London's Deep Tube Railways: Visibly Invisible

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Abstract

The most commonly discussed topic regarding London’s underground railways and land use is how the railway stimulated suburban development and the growth of London, scholars tend to ignore the historical relationship between London's underground railways and land-use in the densely developed areas of the central zone. This dissertation focuses on this little-discussed field, and argues that though the railway is out of sight it should not and must not be out of mind.

A developmental trend in the relationship between the tube and property from its earliest days through to the present day is analysed. Whilst the early tubes (those constructed between 1884 and 1907) minimised the interface with other property interests, the new lines, extensions and other improvements, post 1920 through to the present, increased the interface between the two. Whilst this dissertation predominantly focuses on the physical aspects of the presence of the railway, it also covers some of the legislative and legal changes that have enabled these to take place, commenting on aspects of property law, and considering the relevant legislation and parliamentary commission that affected the railways development.

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Author’s declaration

This dissertation is solely my own original work, and has not been copied from any other source.

'There is no physical obstacle which could not be overcome by engineering skill; the difficulty is simply one of money'.
[J.R, Kellett, *The Impact of Railways on Victorian Cities*, (London: Routledge & Kegan Paul, 1969), 395.]

Chapter 1 Introduction

London's underground railways are the oldest in the world; the first opened in 1863 and the latest, Crossrail, is currently under construction. At first glance, they may seem disassociated from the history and legislation of the main line railways of Britain. However, there are similarities and areas of comparison. Just as main line, railways were to revolutionise transport nationally so the underground was to do so in the metropolis; both stimulated increases in population, urban growth and the creation of jobs. By their very nature, they had a close relationship with property, both utilising areas of land that were required or could be used for other purposes, such as housing or commercial use. Yet while the effect of railways on urban form has been much discussed, such as by John R Kellett, Russell Haywood and Alan Jackson, little seems to have been written on how the deep level tube and property relate to one another[1].

This dissertation considers the relationship between the tube and land use within the densely developed central areas of London between 1884 and 1999. It demonstrates how the tubes were at first designed to minimise the effect of property *on them* and the *effect of the tube on property* from the 1950s. Most historians of the underground focus more on the development of the suburbs, the history of the railways and the rolling stock. Croome and Jacksons *Rails Through the Clay*[2], for example, is an informative history of the tube but it fails to analyse some of the fundamental legal and engineering factors of the railway's design. One instance is the treatment of the construction of the Victoria line where Croome and Jackson refer in passing to the new railway taking 'full advantage of legal powers to cut across the street pattern'[3]. But what was the relevance of these powers, and what difference would it have made had the line been built under older powers? If we take for granted their claim that 'by their nature, tube railways should not injuriously affect surface property'[4], we shall fail fully to understand the tube's relationship to property and the development of London.

[1] Kellett, *The Impact of Railways on Victorian Cities;* Russell Haywood, "Railways, urban form and town planning in London: 1900-1947," *Planning Perspectives*, 12, no.1, (1997): 37-69; Alan A. Jackson, *Semi-Detached London: suburban development, life and transport, 1900-1939*. Didcot: Wild Swan, 1991.
[2] Desmond F. Croome & Alan A. Jackson, *Rails through the clay,* (Harrow Weald: Capital Transport, 2nd ed., 1993), 359.
[3] Ibid.
[4] Ibid, 549.

1.1 Property and the tube: a neglected topic

Mention has already been made of the very limited scope of scholarly discussion on the relationship between the tube and land use in the metropolis. The main studies touch upon salient matters that can be used to provide background but do not fully address them. For example, Barker and Robbins' two-volume standard history, the *History of London Transport,* give the context of tube railway development; who the key players were, what the socio-political background and the relationship to other transport systems[5]. But with comprehensive works such as these, it is difficult to be more specific about any one aspect as they cover a wide spectrum of topics and endeavour to combine them in one history. Something similar can be said of Croome and Jackson's *Rails through the Clay*; this popular work covers a wide spectrum of tube railway development and operation including signalling and rolling stock development. The authors have 'much to say about the policy, organisation and management of the whole underground system' but only make one sentence references to key features of the system that are highly pertinent to this dissertation[6]. Other kinds of history can also provide clues. For example, Jerry White's review of the development of taller buildings in London alerts us to the fact that there is a greater interface with the underground than at first may have been assumed[7].

It is perhaps more surprising that those histories, whether academic or popular, that have a particular interest in the engineering aspects of the tube are as neglectful of the relationship with property. Many of these accounts use primary sources such as the discussions, publications and papers on the construction and modification of the railways published by the Institution of Civil Engineers. This leads to a history developed on the same rather narrow sources of data with minimal new research in to alternatives being undertaken. For example, Follenfants' *Reconstructing London's Underground* focuses on civil engineering in narrow technical terms and neglects the legal and property matters that shaped the tube's design and construction[8]. Additionally he only gives a brief superficial outline of the works rather than analysing the whole range of factors that impinged upon the engineering at one site. On the plus side, he does give a detailed technical perspective that enables us to analyse what and why the engineers were considering when they were designing the tubes. From this, we can also gain a valuable

[5] T.C Barker & M. Robbins, *History of London Transport: the Nineteenth Century,* (London, Plaistow: George Unwin & Allen, 1963); T.C Barker & Michael Robbins. *History of London Transport: the Twentieth Century*, (London, Plaistow: George Unwin & Allen, 1974).
[6] Croome and Jackson, *Rails through the clay*, Preface.
[7] Jerry White, *London in the Twentieth Century*, (London: Vintage, 2001), 46-88.
[8] H.G Follenfant, *Reconstructing London's Underground*. Westminster: London Transport, 2nd ed. 1975.

idea about how the legal and other aspects of property and the tube's development.

Other scholarly works are also relevant, in particular Kellet's *The Impact of Railways on the Victorian City* and Haywood's paper on 'Railways: Urban Form and Town Planning in London: 1900-1947' and his book Railways: U*rban Development and Town Planning: 1948-2000*[9]. Kellet's analysis of the effect of railways on the Victorian city provides excellent background on the property interests within London up to and during the period that the tube railways were constructed. Additionally, he comments on the land-use issues presented by large railway termini. Both are essential factors in understanding the benefits of the tube, but perhaps the most relevant part for this dissertation is his note on nineteenth-century compulsory purchase and arbitration[10]. These processes for the purchase of land for the purposes of public benefit were equally applicable to the tube. The work of Haywood builds on Kellet's by discussing the twentieth century relationship between railways and town planning throughout Britain. Of particular interest are his discussions on topics such as retention of land by railway companies for non-operational purposes[11] and the 'intense political debate over the conflicts between private profit and public interest'[12]. Haywood's discussions on the relationship between railways and town planning clarify that urban planning and the tube have an essential inter-relationship, his works giving some insight in to this. With regard to this dissertation it gives us a background to the location of railway assets, such as stations and ventilation facilities, within densely developed areas; the construction of the post 1920s railways and the related improvements, which extended under property during a period that public interest was beginning to take precedence over those of a private nature. All of these created an increase in interface between private property and the tube. However, as Haywood focuses primarily on suburban development stimulated by railways in London and main line railways and town planning there is a lack of data on the underground as a whole; the references he does make generally follow the standard popular history, that the tubes can pass anywhere[13].

Other works relating to the development of London also seem to miss the relationship of the tube and land use, such as Jerry White's *London in the Twentieth Century*[14]*.* Though it is a well-researched history of the development of the city, White's book falls in to the

[9] Kellett, *The Impact of Railways on Victorian Cities;* Russell Haywood, "Railways, urban form and town planning in London: 1900-1947" *Planning Perspectives*, 12, no.1, (1997): 37-69; Russell Haywood, *Railways, Urban Development and Town Planning: 1948-2000*, (Farnham: Ashgate, 2009).
[10] Kellett, *The Impact of Railways on Victorian Cities,* 434-436.
[11] Haywood, *Railways, Urban Development and Town Planning*, 18.
[12] Ibid, 42.
[13] Ibid, 28.
[14] White, *London in the Twentieth Century*.

same trap as other general and even specific works telling the history of London's relationship with the tube by not commenting on the legal and engineering issues. The reason for this is understandable. As with Croome and Jackson, Barker and Robbins, and Haywood, White has a principal focus, which is the general development and history of the city and as such he cannot discuss the complexities of the relationship between the tube and land use in London. However, White's book does give an account of the changes in building design throughout the city since the 1950s.

Why there has been so little discussion on the subject of the historical inter-relationship of the tube and land use is uncertain. It may be that scholars like most people, have become so used to the presence of the tube railways in everyday life that they do not give much thought to its historical importance. Add to this the fact that in the central zone the railway is located underground: it literally falls in to the realms of invisibility. The phrase 'out of sight out of mind' is then highly pertinent, contrasting to the surface transport, which we see every day. For example, the only time that one hears about the tube is if something goes wrong; if there are severe delays, a service suspension, or a strike by staff that affects people's ability to move around the city. It can therefore be argued that the tube is taken for granted: it is literally and metaphorically not visible. This point is re-inforced by historical studies of the underground; the most discussed topic is the tubes effect on suburban growth[15]. In the suburbs, the railway is often above ground and perhaps gains interest from its visibility.

By contrast, the designers of the inner-city tube have done an effective job of minimising its presence on the urban environment; its very appeal lying in its ability to minimise use of land that other transport modes could not. However, we must not assume that because the tubes are underground they had, and have, no effect on those properties at surface level. With the sub-surface railways, it is obvious that they had a temporary adverse effect on property and the public highway when they were being constructed. The tubes' disruption and presence was more subtle than this, but just as real. For example, why are there plots of land empty in an inner-city environment, what about the building with the plain facade and no windows in a highly developed metropolis where land is at a premium for residential and commercial use? Why are typical tube stations of single storey construction; or why does access to a station come out in the pavement or through a building, which has nothing to do with the underground? These are all subjects

[15] Jackson, *Semi-Detached London: suburban development, life and transport, 1900-1939*; White, Jerry. *London in the Twentieth Century.* London: Vintage, 2nd ed., 2001; Levinson, David. "Density and Dispersion: the Co-Development of Land Use and Rail in London", Journal of Economic Geography 8, (2008): 55-77.

of research that are essential not only to the historian of the tube but also of land development and urban planning. By studying these topics, we begin to realise that the tube has had, and continues to have, a greater effect on the urban environment than we may have first appreciated.

1.2 Sources

This dissertation uses legal documents, legislation, historic drawings and current and historic Ordnance Survey mapping, to explore how the design of the tube and the development of the metropolis are more closely inter-related than historians have previously given credit. Some aspects of this dissertation are also based upon technical papers written by engineers who designed and constructed the tubes. These primary sources are available through the Institution of Civil Engineers. They are of great assistance in understanding how people went about tunnelling through a highly built up metropolis such as London. But for this dissertation, these could not be read alone: it was necessary to consult the London Underground engineering archive, which contains detailed historic drawings. These are an essential primary source for determining how railway assets were constructed and how they have changed over the period of the railways' operation. When these are viewed together with modern and historic Ordnance Survey (OS) plans, a greater visual aid is provided. These OS plans have been created specifically for this dissertation from present-day London Underground 'survey source data'. These drawings and plans show how the relationship between the tube and land use developed through the changes in surface development and the alignment of the tunnels and structures through different periods in time. For example fig.1.1, shows Angel station on the Northern line where new tunnels and station facilities were provided to improve access and the passage of passenger traffic, the new station and layout opening in 1993[16]. In many cases plans such as these point to the need to search out archive drawings; the use of historical mapping with modern overlays of tunnel alignments clearly demonstrate where there have not only been changes to the urban environment but also to the railway. These sources require specialist knowledge if they are to be interpreted correctly. For example, the alignment of the railways are shown on the plans as a coloured dashed line which represent the individual tunnel centre lines at their highest point, referred to as the tunnel crown. As these are only representative of the top centre of the tunnel, the viewer must account for the diameter of the tunnels that can be up to 5m overall (2.5m either side of the centre line). Areas shaded grey

[16] TfL, "Milestones" http://www.tfl.gov.uk/corporate/modesoftransport/londonunderground/history/1606.aspx [Accessed 15 August 2012].

represent the extents of sub-surface structures such as ticket halls, escalator shafts, and station tunnels etc. as of 2012. It is also important to note that the plans have been produced by way of two data sources matched together as closely as possible; there is no guarantee that either source is entirely accurate. When looking at a plan with an overlay, a +/- 2m tolerance must be allowed for; this tolerance is sometimes evident on the historical plans when overlaid on modern mapping. Despite this inaccuracy, the hybrid maps they are still highly informative and give a good representation of the historical development between the tube and surrounding property.

In some instances, legal documents have also been used. These are highly effective sources of data for understanding aspects of the construction of the railway; for example, financial and in some cases technical costs, for the purchase of an easement or the imposition of covenants (legal restrictions) on a property. This latter was most common when the underground companies were selling a lease or freehold to a private individual or organisation; it could be used to govern what could or could not be done with a property, to protect the railway. Some of these documents are still commercially or legally confidential and where these have been used in this study only the filing reference and document type have been referenced. While this is less than desirable from a scholarly perspective, the alternative – not using these sources – would be worse. For example, a case study in chapter 5 considers the re-development of a property where there is a definite interface with the railway. This interface is only apparent if one has access to the relevant legal and other restricted information on the works. This goes some way to explaining why authors such as Croome and Jackson, who probably did not have access to this kind of information came to the erroneous conclusion that the tube has no adverse effect on property or vice versa. In contrast, this dissertation lends a new insight in to the complex historical relationship between the tube and the city of London.

1.3 Points of clarification

Though London's underground network is generally referred to as 'the tube', the use of this term is incorrect. Within engineering circles the deep-level tunnels, bored through the London sub-soil and constructed of cast iron, concrete or stainless steel segments, are referred to as 'tubes'; they are distinctly different from the sub-surface tunnels or covered ways of the Metropolitan, District and Circle lines. The term 'tube', in this dissertation, will therefore refer solely to the deep bore tunnels and not the London Underground system as a whole. The term is traceable back to 1892 when Mr Gabriel Prior Goldney, the City

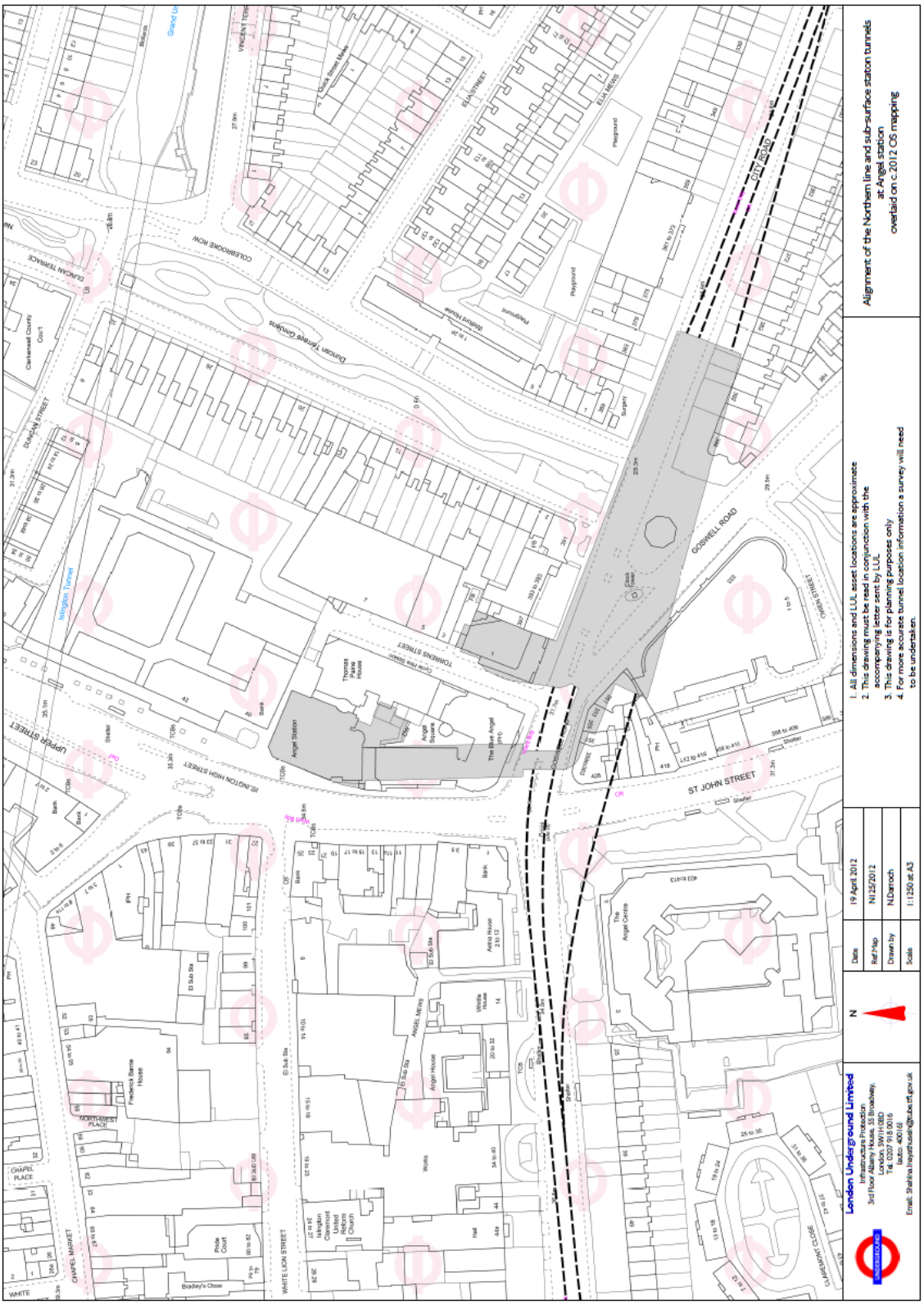

Fig. 1.1

1:1250@A3 plan showing the alignment of the Northern line (dashed black) and sub-surface station tunnels (shaded grey) at Angel station overlaid on c.2012 OS mapping.

Source: London Underground, Ref.Map N125/2012.

Remembrancer, referred to the tunnels for the City and South London Railway (C&SLR) extension to Euston as having 'larger tubes' when giving evidence to the 1892 committee on tube railway construction[17]. Other witnesses, including James Henry Greathead, Chief Engineer to the new tube companies, also liberally used the phrase, as well as the members of the committee whilst discussing the proposals for new deep-level railways in London.

Throughout this dissertation, there are many references to measurements. The units used are those found in the archive material; that is both metric and imperial measurements.

1.4 Changes to the inter-relationship between the tube and land use

The key aspect of the tube and land use, which this dissertation presents, is the gradual incursion of the railway on property rights. Where once a person's property was considered as unquestionably theirs to do with as they will, the presence of underground railways and their related assets have changed this.

When the C&SLR opened in 1890, between Stockwell and King William Street, it followed the route of the principal public highway to the southern London suburb of Clapham. This was not only to tap in to omnibus traffic, its principle source of revenue, its location under the road also minimised the need for the railway promoters to purchase land or sub-soil under private property, which could be prohibitively costly as demonstrated by the locations where the railway company were required to purchase easements under land and buildings. Its presence under the highway was also to have a long-term benefit that it is doubtful the railways speculators could have foreseen. This was the railway minimising its physical presence under buildings, which, sixty years after its opening, would extend deeper in to the ground as they became taller in answer to the need for more urban development.

Extensions of the original tubes further in to the suburbs in the 1920s, were to see a change in design, with the tunnels passing under private property for considerable distances, despite the companies having to purchase easements or the sub-soil, funding

[17] House of Commons Parliamentary Papers, Online, House of Commons Papers; Reports of Committees, (215), "*Report from the Joint Select Committee of the House of Lords and the House of Commons on the Electric and Cable Railways (Metropolis), 1892*". 3. http://parlipapers.chadwyck.co.uk/marketing/index.jsp. [Accessed August 11, 2011].

coming from government treasury guarantees for new works capital[18]. Where initially the presence of the tunnels under property still had a minimal effect on property development and land use, changes in engineering techniques saw the need for property developers to consider the location of the tunnels and determine what effect they may have on the design of the development to accommodate them, if they can be accommodated.

Another feature of this period was improvements to the railway and its facilities at stations, many in the central zone of the city requiring upgrading and capacity enhancements to handle passenger traffic. Where station upgrades for the installation of escalators or the construction of under highway ticket halls, there was a determined effort to minimise the incursion at *shallow depth* on property. There were, however, locations where buildings were purchased to enlarge the original Underground railway station (Oval) or where parts of a building were utilised to form new entrances (Leicester Square). The period from 1920 to 1955 was to see a change in the relationship between the tubes and land use that had and will continue to have an effect on one another, namely private property now having to accommodate the presence of the railway.

This change is clearly identifiable on the Victoria line, first authorised in 1955 with the power for the British Transport Commission to take the sub-soil and lands it required for the purposes of the railway, through to its alignment, predominantly under private property and requiring the diversion of existing railway assets[19]. With the new railway having longer distances between stations compared with its predecessors, this meant that additional ventilation facilities became necessary. These were located not only at stations but also in between them as well. There was also the accommodation of new facilities underground, where a station may once have been accommodated under the public highway, now necessitated the use of a greater area of subsoil, not only for the station tunnels but for the additional passenger flows, with more escalators and larger ticket halls. In both instances the presence of the railway and its related facilities minimised potential use for the surface or the under surface of land for commercial or residential purposes, to a far greater degree than previously.

It was not just the railways effect on land-use that was a developing feature of the inter-relationship between the tube and land use. The railway was now a permanent feature in the subterranean realm of London, and arguably one of the few permanent features of

[18] Barker and Robbins, *History of London Transport: the Twentieth Century*, 206.
[19] 4 Eliz. 2, British Transport Commission Act 1955, Ch.XXX.

the City, especially when compared to buildings that can be and regularly are demolished with the sites re-developed to be higher or deeper. To ensure the safety of the railway the authorising act for the Brixton extension of the Victoria line, had provision for the London Transport Board to purchase any additional lands or sub-soil it required for the protection of its assets[20]. This protective zone theoretically ensuring that the railway is protected through property rights, where previously easements and the purchase of the sub-soil around the tunnels had not granted any protective measures.

