removed once the requirements for heavy lifting from Crossrail platform level have been fulfilled, hereafter any heavy items such as travelling shutters, will be cut apart in-situ to sizes that are within the capacity of the underground plant and site tower crane.

With the southern site area cleared, the concrete working deck used during construction of the tunnels and shaft will be removed to reveal the OSD pile caps and escalator notch retaining wall piles that were installed earlier in the construction sequence. A temporary bracing frame will be installed within the excavated area of the escalator notch as the excavation progresses support the secant pile walls until the permanent inclined floor slab has been placed.

The main shaft diaphragm wall will then be removed by stitch drilling or wire cutting techniques.

Concurrent with this activity the final working level of the site are will be adjusted by excavation or the import of engineering fill and the OSD pile caps will be cast.

With the notch excavated the permanent inclined floor slab will be cast in stages working bottom to top. Once this has gained strength the temporary bracing will be removed and the permanent wall linings will be cast.

All material deliveries and removals during this stage will be by off street loading on Lindsey Street

The basement superstructure will then be constructed including the casting of the permanent retaining walls around the site.

The management of site activities will ensure that access and egress provisions for Smithfield Market Basement car park are maintained through the site area.

On completion of the basement structure the access and egress provisions for Smithfield market basement car park will then be switched to pass through the newly constructed basement and the monitoring and EPP provisions for the Combined Heat and Power tunnel and shaft beneath Long Lane, initially instigated for the secant piling works, will be deactivated.

The street level superstructure will then be constructed across the site with all site access. Loading and unloading undertaken from Lindsey Street.

The final construction links to Hayne Street Bridge and the Barbican will be completed at this time as will the placement of the suspended cantilever supported ground level slab above the LU jack arches to the north of the site.

The site will then progress to the M&E and finishing work activities.

The LU mitigation provisions and 5m hoarding provisions will then become redundant and will be removed and the dust monitoring within Smithfield Market will cease.

### 12.3 Advanced Works Requirements

Advance Works are defined as those works that need to be undertaken, or as a minimum need to be planned and commence, ahead of the Main Contract. This predominantly includes enabling works, as discussed in 12.4, although there are a number of other works required that must be included in advanced works as discussed in this section.

For the Farringdon site in general, there has been no change in our understanding of the site since the Hybrid Bill scheme design and the requirement for further site investigation information remains a vital advanced works activity. The impacts of any findings of the planned Site Investigation works on this site upon the design and construction outlined in this report will require assessing.

As mentioned in the preceding text, the specification of the pilot tunnel TBM for the Farringdon station will be site specific and dictates aspects of the design and methods. Any changes in the final the TBM specification from those implicit in the design and methods covered by this report will require assessment. The fixing of the TBM specification is a vital enabling work activity requiring the input of appropriate specialists. Some of the ramifications of this are discussed in the following section.

The scope and specification of compensation grouting provisions for the site remain to be defined awaiting detailed building assessments. Confirmation of the provisions of compensation grouting outlined in this report and the attendant monitoring provisions will be needed from April 2012 on the current programme and the monitoring will require background readings in advance of active grouting pushing the date of their installation into 2011 which will require permissions negotiating and granting from the various building owners and occupiers affected.

#### 12.3.1 Western Ticket Hall

Critical to the construction programme for the Western Ticket Hall is the early acquisition and demolition of Cardinal House scheduled to commence in June 2009. The interface of this work with Thameslink, especially in relation to an EdF sub-station on the site is critical and requires active management.

Due to the Thameslink upgrade works to Farringdon station programmed to be commenced prior to the start of Crossrail, and the overlap / interface that exists with the 2 adjacent sites, the following advanced works for Crossrail need to be incorporated into Thameslink's work:

- Accommodation of the impacts and opportunities arising from the demolition of Cardinal House within their construction methods and programming.
- Install the piled foundations and ground beams for the future over site development (OSD) which are located within the Thameslink site.

- Install the piled foundations for the Western Ticket Hall structure which are located in the Thameslink site.
- Install the piles for the eastern headwall of the future escalator box which lies beneath the planned Thameslink northbound platform.
- Undertake remedial measures to reinforce and protect or divert the St Johns Branch of the Fleet Sewer which lies beneath the planned Thameslink Northbound platform and infrastructure and will be undermined by the Crossrail Western Ticket Hall escalator.
- Provide crash deck provisions to protect the roof of the new Thameslink station during construction of the Cardinal House OSD and subsequent demolition and construction activities as required under CDM.
- Provide settlement mitigation measures for the new station structure e.g. monitoring and jacking, for the Thameslink ticket hall and access-way bridging structures and escalators.
- Construct the Crossrail lift shaft within the footprint of platform 3.