The above outlined changes in the inter-relationship between the tube and land use, demonstrate that the railway and property were developing just as much in the central areas of the metropolis as they were in the suburbs. Whereas the early tubes were designed to accommodate private property interests, they came to affect them bringing the two in to an even closer relationship, than may at first be considered. This dissertation therefore builds on these points to show that though the railway is below ground and therefore unseen, it should not be taken for granted that it was not affected by or that it does not affect property interests, whether physical (property development) or theoretical (property law).

1.5 Dissertation outline

The aim of this dissertation is to bring to the surface these changes in the relationship between the tube and land-use. Part one looks at the legislation, and requirements for tube railways and the development of their related assets from 1884 to 1949, whilst part 2 considers the changes in the nature of the tube from the 1920s to the present day.

To gain a greater understanding of the specifics of tube railways chapter 2 considers the legal and engineering factors in forming the construction of the tubes between 1884 and 1999. The role of the ground or subsoil in shaping civil engineering scenarios is explored, such as the way that roads and railways utilise a combination of structures to carry their alignment across the land, whereas the tubes utilise the ground as the support. But even with underground railway construction, there are property issues. Matters relating to property ownership and property rights are therefore also reviewed not only from the perspective of a freeholder but also from that of the railway company. What rights had the railway to protect their property, for example? As this is an important topic, consideration of the Land Clauses Consolidation Act of 1845, the clauses of which were

[20] 1966, London Transport Act 1966, Ch.XXXIII, Sct.11 (1).

discussed during a joint parliamentary commission of 1892 with regard to tube railway construction, is also reviewed and the effects considered. But it is not only below ground that the factors of property and rights are applicable; the presence of railway infrastructure on the surface also has an effect on other surface development. The locations of stations or ventilation facilities are examples that are considered in chapter 3 and 4.

Whereas chapter 2 looks at the wider historical factors shaping the tube's relationship to property, chapters 3 and 4 take a more detailed turn by considering what land the railway needs to operate, such as that for depots, station buildings, station tunnels, means to access the trains and improvements to facilities. Each of these either has an impact on property, or is impacted upon by property to such a degree that either can be limited by the presence of the other. For example, if a station building erected in the early twentieth-century cannot handle the quantity of traffic passing through it in the twenty-first century it must be re-designed or re-built. How this was accomplished is a key factor of discussion relating to the tube and land use. Whereas writers such as Croome and Jackson or Follenfant[21] discuss the history, the need for and the engineering factors of tube railways, as already discussed, they miss some of the key factors relating to the upgrade projects, such as the legislation or the legal agreements for the works to be undertaken. This absence is partly corrected in chapter 4, which looks at the need for improvements to Leicester Square station and the provision of a new entrance within existing private property and the legal agreements required.

This dissertation starts to break new ground by analysing the interface between the tube, their related facilities and private property. Where once the tube had taken in to account private property interests and endeavoured to avoid encroaching upon them, a change in policy took place from the 1920s with private property now having to take in to account the presence of the tube. Though the reasoning behind this shift was central to the change in relationship, for reasons of space it is only touched on in this dissertation. This study is concerned with an analysis of the relationship between the tube and land use in specific circumstances, where the tube can not only affect property but also be affected by it. As such, chapters 5 and 6 consider changes in building design from the 1950s. They explore how the presence of the tube under property has the dual potential of being of no concern to properties above and adjacent to the infrastructure of the tube but alternatively requiring costly engineering solutions to accommodate the infrastructure of

[21] Croome and Jackson, *Rails through the clay*; Follenfant, *Reconstructing London's Underground*.

the railway. It will also demonstrate the need for protecting the railway through the purchase of additional sub-soil not required for the purposes of the railway’s operation. Chapter 7 considers the tube and main line railways, demonstrating an additional interface between the tube and other modes of transport and property.

Part 1 The Early Tube and the development of assets

Chapter 2 Minimising incursion on property

This chapter establishes the empirical foundations for this dissertation: from the benefit of tunnels over surface structures, to coverage of basic legal issues, and how a joint commission of both houses of parliament considered property rights and recommended possibilities for tube construction. This provides a platform from which to review the inter-relationship between the tube and land use in London. However, this chapter is only a basic review of property law with regard to the aspects applicable to this research; it does not claim to be a comprehensive analysis of these intricate topics.

2.0 Historical Background

The opening of the Metropolitan Railway (MR) in 1863 was to establish key principles for future underground railway development, the tunnel being located under the public highway following sources of existing traffic in the form of omnibus routes from a residential area to the central location of employment. But despite its presence under the highway, it still had an effect on surface property that at first is not apparent once we look past the method of its construction. Its presence ensures a long-term inter-relationship between the underground and surface property and urban development. When the C&SLR opened in 1890, the same factors were still applicable. The tunnels were located predominantly under the public highway, it followed a major source of existing traffic in the form of omnibus routes with which it was opened in competition[22] and it had a long-term effect on adjoining property. The subsequent lines opened up to 1907 also followed similar principles. But the key factor with regard to the MR and the early tubes was that they all endeavoured to minimise their presence and effect on property.

By the 1920s extensions and improvements to the railways and stations were under consideration or underway, to improve the existing facilities to cater for London's rapidly increasing population. This resulted in the replacement of lifts with escalators, some limited station reconstruction, and the utilisation of under highway ticket halls. A key aspect of these improvements was the use of sub-soil under private property, whereas previously the tubes had endeavoured to stay under the road. The locating of assets under property enabled the creation of new routes to relieve pressure on existing routes.

[22] "*Report from the Joint Select Committee of the House of Lords and the House of Commons on the Electric and Cable Railways (Metropolis), 1892*". 17.

The extension of the Charring Cross Euston and Hampstead Railway (CCEHR) from Charring Cross to Kennington, opened in 1926, for example, allowed passengers an alternative faster route to the west end from Kennington rather than having to change at Elephant and Castle for the slower Bakerloo line, which had more speed restrictions and stations. However, this was not a new concept as Goldney had stated to the 1892 committee that this would be beneficial for future tube railways[23].

By 1948, the need for even more route options and relief on other means of transport had been identified seeing the proposals for new tube railways, one opened as the Victoria line from Walthamstow to Victoria in 1969, with an extension to Brixton by 1971. In the same way that the earlier 1920s extensions had seen station reconstruction and the passage of tunnels under property so it was with the new line. But by the time of the Victoria line's opening building foundations had become deeper due to changes in civil engineering. When the Jubilee line was opened in 1999, it reflected much of the practices, which had gone before. This included its location under main line railway assets, such as the viaducts between Waterloo and west of Bermondsey, its construction under these, especially at Southwark where the station is highly interconnected with the main line structures, establishing a complex relationship between the two railways.

2.1 The tube and sub-soil

The primary factor enabling the design, construction and operation of any underground railway is the sub-soil within which it is located. The tunnels, whether of the sub-surface Metropolitan and District lines or the deep tube lines under consideration here, are supported by and held in shape by the ground around them. The three dimensional nature of the sub-soil allows more complex engineering structures to be formed than may be possible on the surface at a portion of the cost, not just financially but spatially. For example, fig.2.1 shows the sub-surface area of London Underground's (LUL) Waterloo station (shaded grey) served by the Bakerloo, Jubilee, Northern and Waterloo & City (WCR) lines. What is perhaps difficult to comprehend, when looking at drawings such as this, is the depth of the station, which includes ticket halls, escalators, ventilation and electrical power supply facilities as well as the station tunnels for each line, where passengers can join and alight trains. Fig.2.2 demonstrates this, the varying levels constructed at different times, by different companies, the first of which was the Waterloo & City Railway of 1898. Such a structure is only possible due to its presence under the

[23] Ibid, 3.

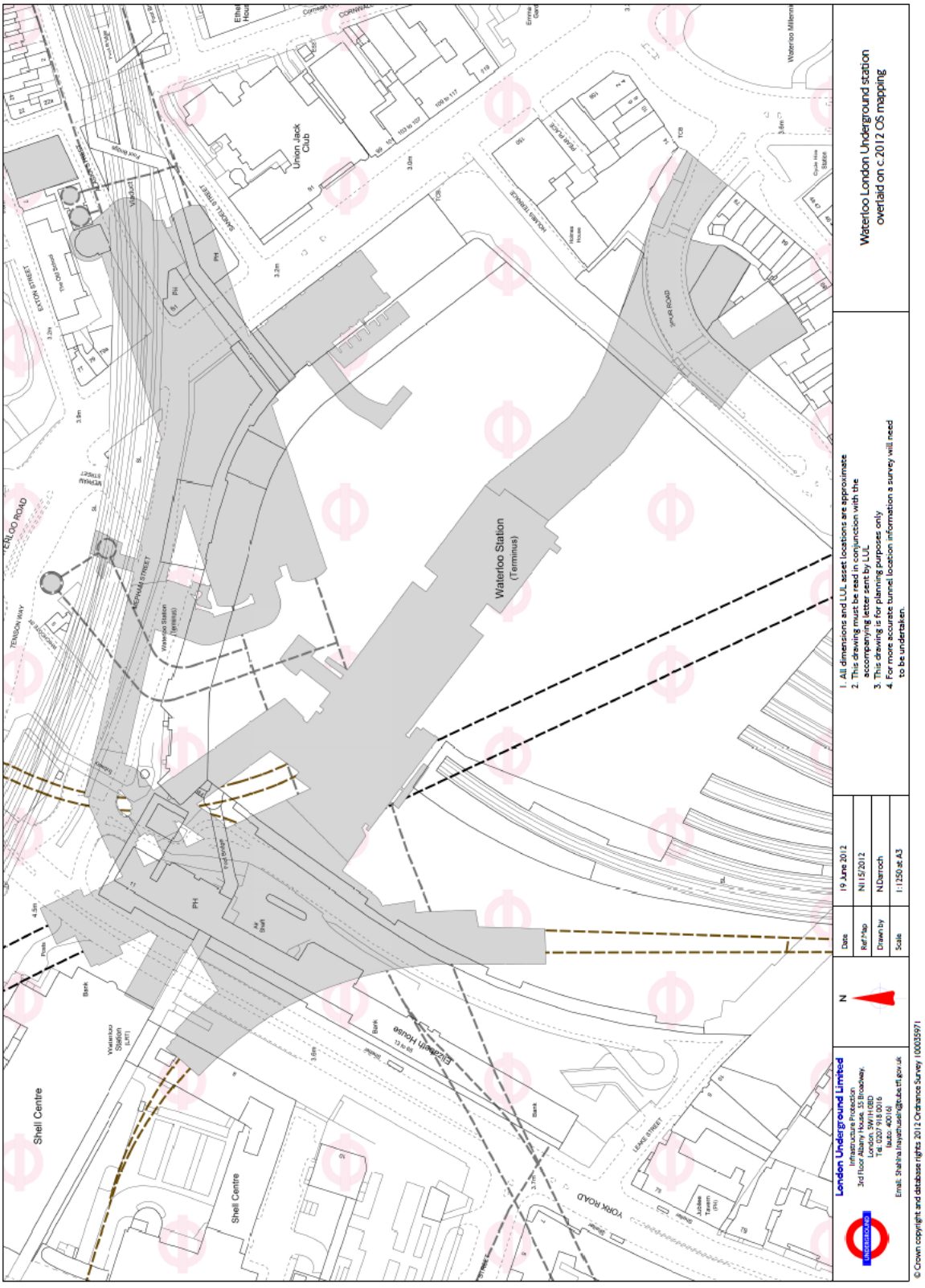

Fig. 2.1

1:1250@A3 plan showing Waterloo London Underground station and sub-surface tunnels (shaded grey) overlaid on c.2012 OS mapping.

Source: London Underground, Ref.Map.N115/2012.

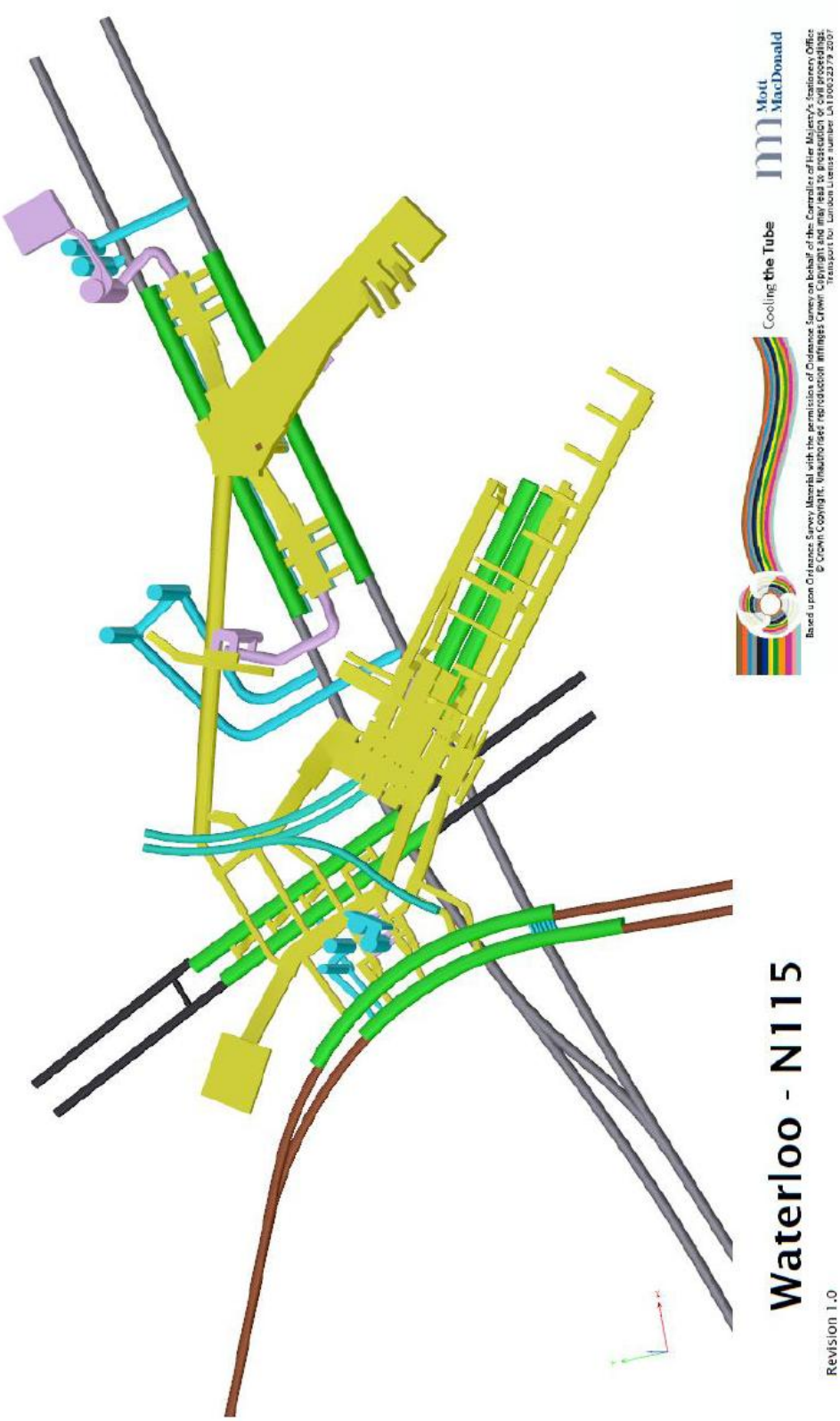

Fig.2.2

Mott MacDonald 3D model of Waterloo Station, 2012.

Source: Courtesy of London Underground.

ground; not only because of the costs mentioned above but also because it can be incorporated within and below existing structures, such as the main line station at Waterloo. It can thus form part of the city rather than being an obstruction to it. Consider how the main line termini have taken up such a quantity of land that they have restricted the construction of houses and property, for example, not just at the sites of the stations but on the approaches to them. By its very design and intention, the tube is an urban railway. Not only does it provide urban transit, it is part of the developed realm of the metropolis, passing through the sub-soil beneath our feet.

There were, and are, many factors that affect the way tube railways are constructed and how they integrate within the city. One of the principal reasons as far as the early tubes were concerned was the cost of property and the rights of landowners. To understand this relationship we must undertake a brief review of some of the background aspects relating to them.

2.2 The Land Clauses Consolidation Act 1845

The Land Clauses Consolidation Act of 1845 (hereinafter the 1845 act) plays a fundamental role in any railway undertaking. With the densely developed nature of the metropolis and the related freehold and leasehold interests, it is perhaps more of an issue to tube railways than it was to the main line railways. This is because of the densely developed and populated urban environment through which the tube passed and the need for them to avoid property interests. However, the reason behind the acts introduction originated with the main line railways.

For many years prior to the railway boom of 1845, both houses of parliament had sought to clarify certain aspects of property law in relation to transport infrastructure of a public benefit, such as canals, roads and railways. MPs desired to simplify the process of compulsory purchase, which could be heavily dependent on the opinions of a few influential parties within parliament. Sharman describes how in the 1840s Lord Shaftesbury (Lord Chairman of Committees), was considered by his contemporaries to be the last word on standing orders in parliament and as such he was consulted on many points of common law relating to bills put before the house[24].

When landowners across the country started to see proposals for railways cutting across

[24] Frank A. Sharman, "The history of the Lands Clauses Consolidation Act 1845-1". Statute Law Review, 7, Issue 1, (Spring 1986): 14.

their land as part of a transport revolution that would eventually see the majority of the country criss-crossed by railways, there was a move to formalise requirements and stipulations in legislation and provide consistency[25]. The result was the passing of two pieces of legislation: the 1845 act and the Railway Clauses Consolidation Act 1845[26]. Both were to have a long-term impact on railway legislation, even to the present day[27]. All acts relating to the tube from the City of London & Southwark Railway Act 1884 to the London Underground Act 1992 ('the 1992 act'), for the construction of the Jubilee Line Extension (JLE) reference both. The purpose of this chapter is to consider the impact the 1845 act had on the construction of London's tube railways in the central zone.

2.2.1 The 1845 act and compulsory purchase

The 1845 act specified the procedure and means for promoters of works of a public nature to purchase land required specifically for their needs as defined in the limits of deviation for the special act, whether by agreement or by compulsory purchase. When one considers the number of clauses specifying what must be undertaken should a free or lease holder dispute the compulsory purchase, it is understandable why the tube companies preferred to come to an agreement between themselves and the owner for the sale of the land, even if there was the potential for property prices to be inflated. This minimised the cost to the company of solicitor's fees, not only for themselves but also for the objector for whom they had to pay[28], as well as the loss of time that the passing of the railway bill would cost the company, especially when their shareholders would have been urging for a quick return on their investment.

The most salient clause of the act with regard to the construction of tube railways, however, was section XCII. This specifies 'that no party shall at any time be required to sell or convey to the promoters of the undertaking a part only of any house or other building or manufactory, if such party be willing and able to sell and convey the whole thereof'[29]. Bearing in mind that railways were predominantly located on the surface at this time, this meant that no part of the property could be separated from another part if the freeholder or long leaseholder (50 years or more) wished to sell the whole to the promoter. If the promoter were a tube railway company requiring only the sub-soil under

[25] Kellett. *The Impact of Railways on Victorian Cities*, 28; Sharman, "The history of the Lands Clauses Consolidation Act 1845 – 1", 13-23; Frank A. Sharman, "The history of the Lands Clauses Consolidation Act 1845 – 2", Statute Law Review, 7, Issue 2, (Summer 1986): 78-79.
[26] 8 Vict., The Railway Clauses Consolidation Act 1845, Ch.20.
[27] Haywood, *Railways, Urban Development and Town Planning,* 18.
[28] 8 Vict., The Railway Clauses Consolidation Act 1845, Ch.20, Sct.XXXIV.
[29] 8 Vict., The Land Clauses Consolidation Act 1845, Ch.18, Sct.XCII.

a property, they would have to purchase the *whole* of the property for the placement of the tunnel. They would then be obliged to sell the remainder of the land back to the original vendor if they wanted it. If they did not, it would need to be offered to the property owners either side. With the construction of the sub-surface lines, they were permitted, in some instances, to purchase an easement under the properties they required. Alternatively, they had to follow the above principle, as was the case between Victoria and Sloane Square on the Metropolitan District Railway (MDR). In that instance the company had purchased the land it required for the construction of its tunnels, demolished the properties along the alignment, constructed the railway, and then sold the land above three feet below ground level back to the Marquess of Westminster who was the land owner[30]. Though this was an understandable process for the sub-surface railways, which were dependent on following the ground level, due to the construction techniques employed, for the deep tube lines this was financially prohibitive, especially as they had no need to take any more land for their tunnels, which were some considerable depth underground.

This would have imposed a huge financial burden on the promoters of the railway, not only for the purchase of the large quantity of properties along their route but also the negotiations for the re-sale. The cost of the construction of the railway would have potentially doubled when one takes into account fees for solicitors to arrange conveyances, hold discussions with purchasers and undertake valuations. The only real beneficiary would therefore be the original vendor who had not only sold the property in the first place but could argue that they should pay less to buy it back as the tunnel or even tunnels underneath could be considered as a blight on the property, especially if vibration or subsidence was anticipated. Because of these considerations the construction of improved mass transit systems in London by the means of tube railways required a return to the principles adopted for the MR of 1863 namely to pass under the public highway, thus limiting potential spiralling costs. To develop some of these points we first look at some of the legal issues relating to the early tubes.

[30] Deed of Appointment of Freehold Hereditaments, dated 31 December 1871, Between the Marquess of Westminster and the Trustees of the Will of Robert Late Marquess of Westminster and the Metropolitan District Railway Company. TfL Muniments Archive: 4327/1009680; Conveyance, dated 17 January 1873, between the Metropolitan District Railway Company and the Marquess of Westminster. TfL Muniments Archive: 1017244.

2.3 A brief overview of property law and related issues

To clarify the former common law rights of property owners we must look to section 205 (1) (ix) of the Law of Property Act 1925 that specifies land as including a vertical and horizontal plane, though it can also be held apart from the surface[31]. This means that a land owner owns everything above and below the horizontal plane of their property, but it may not necessarily include an area of surface. For example, there are instances where the underground railways pass under private freehold property. The tunnel structure and the air space within the tunnel may belong to the railway company but they own no more than that, they do not own the sub-soil around the tunnel for example. The demise is therefore 'held apart from the surface'. We shall consider this further below but in the mean time it is beneficial to give consideration to other aspects of property which affect and are affected by the presence of the railway.

2.3.1 Sub-soil under the public highway

The relevance of being able to own a holding apart from the surface is particularly noticeable when one considers the ownership of the sub-soil beneath an adopted public highway. This is a road, or way, that is open to the public by dedication by the landowner or by statute[32]. It is maintainable by the public purse; namely the secretary of state for transport or the local authority. Generally, the highway maintainer only owns as much of the surface and depth of sub-soil for the needs of constructing and maintaining the road, specified by the authorising act for its construction. The sub-soil beneath is retained either by the overall freeholder of the property or the adjoining freehold property owners. Where there is a row of houses along a street, for example, the freeholders of those properties own to the middle of the road below the foundations of the highway. This is an essential part in understanding the pattern of development of the tube. In 1892 there had been much discussion by the committee on Electric & Cable Railways (Metropolis) as to whether the tube companies needed to pay for easements under the public highway or not[33]. The argument of the tube companies being that as they were a public service provider then they should be granted free use of that sub-soil under the roads as it was worthless to the adjoining property owners.

[31] 15 & 16 Geo. 5, The Law of Property Act 1925, Ch.20.
[32] Osborn's Concise Law Dictionary, edited by Leslie Rutherford and Sheila Bone. London, sweet & Maxwell, 8th edition 1993; 1991, New Roads and Streetworks Act 1991, Ch.22, Sct.22; 1980, Highways Act 1980, Ch.66.
[33] "Report of the Joint Select Committee of the House of Lords and the House of Commons on the Electric & Cable Railways (Metropolis), 1892", 25.

2.3.2 Easements and way-leaves

When the early tubes were authorised, their special acts granted them the right to compulsory purchase for an easement under private property[34]. The definition of an easement is 'a right enjoyed by an owner of land over the land of another such as a right of way'[35]; alternatively, a way leave or a 'right of way over or through land' can be given 'by way of express grant or reservation'[36].

An important factor regarding easements and way-leaves, and one essential to understanding the reasoning behind this dissertation, is that the beneficiary of the easement does not gain any rights that outright ownership of land would give. Instead, they are granted the right to use the land through agreement. If this was not forth coming, for instance if the landowner was to take the company to a tribunal and that tribunal was to rule against the company or insisted the whole of the land was to be taken, the railway company would potentially have had to take a different alignment.

Additionally the company does not have any right to determine what the property owner can do with the sub-soil around the railway. For example if a landowner wished to use their sub-soil to construct a basement directly adjacent to the tunnel, they would be able to do so. The company could only persuade the developer not to undertake any works that may affect the safety of their assets. By contrast, if the railway company owned the sub-soil around the tunnel or structure, they would then have the right to determine what was done to that sub-soil. For example if the landowner wished to excavate a basement that was to pass through sub-soil owned by the railway company it would be the decision of that company whether to grant an easement to the land owner or not. As we shall see in part 2 of this dissertation, this became an important consideration in relation to the Victoria line (authorised in 1955[37]) and the JLE (authorised in 1992[38]).

In some areas of London, proposed but un-built lines in the twentieth century such as the Fleet Line saw the purchase of sub-soil in preparation for the construction of tunnels. Where these plots were located beneath private property and the owner of that property wished to re-develop or sell their land that sub-soil had to be excluded from the disposal. If the owner wished to re-develop their land and wished to use the sub-soil for

[34] 47 & 48 Vict., City of London and Southwark Subway Act 1884, Ch.CLXVII, Sct.31; 63 & 64 Vict., Baker Street and Waterloo Railway Act 1900, Ch.CCXXV, Sct.13-14.
[35] Osborn's Concise Law Dictionary.
[36] Ibid.
[37] 4 Eliz.2, British Transport Commission Act 1955, Ch.XXX.
[38] 1992, London Underground Act 1992, Ch.III.

foundations, then they needed to be granted an easement for its use by the railway company.

2.3.3 Royal Parks and Crown Lands

An additional factor worthy of note is that the lands owned by the crown are not subject to legislation such as the 1845 act. In the context of London, these are the Royal Parks and Crown Land (the Crown's lands). Whereas an easement or way-leave grants the railway company the right to place their tunnels within the sub-soil of private property and to treat the area within the tunnel as their own, the same principle does not apply to Crown Lands. Where the railway passes under these lands, the company is granted a deed of grant for the sub-soil to be used for the purposes of the railway. The company has no actual right to the sub-soil or air space[39]. The property interest within the tunnel, such as the air space, therefore reverts to the crown should the railway fall in to disuse.

2.3.4 Air space

'The owner of land is entitled to the ownership and possession of the column of space above the surface ad inifinitum'[40]. As such, a freehold owner has the right to sell or lease to another party the area above land or a building for whatever uses the freeholder sees fit. For example if an underground railway company has designed their station for development above they can lease the air space they do not require for operational needs for development as offices or residential property. By doing this, the company has an alternative source of income other than from fares.

Any change of use of the leaseholder's building could see the single payment of an 'up-lift' or an annual share of the income based on the revenue from modification to or re-building of the leasehold property. When the lease expires, the railway company can then renew the leaseholder's lease or put the lease on the market in the hope of gaining better offers.

2.3.5 Re-development of property

In some instances, it may be beneficial for a freehold property owner with a building

[39] 1 & 2 Geo.5., London Electric Railway Act 1911, Ch.XXIX, Sct.55; Grant of easement, dated 26 June 1900, between J. F. F. Horner, a Commissioner of Woods and the Central London Railway Company, to maintain Railways and works in Crown Land. TfL Muniments Archive: 1017037.
[40] Osborn's Concise Law Dictionary.

located on prime real estate to re-develop their land to provide alternative facilities located within a larger development owned by another party. The most basic way of dealing with this is either full disposal of the freehold interest or by leasing the land to the other party. With regard to the railway, both provisions by necessity including agreements for provision of facilities within the new development for the railway. These would be designed to the standards and requirements of the railway company. Any such provision would likely include ventilation, electricity supply and control, or passenger facilities such as an entrance to a station; it may even involve provision of more substantial facilities such as sidings. At the opposite end of the spectrum however, it may only be something as simple as a right of passage.

2.3.6 The tube and property

Whereas the 1845 act states that railway companies cannot retain land for purposes other than operational uses[41] the underground companies could, and still do, have the right to develop and lease property to another party as defined under their special acts for their construction[42]. As we shall see throughout this dissertation this was and is an important factor in the inter-relationship between the tube and the metropolis, one that has its origins in the earliest days of construction for the sub-surface railways.

The reason for this provision is the integrated nature of the underground railway within the urban realm. Unlike main line railways, it was possible from a very early stage to contain the railway within a smokeless environment with electricity powering trains. The tube, therefore, did not need to be at surface level or in cutting to pass through the city: thus, it had a minimal requirement for surface property. However, where it had surface property it was beneficial for it to be integrated within the urban realm by the leasing of the air space above its station buildings, railways or depot lands for development. Though the underground railways are primarily transport providers they also had and still have commercial property interests in the city, as such, they have always had commercial bodies within them to manage these aspects of the railways, unlike the main line railways that focus solely on transport and generally dispose of non-operational land. As such, TfL is one of London's major landowners today, most of the property interest being former railway land and air space.

[41] 8 Vict., Land Clauses Consolidation Act 1845, Ch.18, Sct.CXXVII.
[42] 50 & 51 Vict., City of London and Southwark Subway (Kennington Extensions, &c) Act 1887, Ch.CV, Sct.19; 63 & 64 Vict., Baker Street and Waterloo Railway Act 1900, Ch.CCXXV, Sct.11.

2.4 The Joint Select Committee of 1892

A very important factor in understanding the development of the tube was the Joint Select Committee of 1892 that was established to determine the most beneficial method of construction for the railways. Speaking at a presentation to the Institution of Civil Engineers in 1895, James Greathead, consultant engineer to the majority of the original tube construction schemes, stated that 'probably the most general requirement of great cities is a good system of internal communication for passengers'[43]. He observed that there was a particular requirement for improved facilities within London's central zone owing to the far-flung location of the main line termini and the sub-surface railways (the MR and MDR), skirting it. In an effort to tap in to the traffic demands for access to this area and in light of the success of the C&SLR, proposals were put forward for deep tube railways from the suburbs to the City and West End in the 1892 session of parliament.

As a result, and in answer to concerns of vested parties, such as the Corporation of London, a Joint Select Committee was established, sitting from Monday 9 May to Monday 23 May 1892. The panel members from both houses of parliament interviewed promoters of the railways as well as representatives of the local authorities through which the railways were to pass[44]. Greathead was one of the witnesses interviewed due to his involvement with the construction of the C&SLR and knowledge of the requirements for the construction of the railways.

2.4.1 Easements and way-leaves under property

When the City of London and Southwark Subway had been authorised in 1884, permission was granted for the purchase of easements under private property[45]. With the rise in proposals for tube railways, 'the terms and conditions under which the subsoil should be appropriated' became a key factor discussed by the committee[46]. Having heard evidence for and against the proposals the committee recommended that the proposed schemes were beneficial, the routes were appropriate and that the sub-soil under private property required for the construction of the tunnels should be granted by way-leave, compensation payable to the freeholder to be determined by the

[43] Greathead, "The City and South London Railway; with some remarks upon subaqueous tunnelling by shield and compressed air". Institution of Civil Engineers, *Minutes of the Proceedings*, 1, Vol.123, (January 1896): 39.
[44] "Report of the Joint Select Committee of the House of Lords and the House of Commons on the Electric & Cable Railways (Metropolis), 1892", [V].
[45] 47 & 48 Vict., City of London & Southwark Railway Act 1884, Ch.CLXVII, 31.
[46] "Report of the Joint Select Committee of the House of Lords and the House of Commons on the Electric & Cable Railways (Metropolis), 1892", [V].

specifications of the 1845 act[47]. The landowner was required to demonstrate what loss they would incur from the presence of the tube. As, in most cases, the tunnels were some depth underground this would not fully become an issue until the 1950s when buildings with greater height and depth were to play a part in the development of London. However, there were factors that would start to become apparent from the 1920s when escalators began to replace lifts in stations, discussed further in chapters 3 and 4.

Though the recommendation was appropriate for the short distances that Greathead anticipated it was prohibitive for any long-distance route[48]. This was because of the cost of the purchase; solicitors' costs as well as the costs of arguing a case where the landowner objected. The companies had therefore asked the 1892 committee to consider another cheaper option along with the purchase of easements. This was the use of the sub-soil beneath the public highway for no payment except compensation where an adjoining property was affected by the railway.

2.4.2 Easements under the public highway

The alignment of the tunnels was of paramount importance not only to the company but also to those property owners along the line of route. For their part, the companies wished to construct their railway for the minimum cost and along routes that would provide the greatest revenue. They purposefully followed the major highways to attract existing traffic from the omnibuses[49]. On the other hand, property owners did not want their buildings, whether residential or office, to be blighted by the presence of the railway whether through vibration or the inability to develop the property at a later date. As such the issue of payment for easements under the public highway as an alternative to passing under private property was a topic much discussed in the 1892 committee. Greathead argued that easements were an essential factor in the construction of the railway to keep construction costs to a minimum. He used the example of Hibernia Chambers, south of the Thames and the only property under which the C&SLR passed. At this location (fig.2.3), the company had paid £3000 for an easement of fifty to sixty yards, the property's rateable value being about £150,000[50]. The overall costs appear to have been dominated by the legal fees related to the transfers, as the company had paid

[47] Ibid.
[48] Ibid,19.
[49] Ibid, 17; House of Commons Parliamentary Papers, Online, House of Commons Papers; Reports of Committees, (2752), "Report of the Royal Commission appointed to inquire into and report upon the means of Locomotion and Transport in London, Vol. III, 1905". http://parlipapers.chadwyck.co.uk/marketing/index.jsp. [Accessed August 11, 2011].3.
[50] "Report of the Joint Select Committee of the House of Lords and the House of Commons on the Electric & Cable Railways (Metropolis), 1892", 19.

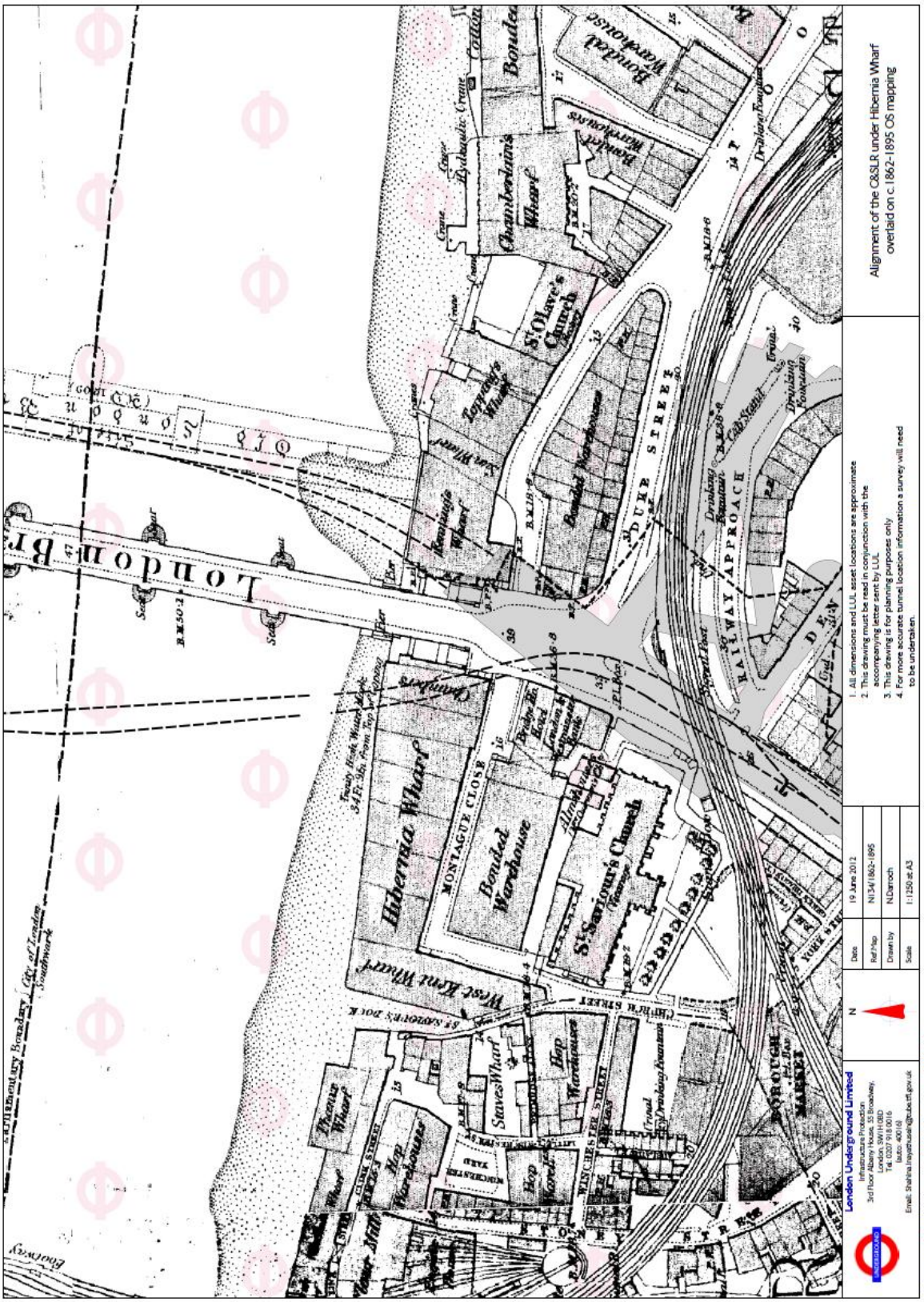

Fig.2.3

1:1250@A3 plan showing the alignment of the C&SLR (dashed black) under Hibernia Wharf overlaid on c.1862-1895 OS mapping.

Source: London Underground, Ref.Map.N134/1862-1895.

in the region of £150 each to several persons with an interest in the property[51], as well as payment for passing under the river[52]. Had the company not reached the agreement it would potentially have had to purchase the property as a whole, hence his argument that easements were preferable. In the City of London and Southwark Railway Act of 1884, the company was granted free use of the sub-soil under the public highway for the construction of the tunnels[53], reflective of the previous Metropolitan Railway acts that had doubtless set the original precedent[54]. However, as we saw above, lands under the highway still belong to the adjacent landowners[55]. To settle the issue of to whom compensation for use of the sub-soil was to be paid, the local authority or the adjoining owners, the commission heard evidence based on the Central London Railway (CLR)[56]. The argument made was that just as gas and water utilities companies, did not have to pay a way-leave or purchase an easement as they were for the public benefit neither should the railway company, which were themselves for the public benefit.

The committee advised that the tube companies should be empowered 'to pass under the streets at sufficient depth without payment of compensation for the way-leave'[57] and only pay the adjoining property owners' compensation if there was any damage to their buildings[58]. They also recommended that the easements should be in return for the provision of 'cheap and convenient trains'[59]. Instead of operating workingmen's trains, however, which the authorising act did not provide a requirement for; the Great Northern Piccadilly & Brompton Railway (GNPBR) paid the London County Council £3500, for its consent for the construction of the railway under Kingsway[60]. Interestingly Croome and Jackson do not make observation of this when referring to the works[61]. Instead, they state that the lack of workingmen's fares and no requirement for partial payment for the presence of the railway under the Kingsway was a 'double rebuff' to the LCC.

[51] Agreement, dated 8 June 1884, between the City of London and Southwark Subway and W. H. Humphery and others. TfL Muniments Archive: 1002069.
[52] Grant, dated 9 July 1886, between the Conservators of the River Thames and the City and South London Railway Company, in reference to construction of subway. TfL Muniments Archive: 1061170.
[53] 47 & 48 Vict., City of London & Southwark Railway Act 1884, Ch.CLXVII, Sct.31.
[54] 16 & 17 Vict ., North Metropolitan Railway Act 1853, Ch.CLXXXVI, Sct.XII-XVIII; 17 & 18 Vict., The Metropolitan Railway Act 1854, Ch.CCXXI.
[55] "Report of the Joint Select Committee of the House of Lords and the House of Commons on the Electric & Cable Railways (Metropolis), 1892", 25.
[56] Ibid.
[57] Ibid, [VI].
[58] Ibid, [V], 25, 108-109.
[59] Ibid, [VI].
[60] Agreement, dated 20 June 1905, between The London County Council and the Great Northern Piccadilly and Brompton Railway Company. TfL Muniments Archive: 1016043.
[61] Croome and Jackson, *Rails Trough the Clay*, 23.

2.5 Conclusion: the alignment of the tube 1884-1920

It is very difficult to say whether the recommendation of the 1892 committee and the provisions within the special acts for the railways enabling the purchase of easements under property were utilised to full effect by the early tube companies, especially when we take in to account their alignments. As with the sub-surface Metropolitan line, opened under the Marylebone, Euston and Farringdon Roads in 1863, most were planned to take in to account available sources of traffic and as such followed the primary highways to London. For example, the C&SLR followed a north-south alignment, the CLR an east to west one; even the Baker Street & Waterloo Railway (BSWR) followed principal highway routes between Elephant & Castle and Baker Street. This suggests that the possibility of using the easements was practically irrelevant, as the majority of roads were wide enough to accommodate the tunnels beneath.

Nevertheless, as far as the GNPBR was concerned, easements under property proved a paramount factor in the construction of the railway. Fig.2.4 shows the alignment of the railway between Kings Cross and Russell Square, with the railway passing under property. The reason for this is apparent. The railway, constructed from Finsbury Park to Hammersmith and opened in 1906, was constructed to attract as much traffic as possible by providing the most direct route possible between major destinations. To do this it had to pass under property to reach these places, located mainly on the principal public highways, such as the new Kingsway and the Charring Cross Road. For example, passengers arriving at Kings Cross wanting to travel to the west end would have much preferred the direct tube route than the circuitous one via the MR or MDR requiring an interchange with the CCEHR.

Nevertheless, the most likely cause of easements not being fully utilised by the majority of early tube railways was the private finance of the railways. The railway had to be constructed and operated in such a way as to maximise revenue and payment to the shareholders[62]. As we have seen above the costs of constructing the railways under property were high when compared to construction under the public highway. Therefore, it is understandable why the companies chose not to pass under private property, as it would have affected the long-term profits of the company until all of the initial costs had been re-paid. After all, who would really pay more than necessary on a business

[62] Barker and Robbins, *A History of London Transport: the Twentieth Century*, 1-282.