The Thameslink programme used in the production of this report was supplied in March 2008 and is known to be out of date and is being actively updated for issue in October 2008, the impact of this changed interface will need to be assessed.

The nature of the mitigation activity for the St John's branch of the fleet sewer has yet to be finalised and the impact of the final option chosen on the Crossrail design and construction methods will need to be assessed.

It is understood that Caxton House to the south of the Western Ticket Hall site is going to be re-developed, this has not been addressed in this report as the scheme has not been developed sufficiently. The timing and impact of this works on the Crossrail scheme will need definition and assessment in the future.

The provision of groundwater discharge infrastructure for this site is a possibility since the fleet sewer is known to be prone to surcharge and so separate discharge provisions may be necessary such as the provision of a dedicated new sewer as was required on CTRL project.

The pilot TBM power requirements remain unclear but must be in place for the first TBM drive in July 2012.

The remainder of advanced works to be undertaken at the West Ticket Hall can be considered as enabling works, and are discussed in section 12.5.

#### 12.3.2 East Ticket Hall.

The following enabling work activities are required to meet the dates stated if the programme is to be achieved as reported:

- The relocation and re-provision of the LU IMR by December 2012.
- The relocation of LU cables through the Barbican station and tunnel adjacent to the IMR by July 2012. (Termed the phase 1 cable relocation).
- The provision of monitoring, protection and emergency response measures for LU assets and operations prior to the start of building demolition in March 2011 including any required background monitoring stipulated by LU, which is potentially 12 months, requiring monitoring to commence by March 2010 and to be maintained during all other LU activities.
- The provision of monitoring, support and emergency response measures within the Combined Heat and Power tunnel beneath Long Lane by September 2011 including any required background monitoring stipulated by the asset owner.
- The relocation of LU cables through the Barbican station and tunnels adjacent to the IMR by July 2013.
- The provision of an accepted design and programme for the LU party wall underpinning and construction works for completion within the programme window.
- The provision and maintenance of dust monitoring within Smithfield Market 12 months before the on site commencement date of March 2011.
- The provision of an acceptable design and construction sequence for the Charterhouse Square construction shaft and attendant monitoring and protection works for LU assets and operations.
- An acceptable design and duct route for the temporary provision of ventilation from Smithfield Market basement car park needs to be finalised to be installed during July 2011.

#### Planning & Procurement

Although not physical advance works, there are numerous planning and procurement issues which relate to the main works that need to be considered in advance, due to their durations and programme implications. These include the following:

- Design, tender and award of the contract for the fabrication, storage and delivery of the pilot tunnel TBM lining segments.
- Specification, tender and award of the contract for fabrication, testing, delivery, fabrication and support during use, of the pilot tunnel EPB pilot tunnel TBMs.
- Negotiation of delivery routes and times for pilot tunnel TBM deliveries with TfL and Local Authorities.
- Planning and programming of dewatering provisions.

- Commencement of negotiations to obtain extraction and discharge consents for groundwater dewatering.
- Commencement of negotiations with TfL and local authorities regarding spoil disposal traffic arrangements during peak spoil generating activities, box excavation, pilot tunnel excavation and SCL tunnel enlargement operations

## 12.5 Enabling Works Requirements

The sequence of enabling works activities listed in this section precede the activities listed in the construction sequence section above.

### 12.5.1 West Ticket Hall

The sequence of enabling works that are required at the West Ticket Hall is as follows:

- Surveys (as discussed in section 10.2.5)
  - Trial trenches (utilities and foundations)
  - Structural and condition – Cardinal House
  - Asbestos – Cardinal House
- Monitoring (as discussed in section 10.2.7)
  - Rail assets (LUL, Thameslink)
  - Environmental (background noise and dust)
- Utility abandonment, diversion and protection measures around perimeter of site (as discussed in 10.3.13).
  - Water mains
  - Gas mains
  - BT cables
  - Telewest cables
  - Colt cables
  - Thus cables
- Site set-up and erection of hoardings, including alterations as necessary to Caxton House basement (or sections of) for the provision of site accommodation and welfare.
- Demolition of properties and structures down to basement level (as discussed in section 10.2.8)
  - Cardinal House
  - Surrounding low level buildings
  - Underground car park
- Diversionary / preparatory works to 225mm diameter local sewer from basement level on completion of demolition (as discussed in section 10.2.8).
- Alterations and modifications to Caxton House underground car park and Snow Hill car park in preparation for use during main construction works.