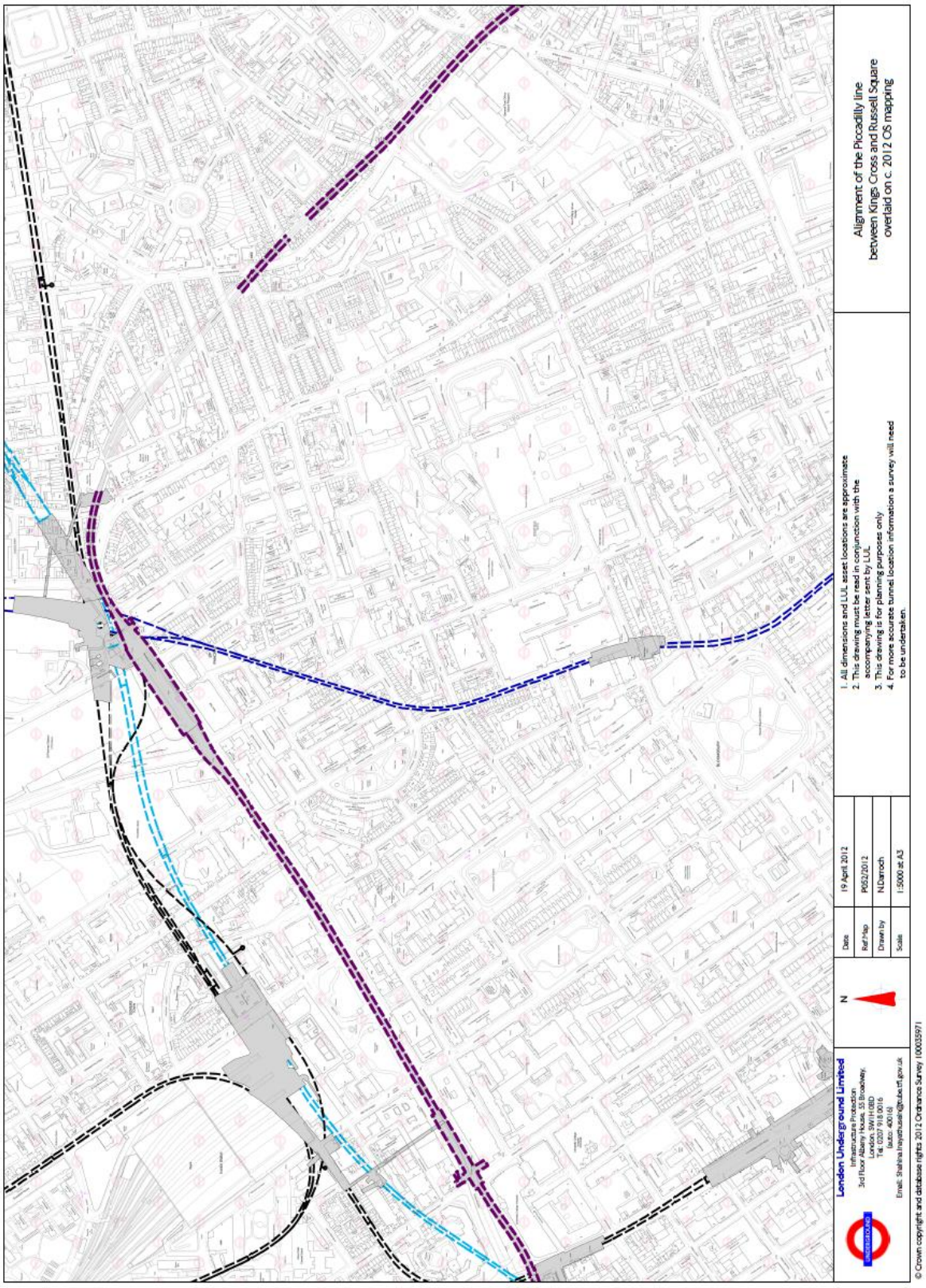

Fig.2.4

1:5000@A3 plan showing the alignment of the Piccadilly line and sub-surface station tunnels between Kings Cross and Russell Square overlaid on c.2012 OS mapping.

Source: London Underground, Ref.Map.P052/2012.

proposition, with little chance of a quick return on the initial investment[63]?

What enabled the tubes to be so effectively located under the public highway was the use of single bore tubes. The separate tunnels able to be located one on top of another or at a different depth to its partner when negotiating the medieval street pattern of London, the latter due to London's growth with minimal town planning, unlike cities such as New York and Paris with their wide straight roads. This not only allowed the tunnels to be located under narrow streets, such as Cheapside near St Paul's Station, where otherwise they would pass under property (fig.2.5 & fig.2.6), but it also allowed the tubes to follow curves in the road which may have been tighter than would have been preferable[64]. Fig.2.7 shows the alignment of the Piccadilly line (the former GNPBR) between South Kensington and Knightsbridge as an example of how one of the earlier tube lines (opened in 1906) took benefit from the easement utility. What is most noticeable is the way the railway fails to take full benefit from it as the tight curves show. This results in a heightened requirement to slow the train, limiting the number of trains that can run over that section of line at any one time; whilst increasing rail and wheel wear and ultimately the cost of maintenance of the vehicles and track, and potentially causes vibration to be felt in adjacent properties[65].

Indeed the majority of the 1884-1907 tube railways followed the same pattern as that established by the C&SLR, namely following the alignment of the public highway as much as possible. This is not to say that the recommendations of the committee were not beneficial to the companies. Up to the 1920s, easements were generally not required, although they did allow the companies some flexibility in route planning. The main benefit of the committee's recommendations took place from the 1920s, when the original tubes were extended to cater for greater demand and provide new alternative travel patterns. By this time, the urban geography meant that the tubes were constructed beneath property to a degree never before seen. This in turn resulted in an increased interface between the tube and land-use in the urban environment. But, we must not focus solely on the tubes as an underground railway as it must also be taken in to consideration that the railway has surface interfaces that are just as paramount to its operation as are the sub-surface assets.

[63] Croome and Jackson, *Rails through the clay,* 81.
[64] "Report of the Joint Select Committee of the House of Lords and the House of Commons on the Electric & Cable Railways (Metropolis), 1892", 20-21.
[65] Croome and Jackson, *Rails Trough the Clay*, 510.

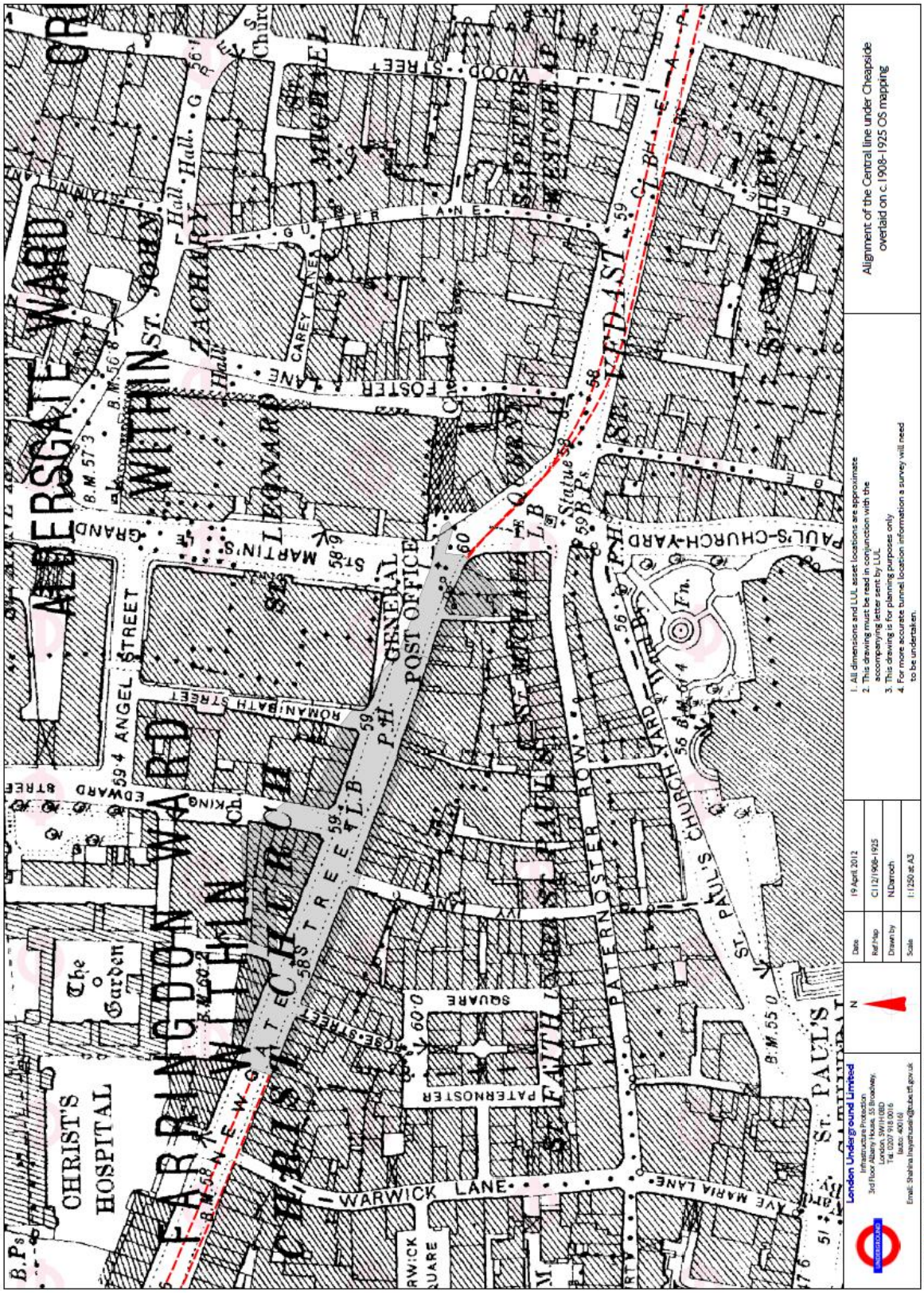

Fig.2.5

1:1250@A3 plan showing the alignment of the Central line (dashed red) and sub-surface station tunnels (shaded grey) under Cheapside overlaid on c.1908-1925 OS mapping.

Source: London Underground, Ref.Map.C112/1908-1925.

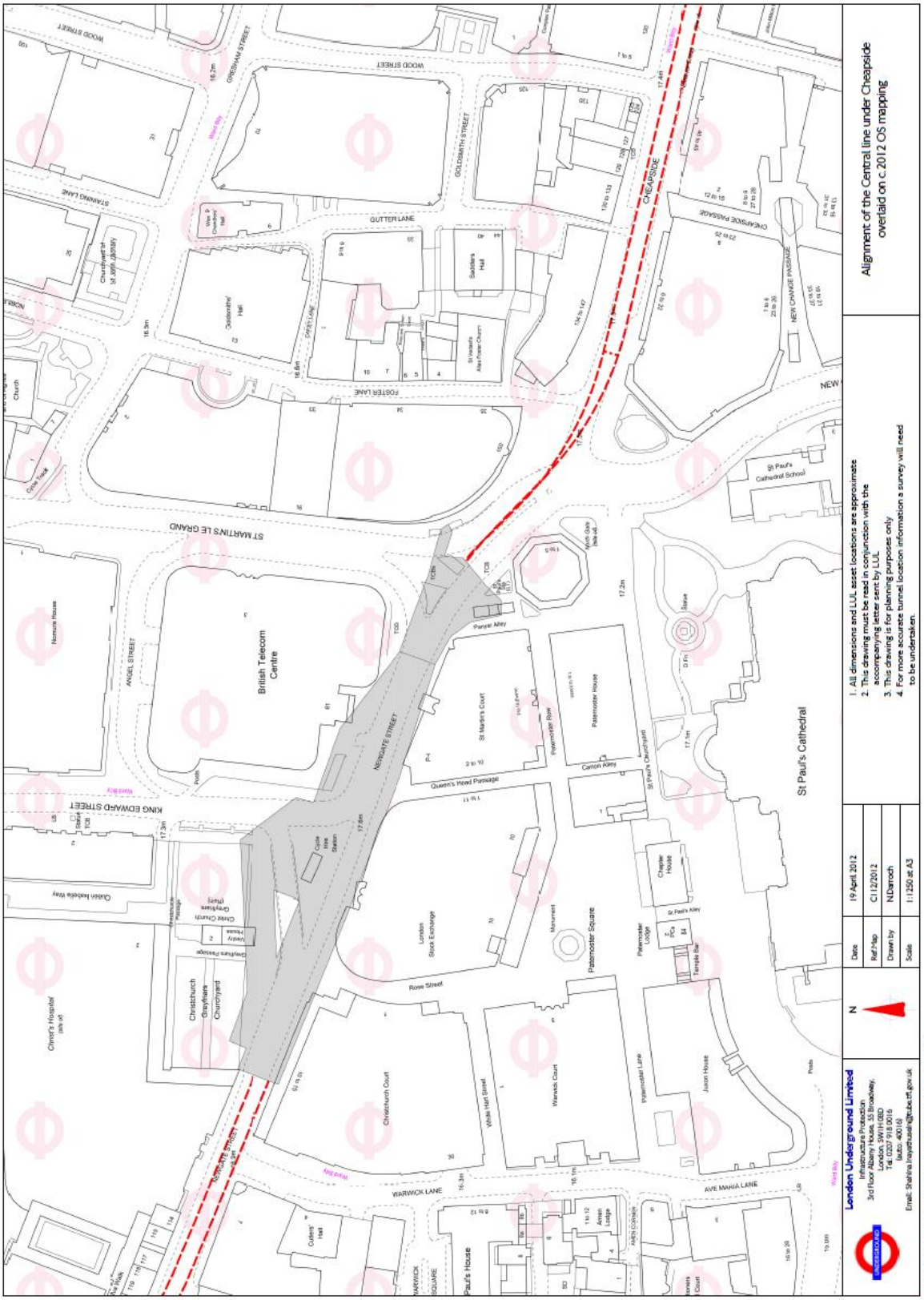

Fig.2.6

1:1250@A3 plan showing the alignment of the Central line (dashed red) and sub-surface station tunnels (shaded grey) under Cheapside overlaid on c.2012 OS mapping.

Source: London Underground, Ref.Map.C112/2012.

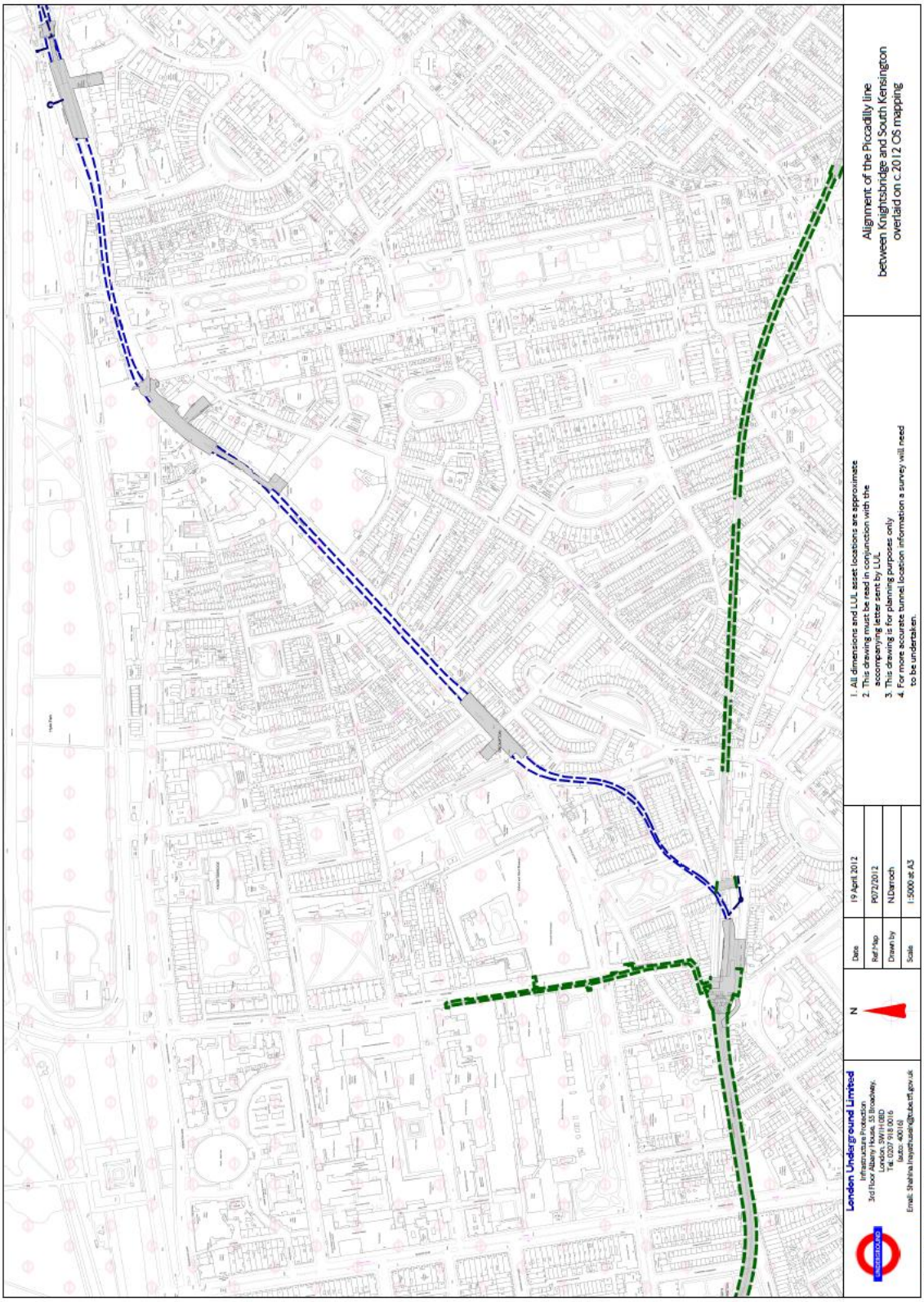

Fig.2.7

1:5000@A3 plan showing the alignment of the Piccadilly line (dashed blue) and sub-surface station tunnels (shaded grey) between Knightsbridge and South Kensington overlaid on c.2012 OS mapping.

Source: London Underground, Ref.Map.P072/2012.

Chapter 3 Surface structures

Though the tube tunnels are below ground, they still have to interface with the surface. This affects land use; people's need to gain access to the trains is perhaps the most obvious feature of this interaction. But there are also other factors such as train storage, power supply, the developing requirement for ventilation, the potential loss of commercial or residential space where there are station buildings and the use of these when alternative facilities are provided.

3 .0 Depots and land use

A location for the storage, maintenance and repair of vehicles is an essential aspect of any transport system. With regard to the tube, the location of the depot or works has to be in close proximity to the main line so that there is no additional expenditure on a section of line that has no revenue earning function. Such a location also reduces the periods of time that trains are out of service travelling between the terminus and the depot. As such, the preferable location must be at or near a terminus, or, failing that somewhere along the line. The most beneficial location however is not always the cheapest and a lot of thought has to be given to where these sites could be. This can mean purchase of property in a developed area. However, these sites, as London grew, became too confined for the number of vehicles required for increasing traffic and extensions to lines[66] and as such either alternative facilities were required or the site, as we shall see, would become an area restricting potential development for either the railway or a commercial use.

When the C&SLR opened in 1890, it ran from Stockwell to King William Street in the City, from one highly developed area to another. However, the railway company had to provide facilities for the storage and maintenance of its fleet so a depot and power station were provided at Stockwell (fig.3.1). Such a proposal today, a train depot in the centre of a developed area, would doubtless not be considered acceptable due to local and political objection. It is also doubtful whether the railway company would even propose such a development today, due to the economic and environmental impacts, such as land use, noise, lighting etc. that such a development would have on the urban environment. Indeed these contentious issues are regular causes of complaints from neighbours to some of London Underground's suburban depots today. The loss of

[66] Follenffant, *Reconstructing London's Underground,* 124-131.

Fig.3.1

1:1250@A3 plan showing Stockwell C&SLR depot on c.1908-1925 OS mapping.

Source: London Underground, Ref.Map.N147/1908-1925.

private land for commercial development was potentially not as disruptive to overall land-use as it would be today. After all, there were few limits to where London could expand, demonstrated by the continued suburban expansion of the city during the period under consideration (1890-1907) until the late 1940s and the introduction of the green belt. If we consider the historic mapping for the Stockwell depot we can see that it took up little more land than the orchard it replaced (fig.3.2). Though the depot was closed around 1924 with the site purchased by the Commissioners for Crown Lands in 1929 for development as housing[67], the company retained some interest in the site for operational purposes. The original power station remained in use for some time before it was converted in to a sub-station for converting power from the National Grid to use on the railway and London's tramways.

A highly pertinent example of how the railway continues to affect land use for the purposes of operational matters is London Road sidings in Lambeth (fig.3.3). Constructed as a depot for the BSWR (opened in 1906) it utilised the existing footprint of a School for the Indigent Blind[68] which was demolished for its construction (fig.3.4 and fig.3.5), the land purchase costing £140,000[69]. The use of this site not only benefited the railway company, as it minimised the need to negotiate purchase of property with multiple property owners, it also benefited the owners and patients of the hospital as newer facilities could be provided at an alternative location. To gain access to the depot from the main line a single-track tunnel was bored, following the existing practices, under the public highway. Unlike the earlier sub-surface railways of the MR and MDR, which saw many open sections covered over and put to development use, (fig.3.6 and fig.3.7), the depot site was and is too large for this to be undertaken cost effectively. Despite many proposals for re-development, the engineering required is financially prohibitive, meaning that the only other option would be to re-locate the depot elsewhere. In this instance, any such move would require an extension of the line to some considerable distance from its current terminus at Elephant & Castle. However, this is not to say that with the will and money to do so, that the air space above a site such as London Road sidings could not be developed. For example, the Westfield shopping centre in Shepherds Bush and Earls Court Exhibition Centre are both constructed over what were originally sections of open railway, the freehold of which is still owned by LUL. The former is located on the site of the former White City Central line depot (fig.3.8) and still

[67] Conveyance, dated 18 March 1929, between The City and South London Railway Company and the King's Most Excellent Majesty. TfL Muniments Archive: K 868/1002840.
[68] Conveyance, dated 26 January 1901, between the President of the School for the Indigent Blind and the Baker Street and Waterloo Railway Company. TfL Muniments Archive, 1006307.
[69] Conveyance, dated 26 January 1901, between the President of the School for the Indigent Blind and the Baker Street and Waterloo Railway Company. TfL Muniments Archive: 1006307.

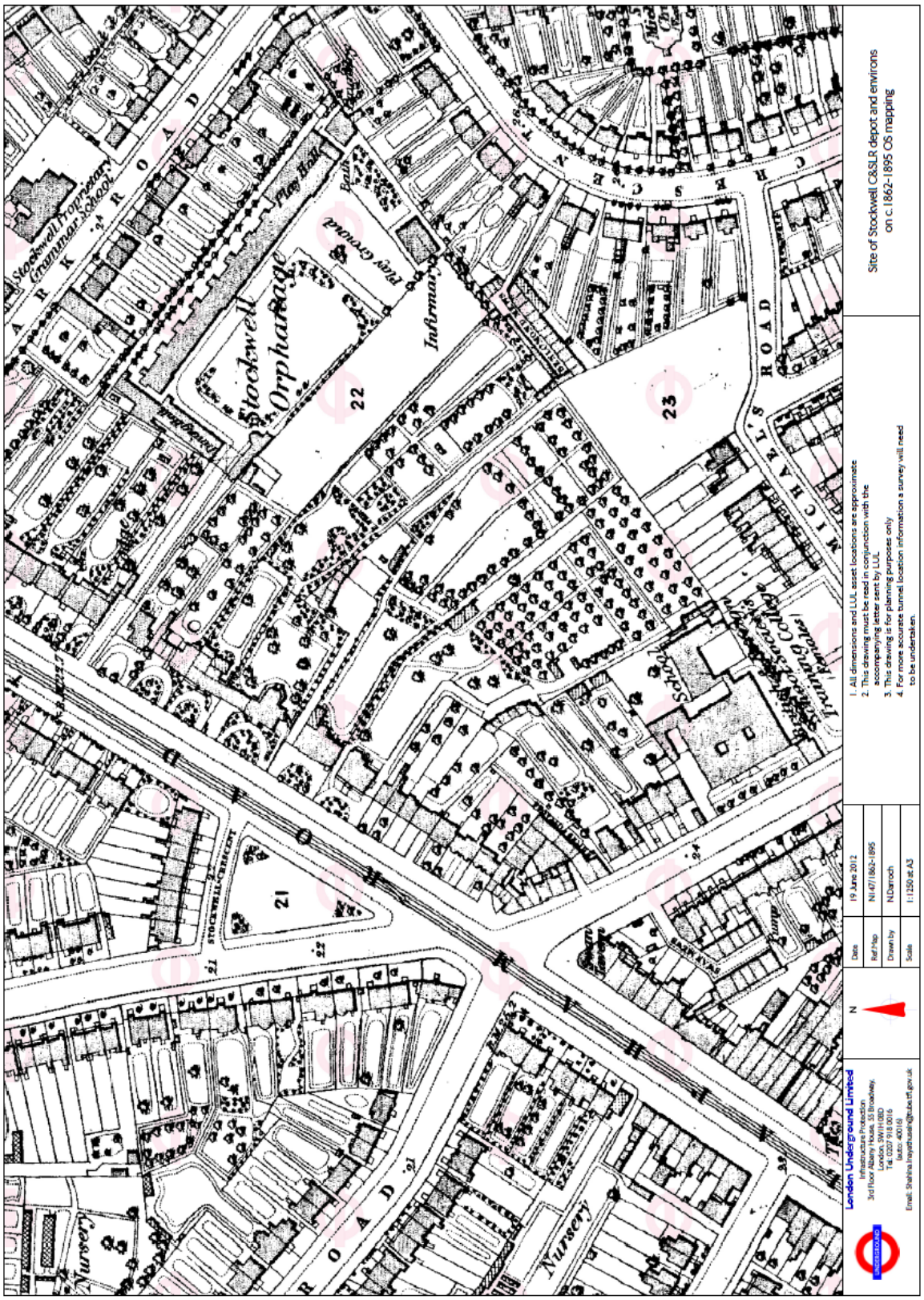

Fig.3.2

1:1250@A3 plan showing the site of Stockwell C&SLR depot and environs on c.1862-1895 OS mapping.

Source: London Underground, Ref.Map.N147/1862-1895.

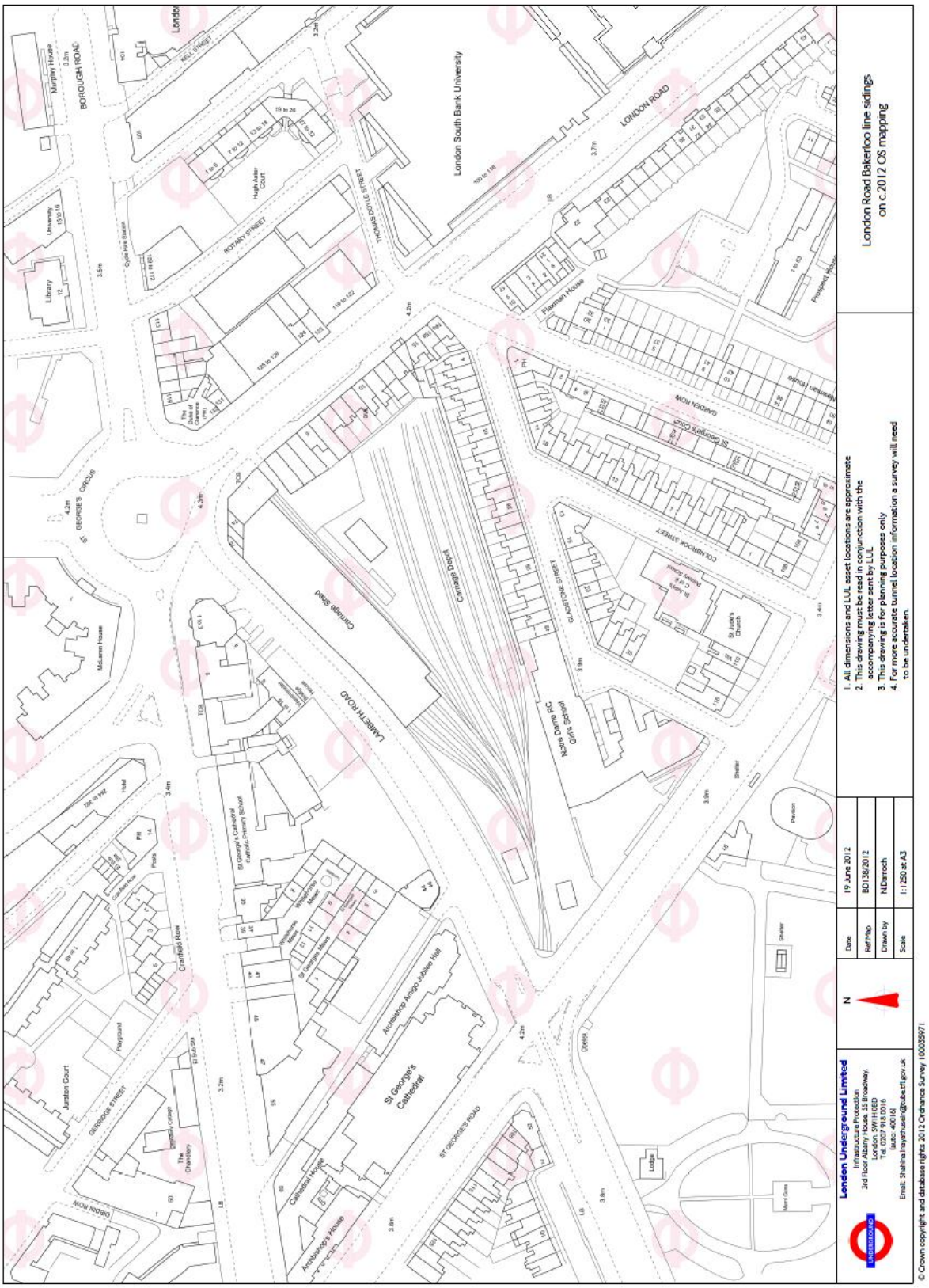

Fig.3.3

1:1250@A3 plan showing London Road Bakerloo line sidings on c.2012 OS mapping.

Source: London Underground, Ref.Map.BD138/2012.

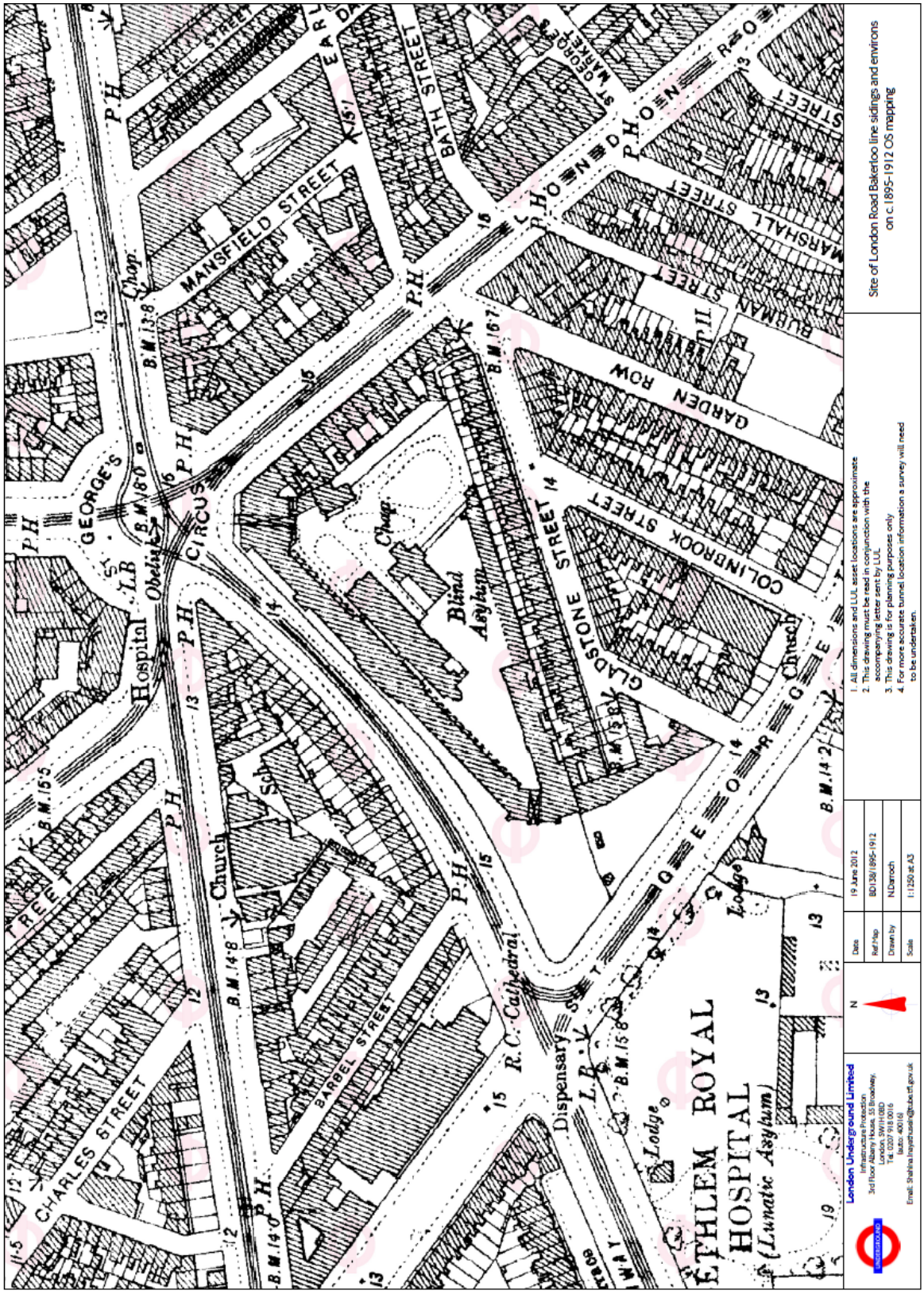

Fig.3.4

1:1250@A3 plan showing the site of London Road Bakerloo line sidings and environs on c.1895-1912 OS mapping.

Source: London Underground, Ref.Map.BD138/1895-1912.

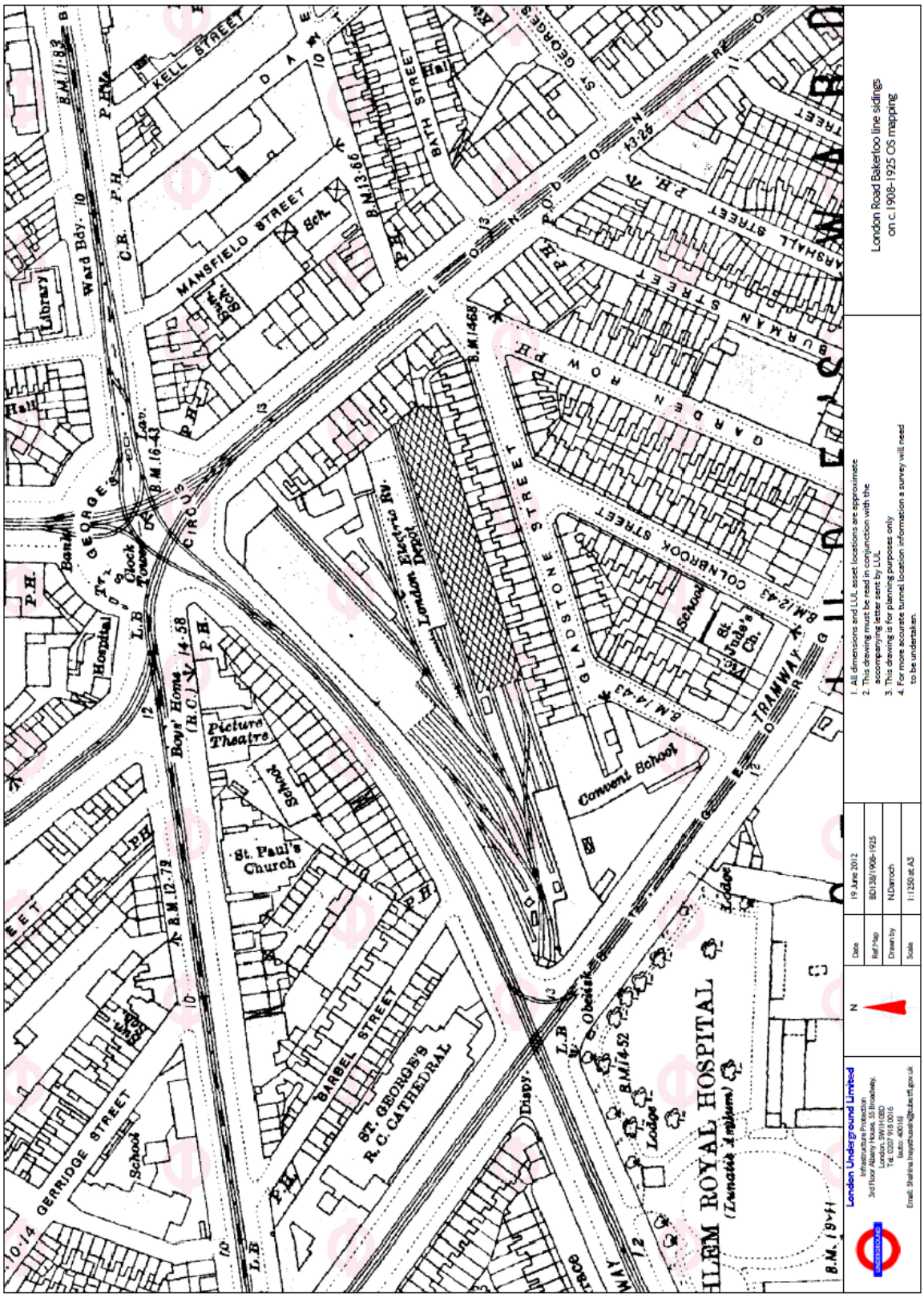

Fig.3.5

1:1250@A3 plan showing London Road Bakerloo line sidings on c.1908-1925 OS mapping.

Source: London Underground, Ref.Map.BD138/1908-1925.

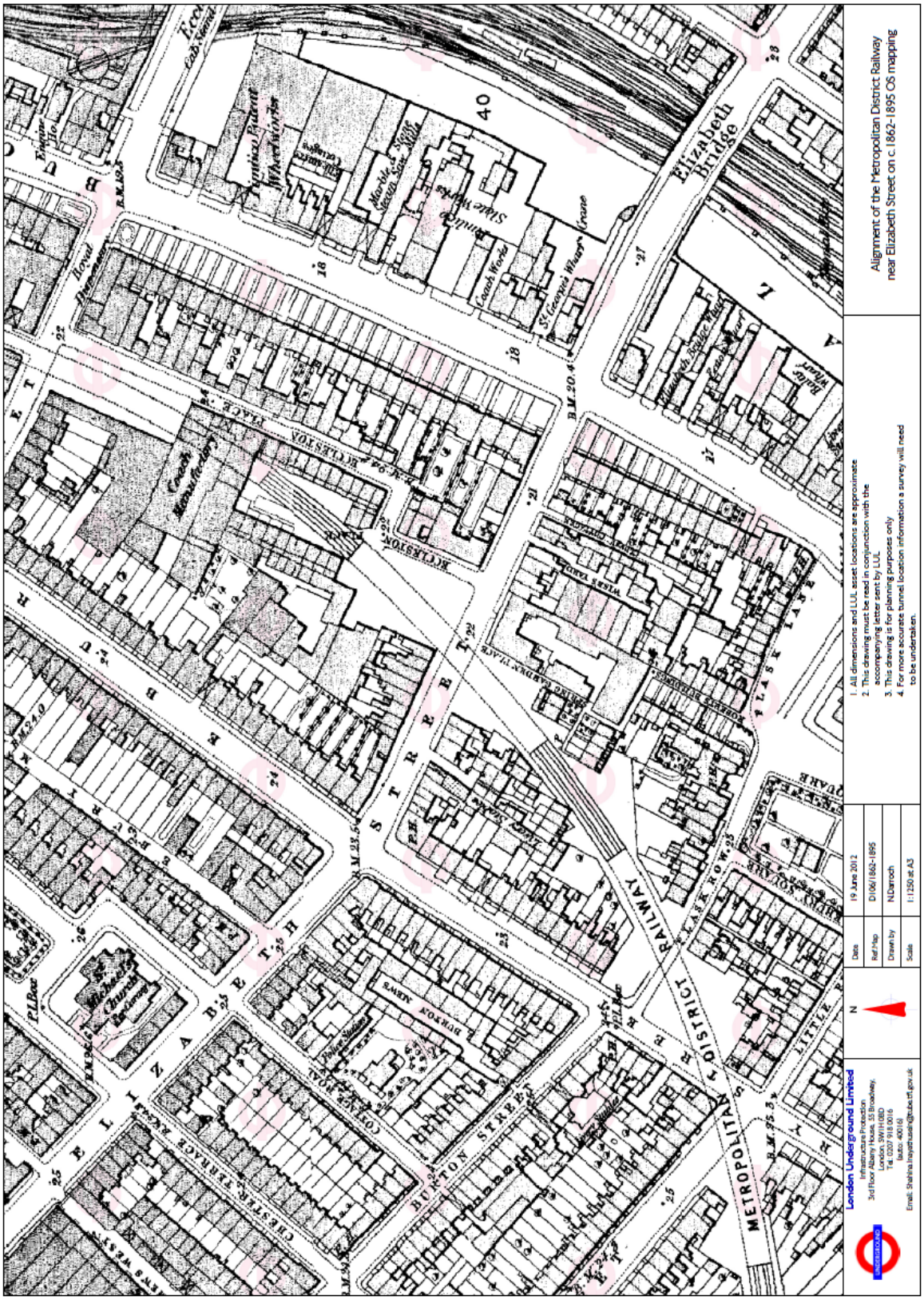

Fig.3.6

1:1250@A3 plan showing the alignment of the Metropolitan District Railway near Elizabeth Street on c.1862-1895 OS mapping.

Source: London Underground, Drg.No.D106/1862-1895.

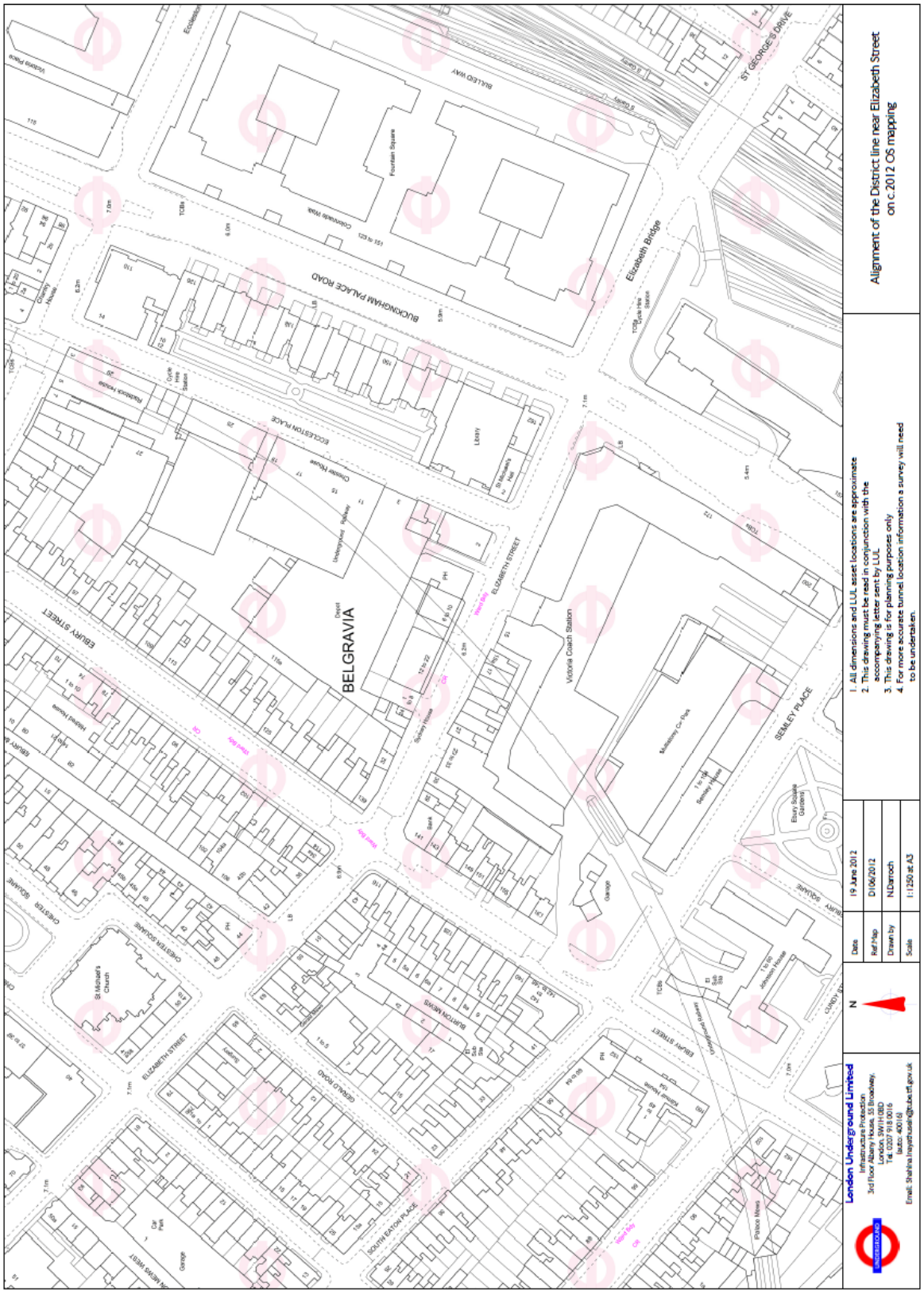

Fig.3.7

1:1250@A3 plan showing the alignment of the District line near Elizabeth Street on c.2012 OS mapping.