### 12.5.2 Fox & Knot St Shaft

This is no longer required. Refer to Table 22.

### 12.5.3 East Ticket Hall

The sequence of enabling works that are required at the East Ticket Hall is as follows:

- Surveys (as discussed in section 10.2.5)
  - Trial trenches (utilities and foundations)
  - Hand trace and tag of rail utilities, track and gauging surveys of the tracks to identify pinch points and track serviceability conformance
  - Structural (all affected buildings and structures where no information available, particularly the deck above the LUL lines and its interface with the adjacent deck above the Thameslink lines).
  - Asbestos (for all buildings to be demolished)
  - Dimensional – basements abutting site
- Monitoring (as discussed in section 10.2.7)
  - Environmental (background noise and dust at Smithfield Market) – to be commenced a year in advance of demolition (Parliamentary undertaking)
  - Rail assets (LUL), potentially 1 year in advance of demolition
- Public utility abandonment, diversion and protection measures around perimeter of site (as discussed in 10.3.13 and 10.3.14).
  - Water mains
  - Sewers
  - EDF Cables
  - Cable & Wireless cables
  - BT cables
  - Level 3 cables
- Rail utility diversions and protection (as discussed in 10.3.14).
  - IMR
  - Cables on retaining walls, decks and beams to be demolished
- Site set-up and erection of hoardings, including installation of 5m free-standing protective dust and noise hoardings prior to demolition, maintained through the construction period.
- Alterations as necessary to Smithfield Market basement (or required sections of) for the provision of site accommodation and welfare.
- Demolition of buildings down to basement level at southern end of site to enable installation of access ramp (as discussed in section 10.2.8)
  - 3 Lindsey Street
  - 20-23 Long Lane
- Demolition of buildings down to road level (as discussed in section 10.2.8)
  - 8&9 Hayne Street
  - 4 Lindsey Street
  - 5 Lindsey Street
  - 56 - 64 Charterhouse Square
  - 5 Lindsey Street

- temporary works as necessary to support surrounding structures as demolition proceeds, depending on results of structural and condition surveys.
- Re-provision of Smithfield Market basement escape route (as discussed in section 10.3.15)
- Re-provision of Smithfield Market basement ventilation ducts and fan outlets (as discussed in section 10.3.15)

### 12.6 Contractor's Compound and Worksite

Three main worksites are proposed for the construction of Farringdon Station, these are located at:

1. The junction of Cowcross Street and Farringdon Road, referred to as the Western Ticket Hall Site.
2. The area delineated by Lindsey Street, Long Lane, Hayne Street and Charterhouse Street, referred to as the Eastern Ticket Hall site.

The two sites will be demolished to ground level which lies approximately 4m below road level.

Two subsidiary work sites are also proposed which are linked to the Eastern Ticket Hall Site these are referred to as:

- Charterhouse Square Site (33-37) – located on the southern side of Charterhouse Square east of Hayne Street, and North of the Barbican LU station.
- Hayne Street Site – located on the site of No 3 Hayne Street, immediately to the south of the LU Barbican Station on the Eastern side of Hayne Street.

Three further subsidiary sites are proposed to provide offices, welfare and limited storage facilities linked to the main sites above, these are:

- Caxton House Basement car-park – abutting the Western Ticket Hall site
- Smithfield Market Basement car Park – abutting the Eastern Ticket Hall site.
- 38 Charterhouse Street – abutting Fox & Knot Street site.

#### 12.6.1 Western Ticket Hall Site

Location	Junction of Farringdon Road and Cowcross Street.
Area (m <sup>2</sup> )	3030m <sup>2</sup> Approx.
Proposed Use	Main site for the western end of station including ticket hall, ventilation, escalators and MIP, emergency and intervention access.  Main site for the excavation and construction of the Ventilation and Access shafts.