Source: London Underground, Ref.Map.D106/2012.

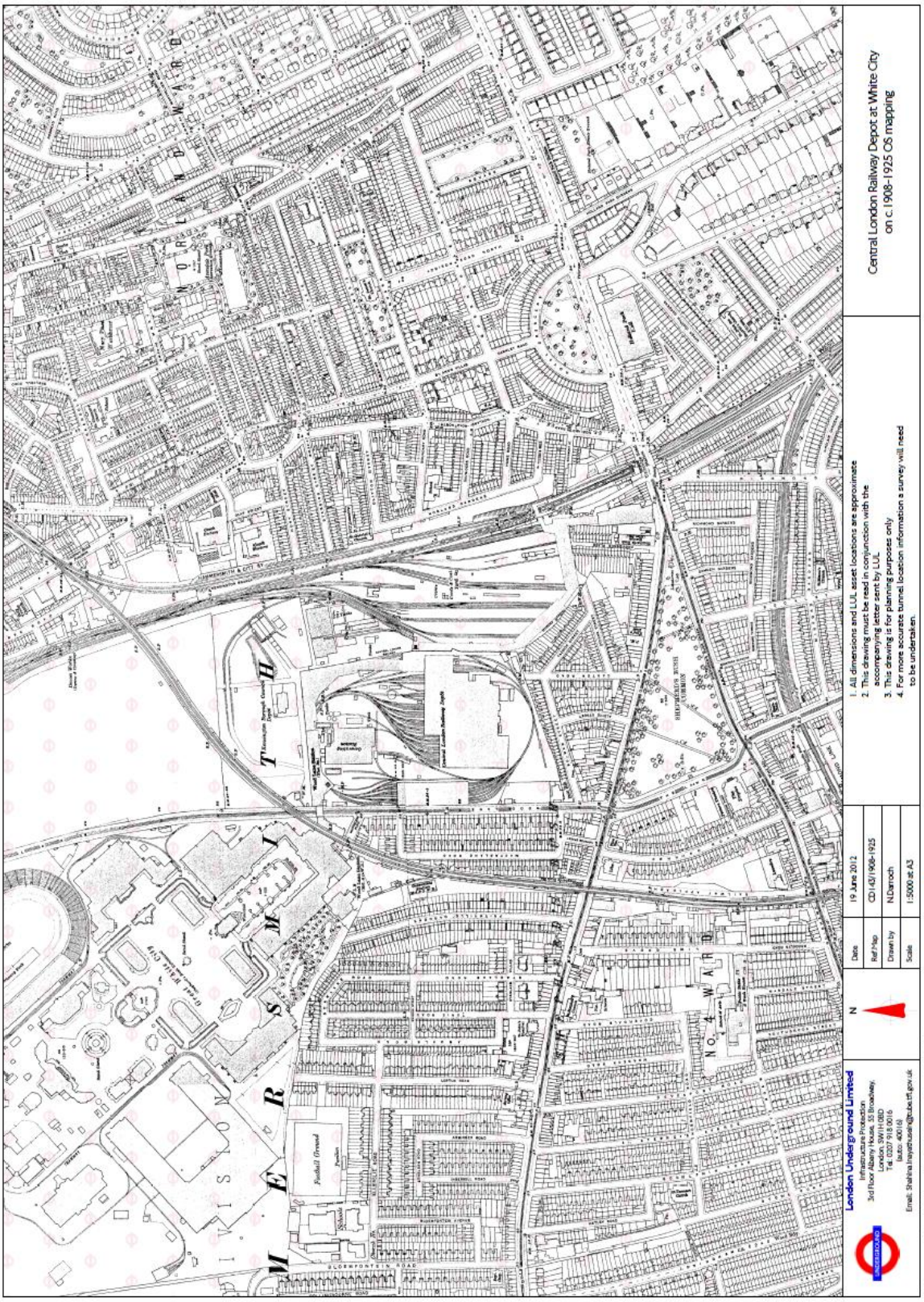

Fig.3.8

1:5000@A3 plan showing the CLR Depot at White City on c.1908-1925 OS mapping.

Source: London Underground, Ref.Map.CD143/1908-1925.

retains provision for sidings underneath (shown by the dashed red lines in fig.3.9). The latter was constructed over the District line branches to West Brompton and West Kensington (fig.3.10). This site, which is also adjacent to Lillie Bridge depot, has been included in proposals to re-develop the area, with even more of the air-space above the railway and depot to be utilised for housing and retail purposes[70]. What makes both developments cost effective, unlike London Road, is the available space for the location of the buildings' foundations.

The location of London Road depot, adjacent to residential properties, also poses other land-use issues that may at first not be apparent. Adjoining neighbours need to take in to account that any works they undertake on *their* property that might have an adverse impact on the adjoining railway infrastructure. For example, if a property owner on Gladstone Street wished to excavate a basement and erect a rear extension, they would need to ensure that they did not damage the retaining wall supporting their property. This retaining wall was built with the depot to support the houses around the periphery of the site as the sidings are below ground level. If any damage were occasioned to the retaining wall (owned by the railway company and partially located under the houses), there would be the potential of ground movement, which could cause subsidence to the houses.

3.1 Stations and air space

There are other less noticeable aspects of the tube that we take for granted every day and perhaps do not think how they integrate in to the city. These are the stations that grant us access to the trains.

In chapter 2, we briefly reviewed issues of property where the freeholder's ownership includes the subsoil and the air space above the property. Though the tube companies were able to purchase way-leaves or easements for their railway from 1884 they only had the right to and control over what they required for the tunnels and related infrastructure. They did not own any other property interests either in the adjoining sub-soil, at ground level or above except where they owned the freehold such as at stations. As with any freeholder when it came to surface property, they made sure they made good provision for use of all of their demise. Passengers' use of stations is transitory. Stations are utilised by the travelling public for mere minutes as they enter the building,

[70] Earls Court Properties. "My Earls Court Website" http://www.myearlscourt.com. [Accessed June 16, 2012].

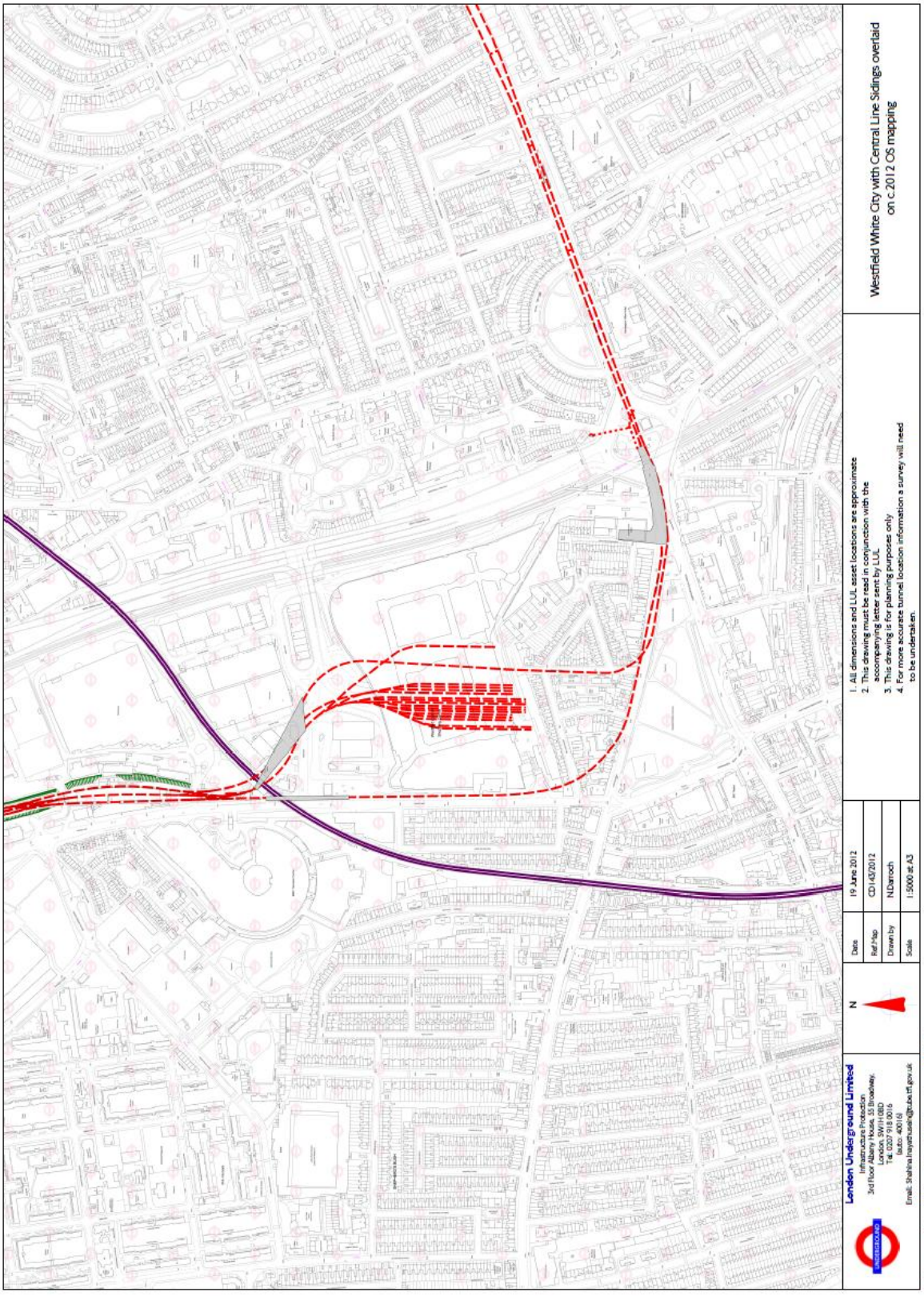

Fig.3.9

1:5000@A3 plan showing Westfield White City with Central Line Sidings (dashed red) overlaid on c.2012 OS mapping.

Source: London Underground, Ref.Map.CD143/2012.

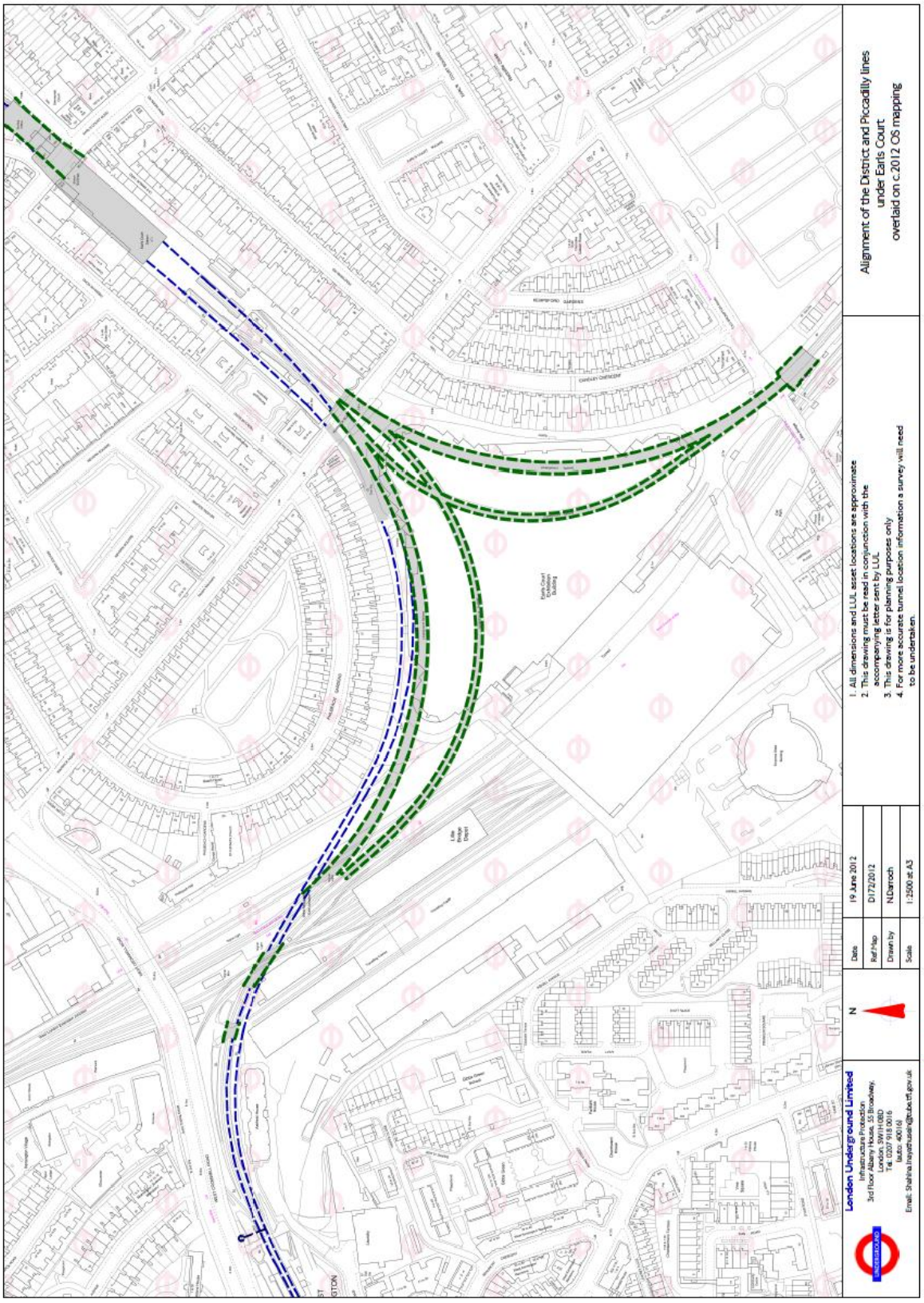

Fig.3.10

1:2500@A3 plan showing the alignment of the District (dashed green, shaded grey) and Piccadilly (dashed blue) lines under Earls Court overlaid on c.2012 OS mapping.

Source: London Underground, Ref.Map.D172/2012.

wait for and board a lift, or descend by escalator and then are carried away on a train. Even in shops, people spend longer than one does in a station. But stations are essential to the smooth running of the city as they serve many functions. These include the provision of facilities for the sale and purchase of tickets, staff accommodation, the means for passengers to be carried to the trains, or a means for ventilating the railway. But station buildings are not a blight on the commercial map of London because they can be put over to additional functions such as providing shops within the ticket hall area as well as inclusion in a larger development. For example, access to Bond Street Station is through an underground shopping centre and the much newer Canary Wharf station on the JLE is located between two shopping arcades as part of the Canary Wharf development.

With the highly developed nature of central London, land is at a premium, and it has been for the entire history of the tube. Therefore, all available land is – and historically has been - put to some use whether it is for retail, office or residential purposes; the proximity of these enabling people to avoid the inconvenience of having to travel too far from their place of employment, pleasure or residence. As such, any land required for stations would also be expensive. Greathead, in 1892, stated that one plot of land in the City (King William Street Station) cost the company £25,000 for a site of just 35 feet by 40 feet[71]. When the CLR was proposed, it was decided that stations on Oxford Street 'would only form the ground floor of large buildings'[72] for this very reason, allowing the company to lease the air space above the stations and earn a financial return that could be used to offset construction and operational costs. For example, the photograph in fig.3.11 shows the station building at Oxford Circus with offices located above. Though facilities were provided for the erection of additional levels to station buildings in the central zone this was not always followed through. For example, Russell Square station, on the Piccadilly line, still has no additional storeys one hundred and six years after opening (fig.3.12). Why this may be the case is undeterminable, however speculatively it could have something to do with the location, especially when we see that the adjoining properties are relatively low level, nineteenth century housing which have not been re-developed suggesting that there was no need to provide additional residential properties.

Designing stations for provision of additional storeys had not always been the norm. Whereas the original C&SLR stations *were* single-storey structures they were not

[71] "Report of the Joint Select Committee of the House of Lords and the House of Commons on the Electric & Cable Railways (Metropolis), 1892", 23.
[72] Ibid, 24.

Fig.3.11

Oxford Circus London Underground Station, 17 June 2012.

Source: Author's collection.

Fig.3.12

Russell Square London Underground Station, 17 June 2012.

Source: Author’s collection.

considered for the purposes of allowing development above. Greathead stated to the 1892 committee that the stations were designed in such a way as to be distinctive[73], perhaps comparable to today's Underground signs placed outside stations to alert people. This distinctive style included a large glass dome on the roof serving four functions; there were the aesthetics as described by Greathead; the accommodation of the lifts; provision of light in to the ticket halls, which were lit by electricity, comparable to the 1911 sub-surface ticket hall at King's Cross MR station, 1863-1941, which had a glazed roof for this purpose, and lastly the use of the lift shaft as a means of ventilation for the railway[74]. An additional possibility is that the stations were in areas where land and property was still affordable, and as such did not require any development facility to be provided over the time the station has been in situ. But why were some of the later stations not utilised for development above either? For this, we need to understand something more about the ventilation of the railway and make a supposition based on some of the evidence available.

3.2 Ventilating the tubes

When the C&SLR first opened in 1890 ventilation was provided by the piston effect of trains, in the narrow-bore tunnels (fig.3.13) pushing air through the passages and lift shafts within stations and out to the atmosphere through the same entrances and exits as the passengers and through the domed roof on top of the station[75]. This is still apparent at some stations today and the affect can be quite disconcerting to those in the station when the train approaches. This is because there is limited facility for ventilation due to the age of the buildings or the inability to provide suitable facilities due to existing buildings adjacent to or above the station. Any improvements would potentially see a loss of revenue should the property above require demolition and reconstruction for the provision of a ventilation shaft.

During the earliest period of tube railway operation (1890-1902) the main concerns with regard to ventilation appears to have been odour, dust and sufficient air for breathing[76]. As service levels increased, an additional function for ventilation shafts became apparent. Jackson and Croome, state that the Yerkes tube stations were the first to incorporate dedicated ventilation facilities within them. This consisted of a duct passing

[73] Ibid.
[74] Ibid, 22.
[75] Ibid, 21-22; Greathead, "The City and South London Railway", 52-53.
[76] "Report of the Royal Commission appointed to inquire into and report upon the means of Locomotion and Transport in London, Vol. III, 1905", 813; Jackson & Croome, *Rails through the clay,* 40, 89.

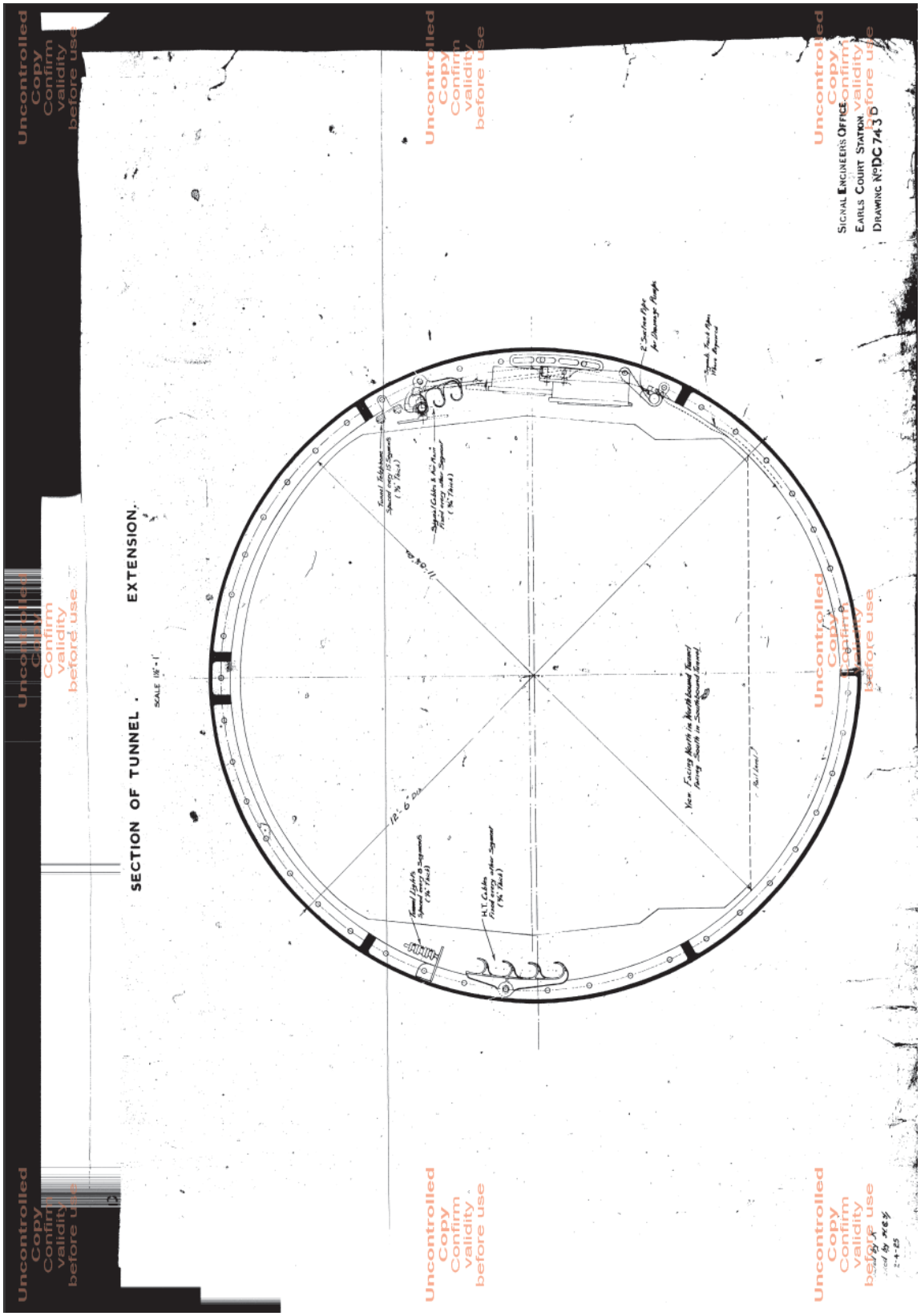

Fig.3.13

City & South London Railway drawing showing a typical section of tube tunnel for the C&SLR 1920s widening, 2 April 1924.

LUL Electronic Archive No.: N143 12012.

up the middle of the spiral emergency staircase and venting to the atmosphere through the roof, the air drawn through by way of fans and the working of the trains[77]. The ducts were provided in an endeavour to reduce the noticeable heat increases in the tunnels of the older railways that had little, if any, ventilation facilities other than those they had been initially provided with, although the CLR had been experimenting with ventilating systems[78]. The principal problem for any of the companies would have been where to locate these facilities.

As the railways were extended and stations were re-built to cater for increasing demand, greater thought had to be given to the provision of heat reduction, especially when more trains and passengers were using the tunnels. Granville Cunningham, General Manager of the CLR, had suggested to the 1905 Commission on London Transport that 'a system of horizontal tunnels running out from the middle part [of any one section of line] between the stations back to a distance, in to a back yard, for instance where a vertical shaft might be built and a fan placed in that shaft running constantly, which would draw the air out of the tunnels while the trains were running'[79]. As will be seen in chapters 6 and 7, whilst discussing the Victoria line and JLE, this was to become common practice. Most ventilation plant was installed from the 1930s as stations were re-constructed or as extensions were undertaken. As the latter covered longer distances between stations, mid-section plant was required and generally utilised the construction shafts[80]. Where lifts were replaced at stations by escalators land costs were minimised, as no new facilities were required. For example, at Holborn station on the Central and Piccadilly lines one of the lift shafts was put to forced ventilation use when escalators replaced the lifts in 1933[81]. At the former C&SLR station at King William Street and the former GNPBR station at Brompton Road, both stations had a lift shaft or part of one retained for ventilation once they had been closed to passenger traffic in 1900 and 1934 respectively. The former station sold in 1926 for the sum of £18,500, with a clause in the transfer stating that the purchaser, when they wished to re-develop the property, had to include ventilation facilities within any new building on the site[82]. This was despite the fact that the tunnels were no longer served by the main line. The railway company having no doubt realised the benefit of having such facilities in a location where land was at a

[77] Croome and Jackson, *Rails through the clay,* 89.
[78] Follenfant, *Reconstructing London's Underground*, 160-170.
[79] House of Commons Parliamentary Papers, Online, House of Commons Papers; Reports of Committees, (2751), "Report of the Royal Commission appointed to inquire into and report upon the means of Locomotion and Transport in London, Vol. II, 1905". http://parlipapers.chadwyck.co.uk/marketing/index.jsp. [Accessed August 11, 2011]. 813.
[80] Follenfant, *Reconstructing London's Underground*, 38-40.
[81] Ibid, 36-38.
[82] Transfer, dated 12 January 1926, between the City & South London Railway Company and R. Palumbo. TfL Muniments Archive, 1040929.

premium and where there was no available location for the sinking of a new shaft.

The reason for the lack of development above the early stations becomes apparent when we look at Greathead's evidence to the 1892 commission and the evidence presented to the 1905 commission. This is that for better ventilation, facilities are required at or above surface level. As the tubes were running under the highway, the companies probably considered it much more practical and economic for this provision to be at sites, which they already owned, such as stations, thus minimising the impact on land use. This point may well explain why some of the earlier stations, such as Russell Square, have never been developed above. The requirement for enhanced ventilation potentially severely restricted the tube companies from allowing development above their stations. But once stations required comprehensive re-structuring to accommodate new technology, such as escalators, and rising passenger numbers in the 1920s, the former lift shafts could then be put over to ventilation, freeing areas within the station for the provision of fans and related machinery. This at least allowed the possibility of re-development for commercial purposes although If the station were developed above from this period then any new building would have to provide ventilation facilities (as we shall see in chapter 4). Extensions to the older lines saw the introduction of mid-section ventilation by utilising construction shafts, a requirement for the longer distances between stations[83].

3.3 Case study: Brompton Road disused station (fig.3.14)

Mention has already been made of disused stations and it is worth taking a brief review of how these can be re-used for an operational benefit in ways that minimised the impact of tube railways on other property. As we shall see in more detail in chapter 4, changes in design to stations are not a new aspect of the underground's history. They have been going on for many years, such as the widening of tunnels and re-construction of some stations on the former C&SLR from 1922[84], as well as the putting over of former station sites to re-development such as at King William Street that was demolished and an office block located on the site in 1933. Though a station may fall in to disuse as far as passengers are concerned the buildings and structures more often than not serve an alternative operational purpose as well as providing an alternative source of income[85]. This was the case with the former GNPBR station at Brompton Road. The station, opened by the GNPBR in 1906, was located a short distance from Knightsbridge and

[83] Follenfant, *Reconstructing London's Underground*, 38-40.
[84] Ibid, 7-16.
[85] Ibid, 160-40.

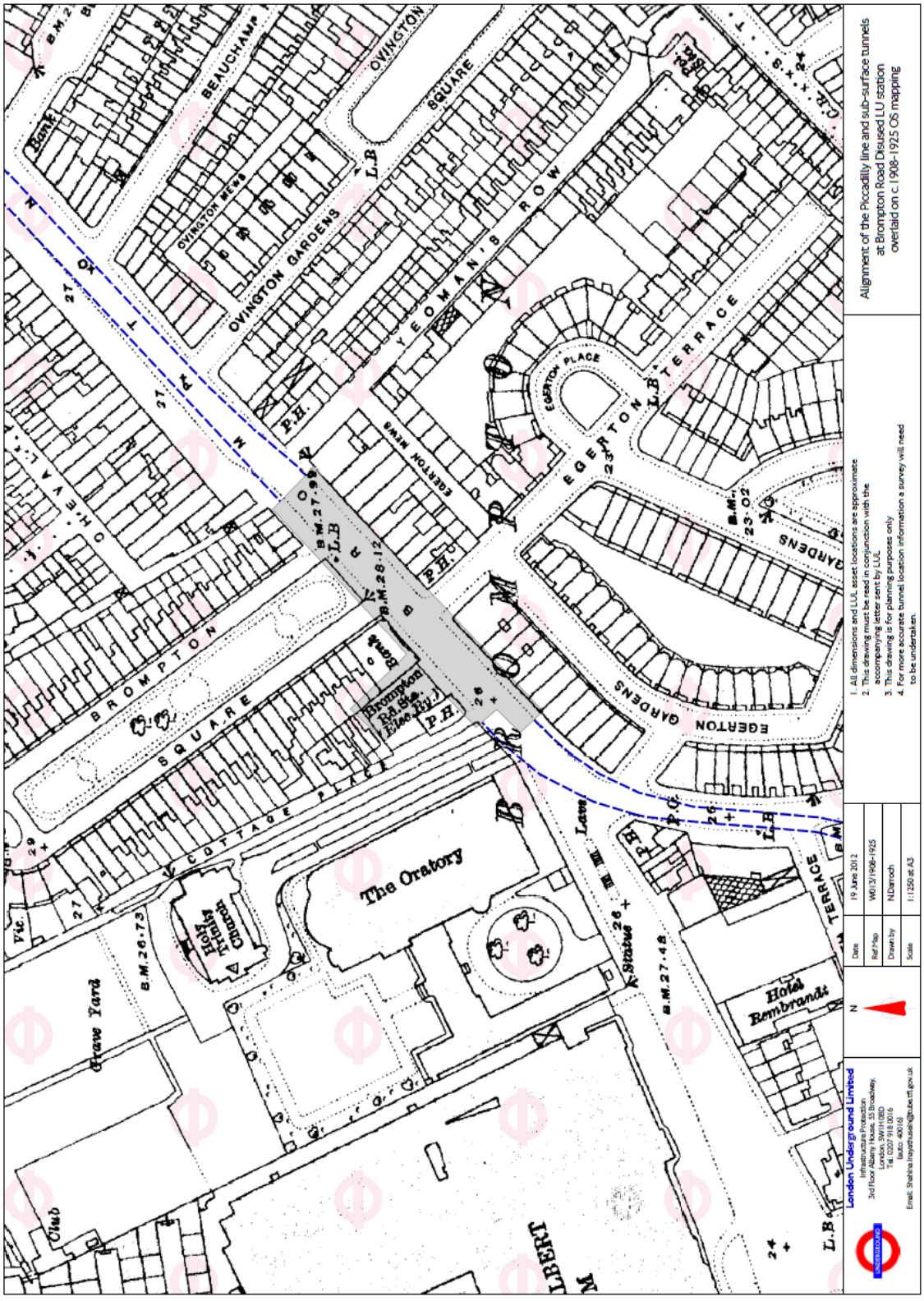

Fig.3.14

1:1250@A3 plan showing the alignment of the Piccadilly line (dashed blue) and sub-surface station tunnels (shaded grey) at Brompton Road Disused LUL station overlaid on c.1908-1925 OS mapping.

Source: London Underground, Ref.Map.W013/1908-1925.

South Kensington stations to the east and west respectively (see fig.2.7). It incorporated two lift shafts and a stair shaft in anticipation of the volume of traffic that was hoped would use the facility. From the lift landing level, passages led over the eastbound station tunnel to an area between it and the westbound tunnel with stairs taking passengers to and from the platforms, the station tunnels located under the road. Due to lack of use, because of the more convenient stations either side, it was closed in 1934.

By 1938, the government were becoming concerned at events in Europe particularly with regard to German militarisation. As a result, the War Department (WD) agreed to purchase from the London Passenger Transport Board (LPTB) such areas of the station building and tunnels as would be required for monitoring incoming air raids. This included the station tunnels, the lift shafts and the station building, walls erected along the former platform edges to maintain the security and safety of the facility from the running tunnels c.1939 (fig.3.15). Though it was only in 1942 that the deed of sale was produced[86]. What is most interesting is that the LPTB retained one passage and part of a lift shaft for the use of ventilating the railway, the vent passing up through the roof to the atmosphere. Once the war had ended the WD, later to become the Ministry of Defence (MoD), retained the station building as well as that part of the property located under the footprint including the lift shafts, minus the half of the one for railway ventilation, the stair shaft and the lower lift landing area. The Underground retained the station tunnels and the passages from the lift landing level. At a later date, the MoD demise was put to use by the University of London RAF Air Cadet Corp. However, the Underground still retained their ventilation facilities. About 1968, the MoD added extra storeys to the original station building, for which it had been designed to accommodate. To ensure ventilation of the railway was maintained the vent shaft was extended up through the new levels with a purpose built vent building erected at roof level. The former station building is still used for both of these purposes today.

That is not the end of the story. As we have seen from this chapter, heat on the Underground has been a developing problem since the railway first started running. As such, LUL has a department endeavouring, if not to resolve, at least to control temperature increases. This has seen the boring of holes to tap in to cool ground water many metres below the ground as well as upgrade existing ventilating facilities[87]. In

[86] Transfer, dated 31 March 1942, between the London Passenger Transport Board and the War Department. TfL Muniments Archive: 1013690.

[87] BBC News Website. "Map reveals of hot spots of the tube" http://news.bbc.co.uk/1/hi/8218059.stm [Accessed June 16, 2012]; TfL Corporate Website. "Work continues to keep passengers cool this summer and beyond" http://www.tfl.gov.uk/corporate/media/newscentre/archive/20386.aspx [Accessed June 16, 2012].

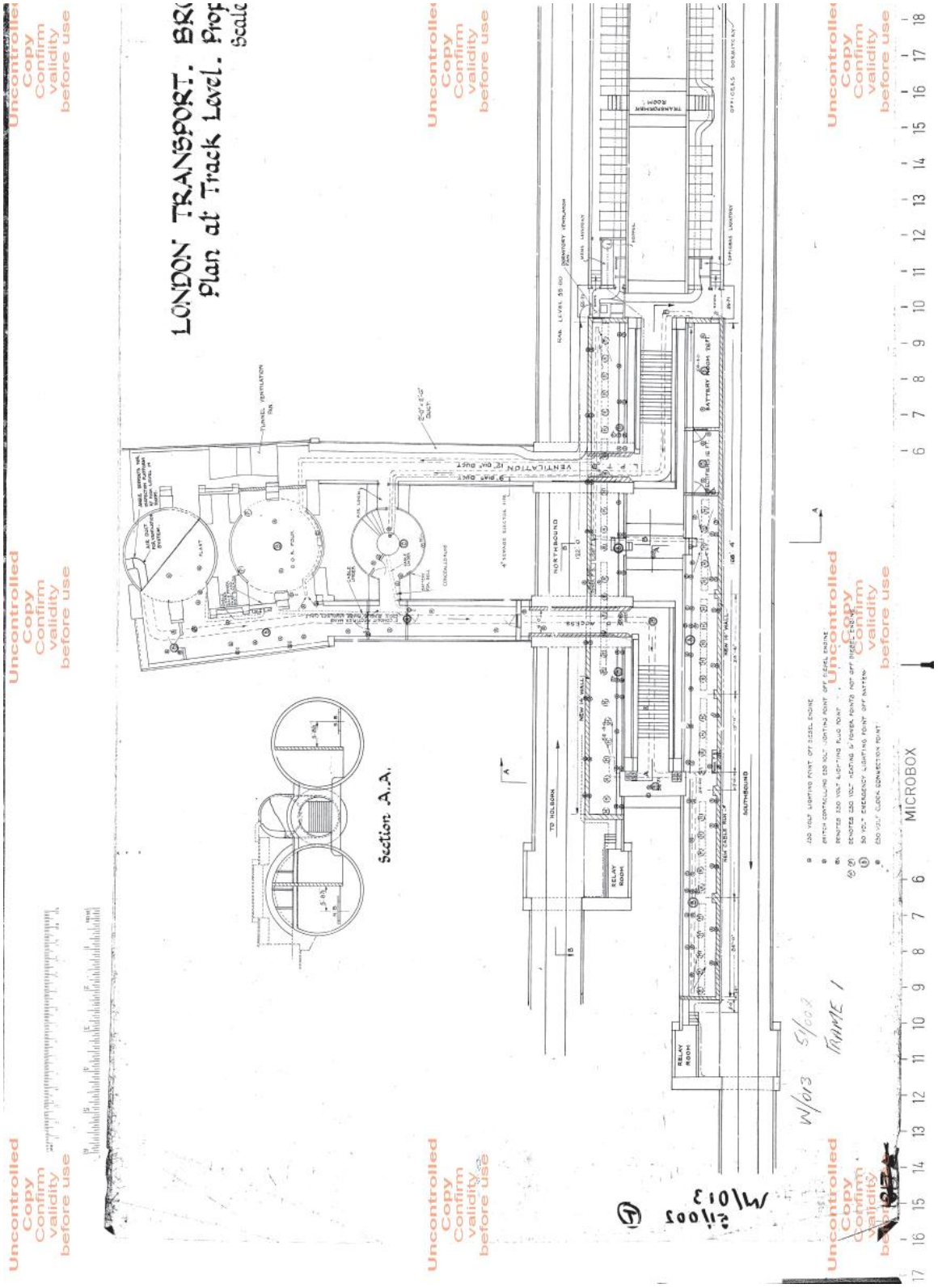

Fig.3.15

London Passenger Transport Board partial drawing showing the Internal Layout of Brompton Road station, 9 March 1939.

LUL Electronic Archive No.: W013 51002.

some locations, the disused roofs of stations have seen the location of equipment such as chiller units to help cool the stations. Here is another way that the tube integrates with the surrounding developed landscape, by minimising the need for additional land for cooling the railway. However, with regard to Brompton Road there is a further major consideration. There is an existing ventilation shaft located in a highly developed, high property price area that is only partially utilised; therefore, two options can be considered for the upgrading of ventilation and temperature control on this long section of line. Either the sinking of a new shaft, independent of the original station site, which would likely cause much objection from local residents, as is currently happening with the Thames Water super sewer[88]. The other option is the re-purchase of the former station building, and the upgrading of the existing shaft with a new development on the site incorporating it, which, would bring in greater revenue for the Company by allowing the redevelopment of the site as office or residential accommodation whilst retaining its use for ventilating the railway.

3.4 Conclusion: the tube and its surface structures

This chapter has demonstrated that although the tube is a considerable depth below ground it still requires surface interfaces. Whether it is for the storage and maintenance of the fleet, access to and from the trains, ventilating the tubes and stations and keeping the heat down, the tube still has an impact on the urban environment. But these interfaces are an essential requirement for the railways' operation, and the life of the city. Without all of the above considerations, such as ventilation and well-placed depots, it is questionable whether the railway could operate efficiently and if it cannot, then the city itself cannot function efficiently. The key factor therefore is how the railway has been designed in relation to the living, evolving city; how it accommodates its own needs as well as those of future development, as much as possible, through the re-use, disposal or letting out of surplus buildings or air space.

Where stations were involved this was no difficult matter, after all the original CLR stations were designed to accommodate development above, as described by Greathead to the 1892 committee[89]. But for reasons that have not been able to be determined some stations did not and have not seen above station development. Why

[88] Thames Water Website. "Thames Tideway Improvements" http://www.thameswater.co.uk/cps/rde/xchg/corp/hs.xsl/2833.htm [accessed 16 June 2012]; BBC News Website: http://www.bbc.co.uk/news/uk-england-london-12184675 [Accessed June 16, 2012].
[89] "Report of the Joint Select Committee of the House of Lords and the House of Commons on the Electric & Cable Railways (Metropolis), 1892", 24.

this is the case can be difficult to explain, mostly because there is no record of why something has not happened. However, what we can see is that areas of railway can be and have been incorporated within the urban environment by way of development above, whether at stations or at large sites such as depots, where there is available space. But there are also sites where development cannot be undertaken and therefore the presence of the tube becomes a hindrance to urban development. As shall be demonstrated further, this is more common than may at first be appreciated, especially when it comes to the effect of sub-surface assets under property.

Chapter 4 Sub-surface structures

So far, this dissertation has considered the location of the tubes, predominantly beneath the highway to avoid affecting property; how the railway has an interface with the surface via stations; and the requirement for facilities to ventilate the tunnels. These are typical aspects of tube railways, designed with economy in mind: economy not only of finances but also economy with regard to the quantity of land required for the railway. This chapter continues this theme by analysing how the early tube stations were constructed and laid out to minimise incursion on adjoining property. It also explores how a combination of new technology and increases in traffic led to the tubes taking on a more prevalent role in land-use within the central zone of the metropolis, especially from the 1920s onwards as the tubes were extended.

4.0 Construction shafts

One of the many considerations for the construction of a tube railway is where to start the tunnel drive. For the CSL, BSWR, and Waterloo & City railways, the most logical location was in the river Thames (fig.4.1), piers connecting the shafts to the riverbank. Though this provided a site for the sinking of the initial construction shaft and the launching of the shield it could not cater for storage or provide easy access to the work face, especially as the works progressed and the tunnels became longer. The CLR and GNPBR did not have the advantage of the river for these purposes. Therefore, alternative or additional worksites were required.

The most beneficial location for the sinking of a shaft, the storage of materials, and the removal of spoil was therefore upon the sites of the future stations. Work undertaken within the company's demise minimised not only the adverse affect on the public highway, but also meant there was no need to acquire additional land, though there was often facility for them to do both in the 1920s[90]. Therefore, the construction taking place predominantly within the station site helped minimise construction costs and additional costs for surveyors and solicitors fees for the re-sale of land away from operational areas and no longer required for the railway. However, these sites were very limited in their size. Greathead, in his evidence to the 1892 Commission, stated that one station in the

[90] 47 & 48 Vict., City of London & Southwark Subway Act 1884, Ch.CLXVII, Sct.33; 50 & 51 Vict., City of London and Southwark Subway (Kennington Extensions, &c) Act 1887, Ch.CV, Scts.26-27; 63 & 64 Vict., Baker Street and Waterloo Railway Act 1900, Ch.CCXXV, Sct.7; "Report of the Joint Select Committee of the House of Lords and the House of Commons on the Electric & Cable Railways (Metropolis), 1892", [V].

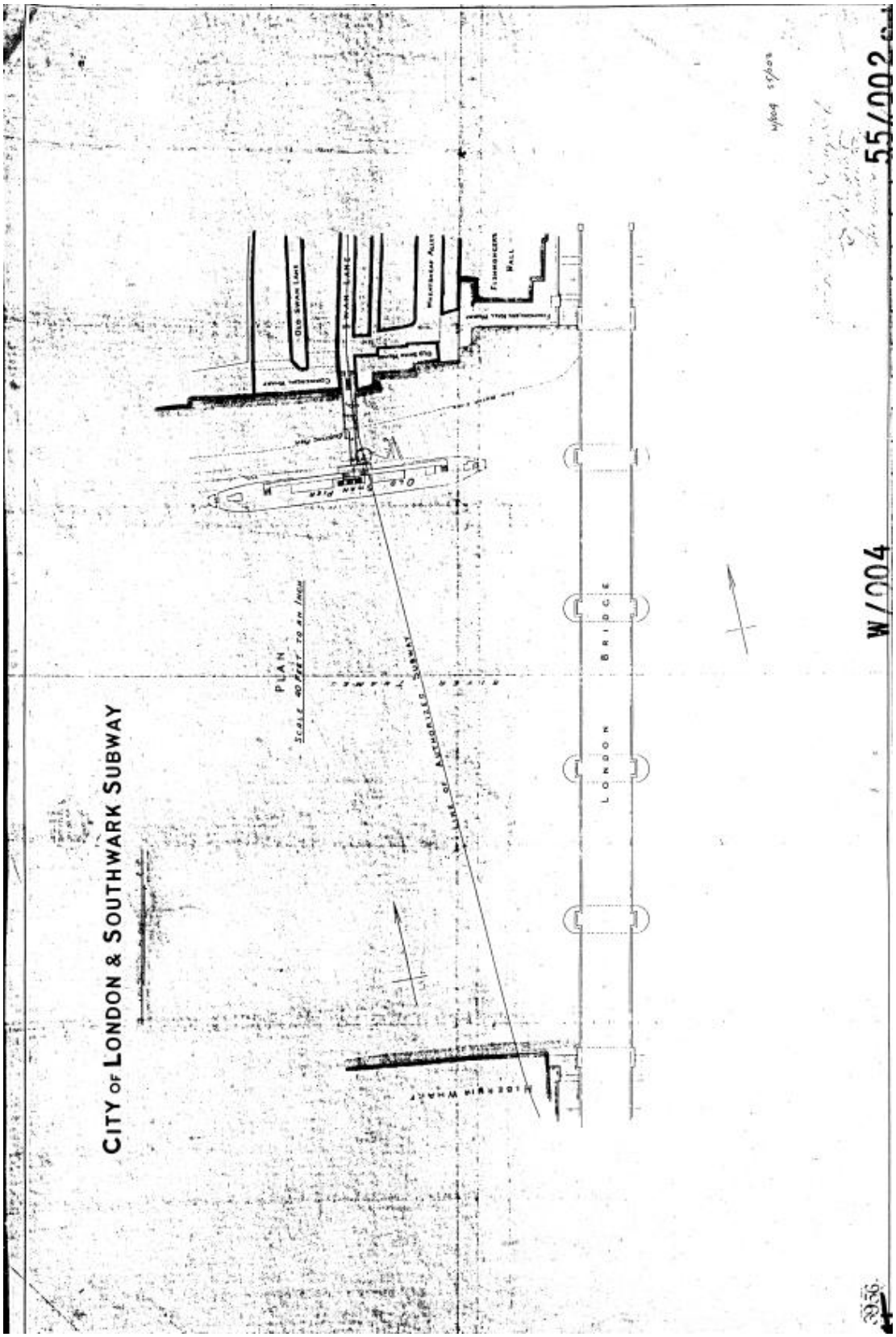

Fig.4.1

Extract from a City of London & Southwark Subway drawing showing the proposed location of Swan Lane pier construction shaft. 1 January 1896.