	<p>Access and logistic support during excavation and construction of the station tunnels including the platform pilot EPB TBM drives and subsequent SCL enlargements.</p> <p>Site of TBM delivery/launch and reception/removal.</p> <p>Construction of escalator and ventilation tunnels</p> <p>Construction of ticket hall superstructure &amp; OSD</p> <p>Typical activities include: Cranage, Spoil &amp; Segment loading and handling facilities, grout and shotcrete batching facilities, emergency access, location of emergency generator, compressors, wheelwash and ventilation fans and workshops during construction, “just in time” logistic deliveries.</p>
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**Table 31 WTH Site Proposed Use**

	<p>Access and logistic support during construction of bridges spanning LU assets.</p> <p>Construction of East Ticket Hall Box.</p> <p>TBM reception and removals.</p> <p>Logistic support during lining of the box &amp; station tunnels.</p> <p>Construction of escalator and ventilation tunnels</p> <p>Construction of ticket hall superstructure &amp; OSD.</p> <p>Typical activities include: Cranage, Spoil loading and handling facilities, shotcrete reception and storage facilities, emergency access, location of emergency generator, compressors, wheelwash and ventilation fans and workshops during construction, “just in time” logistic deliveries.</p>
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**Table 32 WTH Site Proposed Use**

The main area of worksite will be created by the demolition of Cardinal House.

Access to the site is a significant constraint with short two axle vehicles being able to access the site through the Caxton House basement car park. Larger vehicle and HGV access will only be possible once temporary access ramps have been provided to give access and egress from Farringdon Road and Cowcross Street. This will impact on pedestrian routes on these roads and require banksman control of vehicle movements, during periods of high vehicle movements traffic controls may be required.

Planning of pedestrian routes will need detailed consideration to ensure the safety of the public.

12.6.2 Eastern Ticket Hall Site

<b>Location</b>	<b>2-5 Lindsey Street, 20-23 Long Lane, 56-64 Charterhouse Street, 8-9 Hayne Street</b>
Area (m <sup>2</sup> )	2600m <sup>2</sup> Approx.
Proposed Use	<p>Main site for the eastern end of the station to be used for:</p> <p>Access and logistic support during demolitions of buildings and structures.</p>

The Eastern Ticket Hall site is created by the demolition of many buildings followed by a structural deck and retaining wall structure to effective ground level. This provides a work site some 6m or so below street level, the same level as the disused Thameslink Moorgate branch line.

There is no means of access to effective ground level until it is created by demolition and ramp construction, this access then services all further works.

The following sketches have been prepared to show the layout of this site during the main phases of construction:

- Sketch P30201-C1M10-SK-CP-50205, Farringdon Station East Ticket Construction Sequence Stage 1 (Demolition & Setup);
- Sketch P30201-C1M10-SK-CP-50206, Farringdon Station East Ticket Construction Sequence Stage 2 (Piling and Diaphragm Walling) (Sheet 1 of 2);
- Sketch P30201-C1M10-SK-CP-50207, Farringdon Station East Ticket Construction Sequence Stage 2 (Piling and Diaphragm Walling) (Sheet 2 of 2) ;
- Sketch P30201-C1M10-SK-CP-50208, Farringdon Station East Ticket Construction Sequence Stage 3 (Bridge Construction and Box Excavation).

12.6.3 Charterhouse Square Site

<b>Location</b>	<b>33-37 Charterhouse Square.</b>
Area (m <sup>2</sup> )	260m <sup>2</sup>
Proposed Use	<p>Site of northern abutment and stairs for LUL interchange bridge to be used for:</p> <p>Access and logistic support during demolition of building.</p> <p>Construction of abutment and stairs.</p> <p>Logistic support during installation of bridge spanning LUL assets.</p>

**Table 33 Charterhouse Square Site Proposed Use**

The Charterhouse Square site is created by the demolition of 33-37 Charterhouse St. Access is from road level as there is insufficient space to install a ramp.

#### 12.6.4 Hayne Street Site

<b>Location</b>	<b>3 Hayne Street.</b>
Area (m <sup>2</sup> )	120m <sup>2</sup>
Proposed Use	<p>Site of southern abutment for LUL interchange bridge to be used for:</p> <p>Access and logistic support during demolition of building.</p> <p>Construction of abutment.</p> <p>Logistic support during installation of bridge spanning LUL assets.</p>

**Table 34 Hayne Street Site Proposed Use**

The Hayne St site is created by the demolition of 3 Hayne St. Access is from road level as there is insufficient space to install a ramp.