LUL Electronic Archive No.: W004 55002.

City (presumably King William Street) had an area of 40 ft.sq[91] (fig.4.2). Within this footprint was the requirement for the accommodation of a ticket office, staff facilities and a lift shaft (25ft int. dia). The spiral emergency staircase (15ft int.dia)[92] was located under the public highway, due to the site restrictions. Fig.4.3 shows the internal layout of the station. Fig.4.4 shows a typical internal plan of the C&SLR stations at ground level, in this case Oval. Greathead also pointed out that the CLR stations between Marble Arch and Oxford Circus would cover an area of 50 by 60ft, though he said it was possible to undertake the work on such a site, he did not specify how easy it would be[93]. In some of the later stations especially at locations anticipated, as being busy, such as Brompton Road on the GNPBR, there was facility for two lift shafts (incorporating four lifts) and a stair shaft. Once the shaft had been constructed to the desired depth, an adit (passage) was dug to a central point under the highway. Here a chamber for the construction of the tunnelling shields was excavated and the shield erected[94].

4.1 Station tunnels

Just as the running tunnels were located under the public highway to minimise their incursion on surface property and to minimise the requirement to purchase easements, so it was with the station tunnels, the minimum depth below surface level for both specified within the authorising acts[95]. These tunnels are dealt with separately here, rather than with the main tunnels, as the station is a unique environment. The station tunnels are larger than the running tunnels, generally 21ft. in diameter and in some cases connected to the station by way of footbridges over the track (fig.4.5), thus emphasising the three-dimensional nature of the station and the volume of sub-soil it utilises. There are other considerations relating to the three-dimensional nature of stations and the quantity of sub-soil that they use, although space prevents detailed analysis. Examples include single bore station tunnels with a central island platform such as that at Clapham Common; interchange stations where there is facility for cross platform interchange such as Kennington C&SLR station; or those where one line crosses another at right angles, such as at Bond Street with the Central and Jubilee lines.

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[91] "Report of the Joint Select Committee of the House of Lords and the House of Commons on the Electric & Cable Railways (Metropolis), 1892", 19.
[92] Greathead, "The City and South London Railway", 47;
[93] "Report of the Joint Select Committee of the House of Lords and the House of Commons on the Electric & Cable Railways (Metropolis), 1892", 19.
[94] Arthur Harry Haigh, "Subaqueous tunnelling through the Thames gravel: Baker Street and Waterloo Railway", Institution of Civil Engineers, *Minutes of the Proceedings* 4, 150, (January 1902): 19.
[95] 50 & 51 Vict., City of London and Southwark Subway (Kennington Extensions, &c) Act, 1887, Ch.CV, Sct.28; 63 &64 Vict., Baker Street & Waterloo Railway Act 1900, Ch.CXXV, Sct.7.

Fig.4.2

1:500@A3 plan showing the alignment of the C&SLR (dashed black) and sub surface station tunnel (shaded grey) at King William Street overlaid on c.1862-1895 OS mapping.

Source: London Underground, Ref.Map.W004/1862-1895.

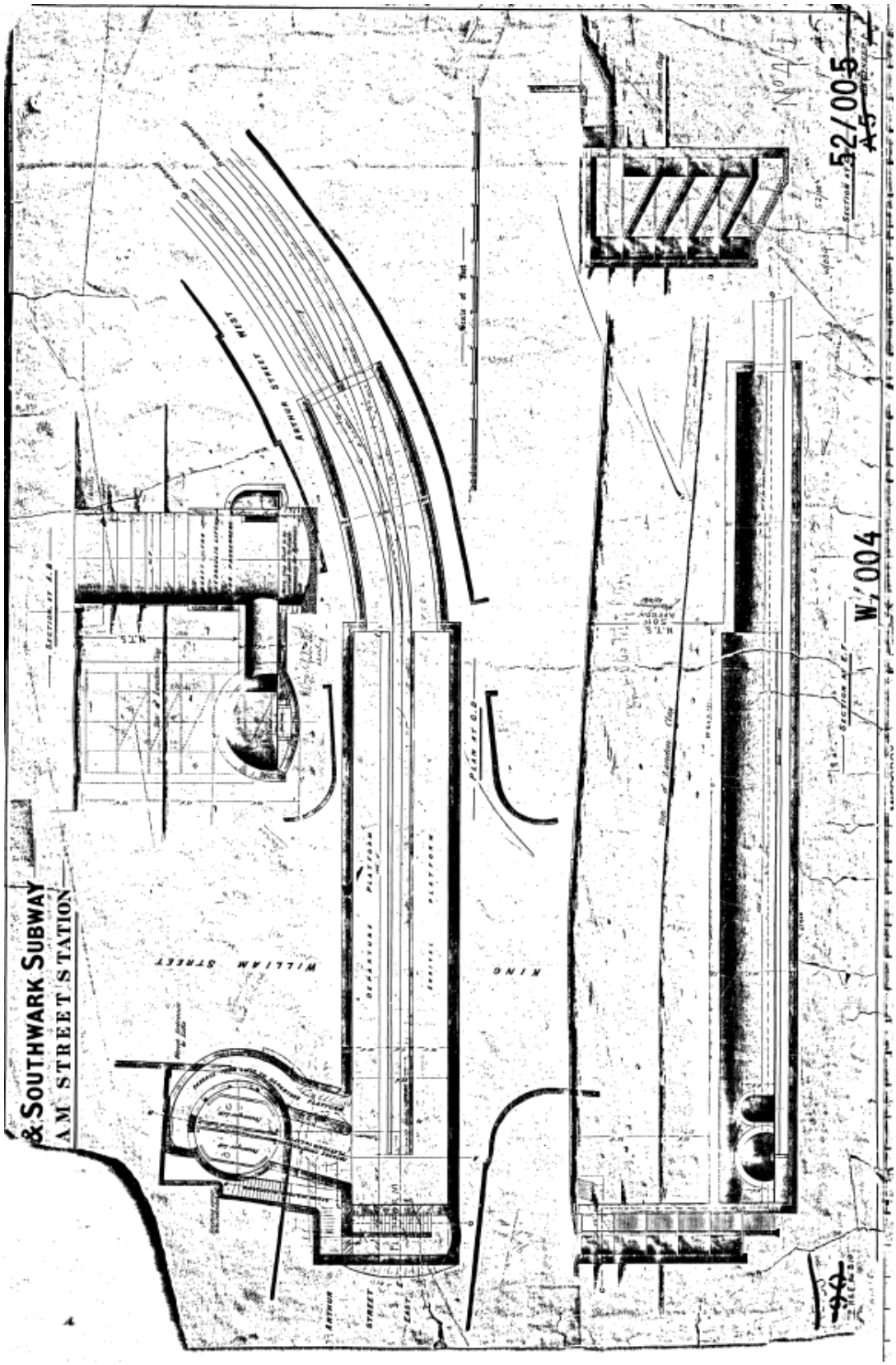

Fig.4.3

City of London & Southwark Subway drawing showing the proposed plan and section of King William Street station, 1 January 1898.

LUL Electronic Archive No.: W004 52005.

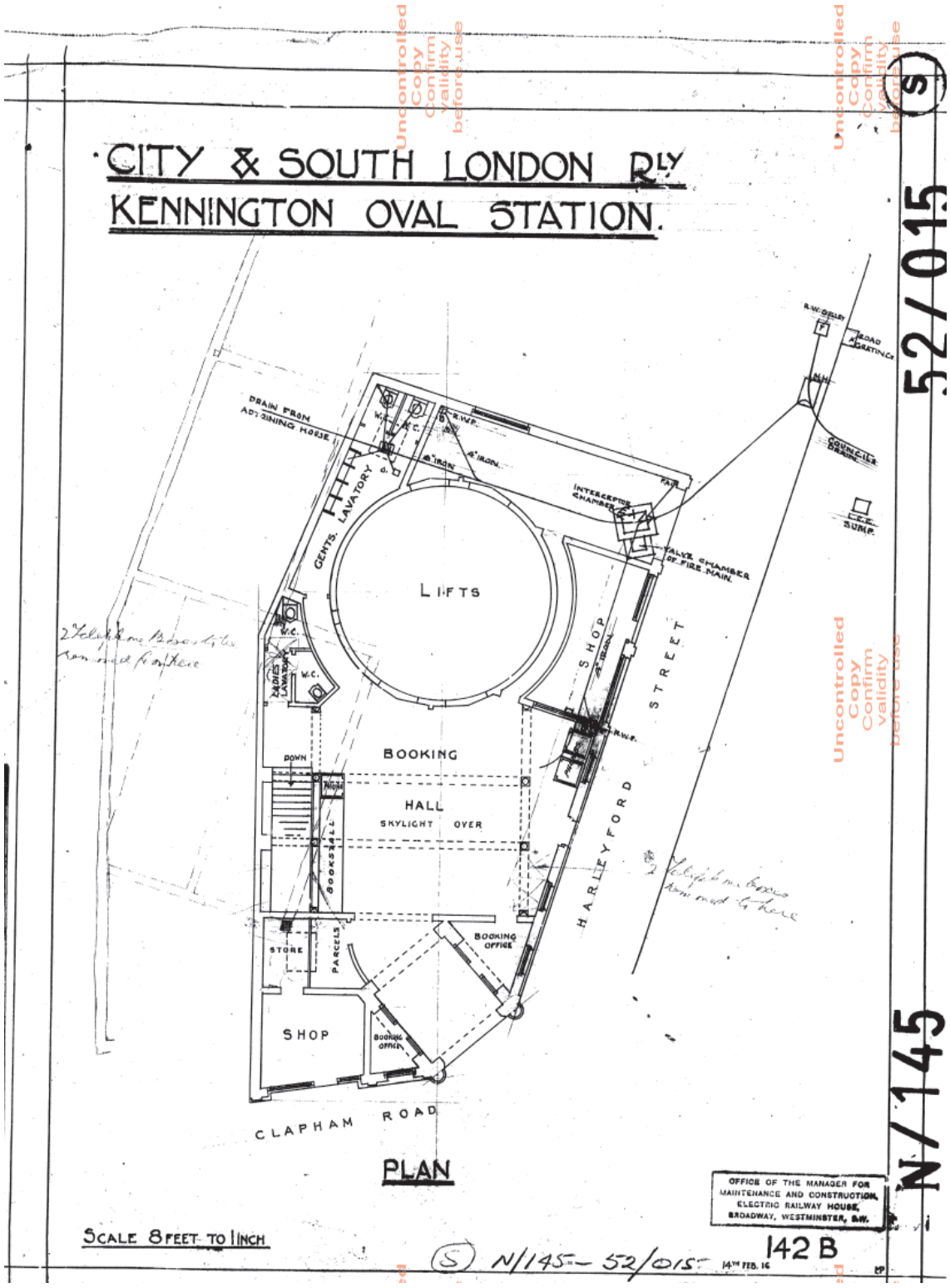

Fig.4.4

City & South London Railway drawing showing the ground floor layout of Kennington Oval Station, 14 February 1916.

LUL Electronic Archive No.: N145 52015.

Fig.4.5

Station tunnel and footbridges over the track at Green Park, 17 June 2012.

Source: Author’s Collection

Kennington is worth consideration as it falls within a period of flux from the original principles of the tube where the railway was designed to minimise its interface with private property (1884-1907) to the 1920s when the CCEHR extension to Kennington was driven under private property for a considerable distance (opened in 1926). Here the original brick platform tunnels were at different levels, the northbound tunnels 8ft 6in higher than the southbound[96], as shown in fig.4.6. Greathead would have us believe that this was to minimise steps between the platforms and the lifts[97]. By comparing fig.4.6 with fig.4.7, which shows a 1923 section of Kennington, we can argue that the tunnels were probably laid out in this way so they would avoid passing under the adjoining properties. The disparity between what is presented in this dissertation and what Greathead said is probably due to his position as an advocate of tube railway construction. He was the principal consulting engineer and he was therefore likely to have presented the design in a way to encourage potential users and investors. When the station was reconstructed in the 1920s to accommodate the extension of the CCEHR from Charring Cross, the new station tunnels were added either side of the existing tunnels[98]. These, by necessity, had to pass under the adjoining properties to enable cross-platform interchange between the two railways (fig.4.8); a feature heavily prevalent on the Victoria line of the 1950s-1960s.

4.2 Escalator shafts

During the 1920s and 1930s, there was a major effort to update many of the older underground stations as passenger numbers increased[99]. This included increasing the passenger flow through stations by providing escalators to replace lifts. In some cases, these works resulted in the reconstruction or relocation of the station with the related land use issues, such as purchase of sub-soil and where to locate the new facilities.

The introduction of escalators to the underground began at Earls Court in 1911, connecting the MDR surface lines with the GNPBR line located in tube tunnels beneath. For the Paddington to Watford extension of the Bakerloo line from 1915, the sub-surface stations were provided with escalators instead of lifts. However, due to the cost of construction, it was some years before escalators were introduced on a greater scale across the network. The cost was not only for the equipment but also the sub-soil and

[96] Croome & Jackson. *Rails through the clay*, 151.
[97] Greathead, "The City and South London Railway", 43.
[98] Croome & Jackson. *Rails through the clay*, 151-155; Follenfant, *Reconstructing London's Underground*, 18-20.
[99] Barker & Robbins, *A History of London Transport: the Twentieth Century,* 249-251.

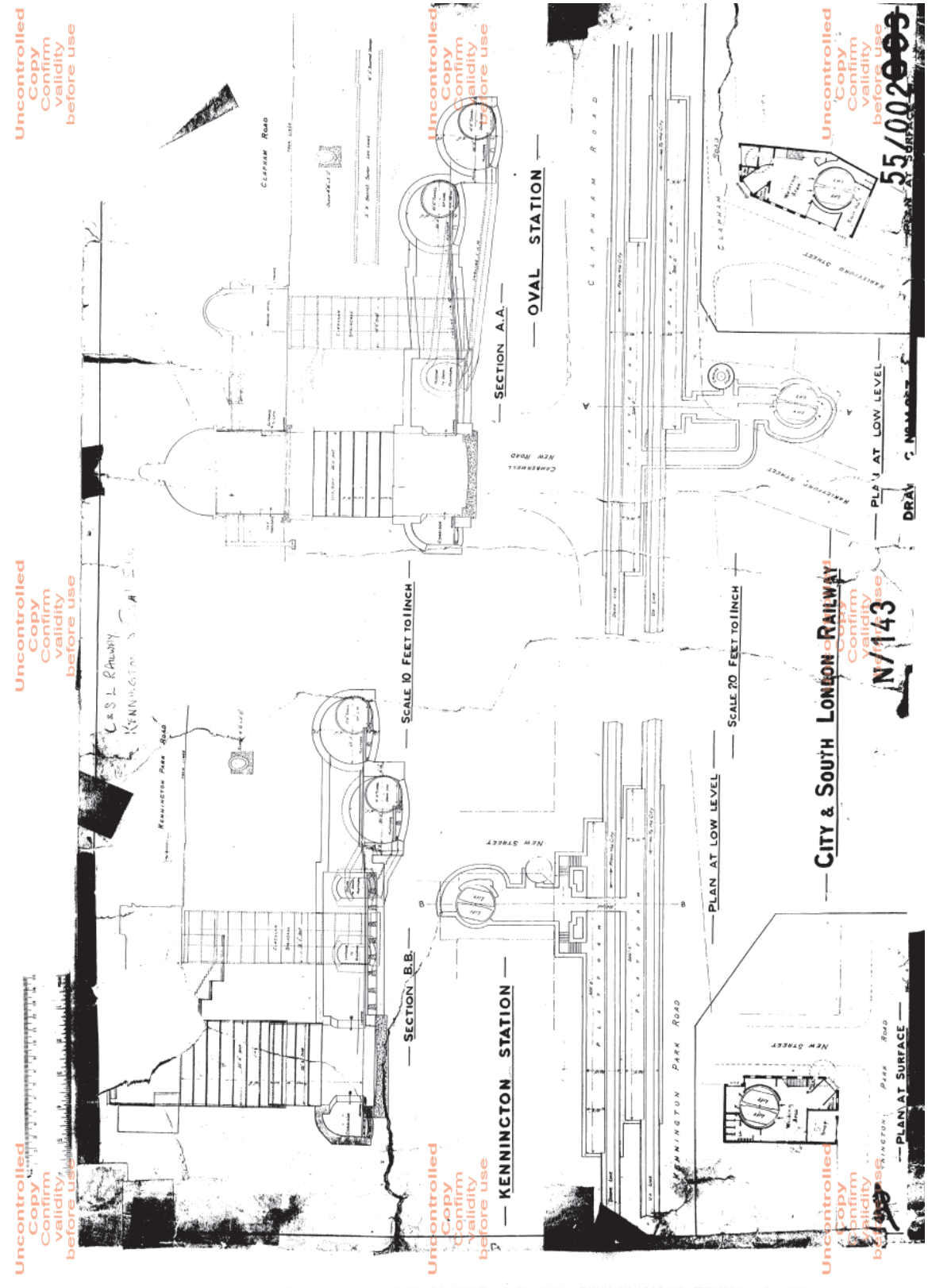

Fig.4.6

City & South London Railway drawing showing Kennington and Oval stations in plan and section, c.1890-1923.

LUL Electronic Archive No.: N143 55002.

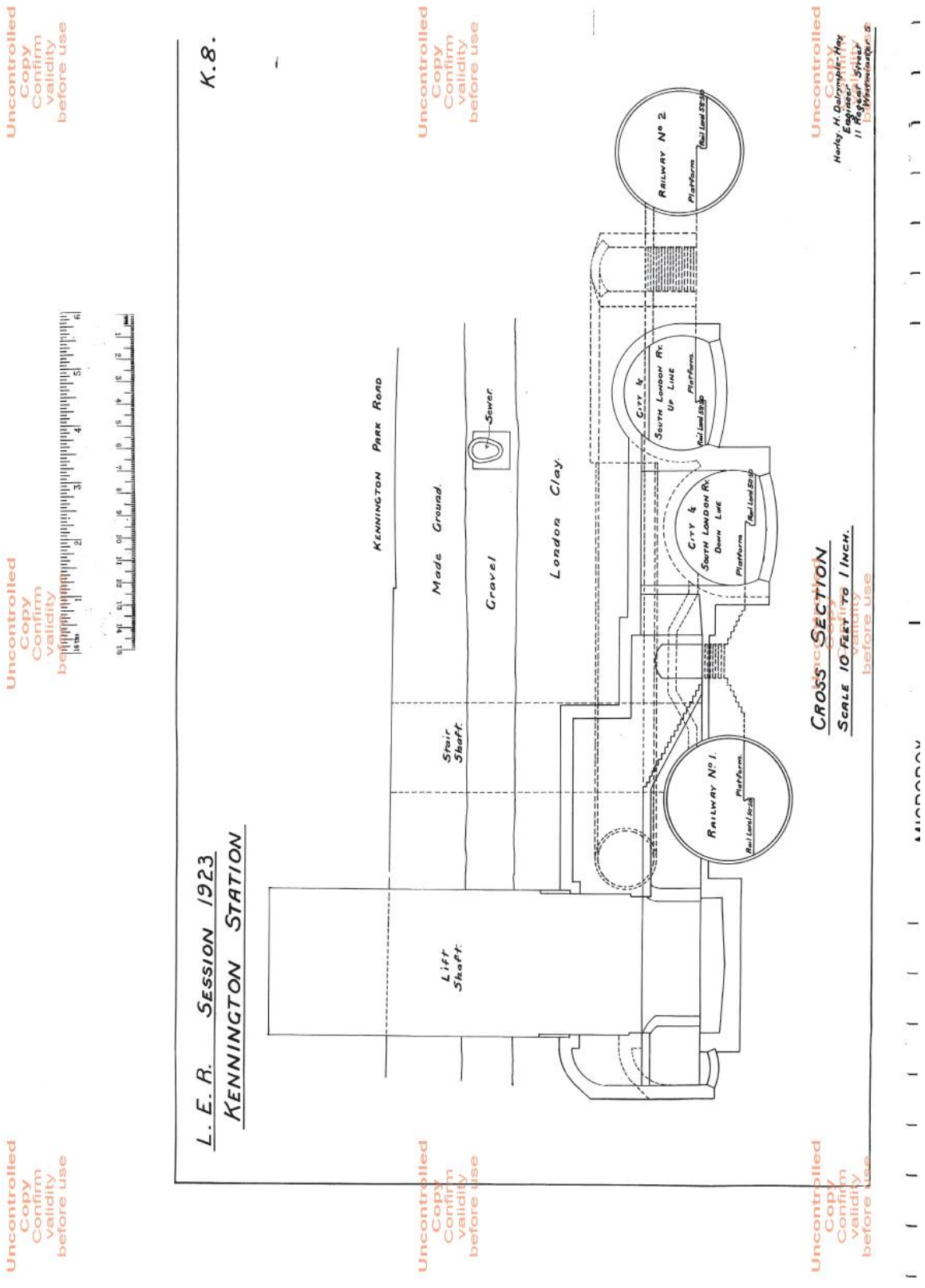

Fig.4.7

London Electric Railway drawing showing a section of Kennington station, 1923.

LUL Electronic Archive No.: N143 52006.

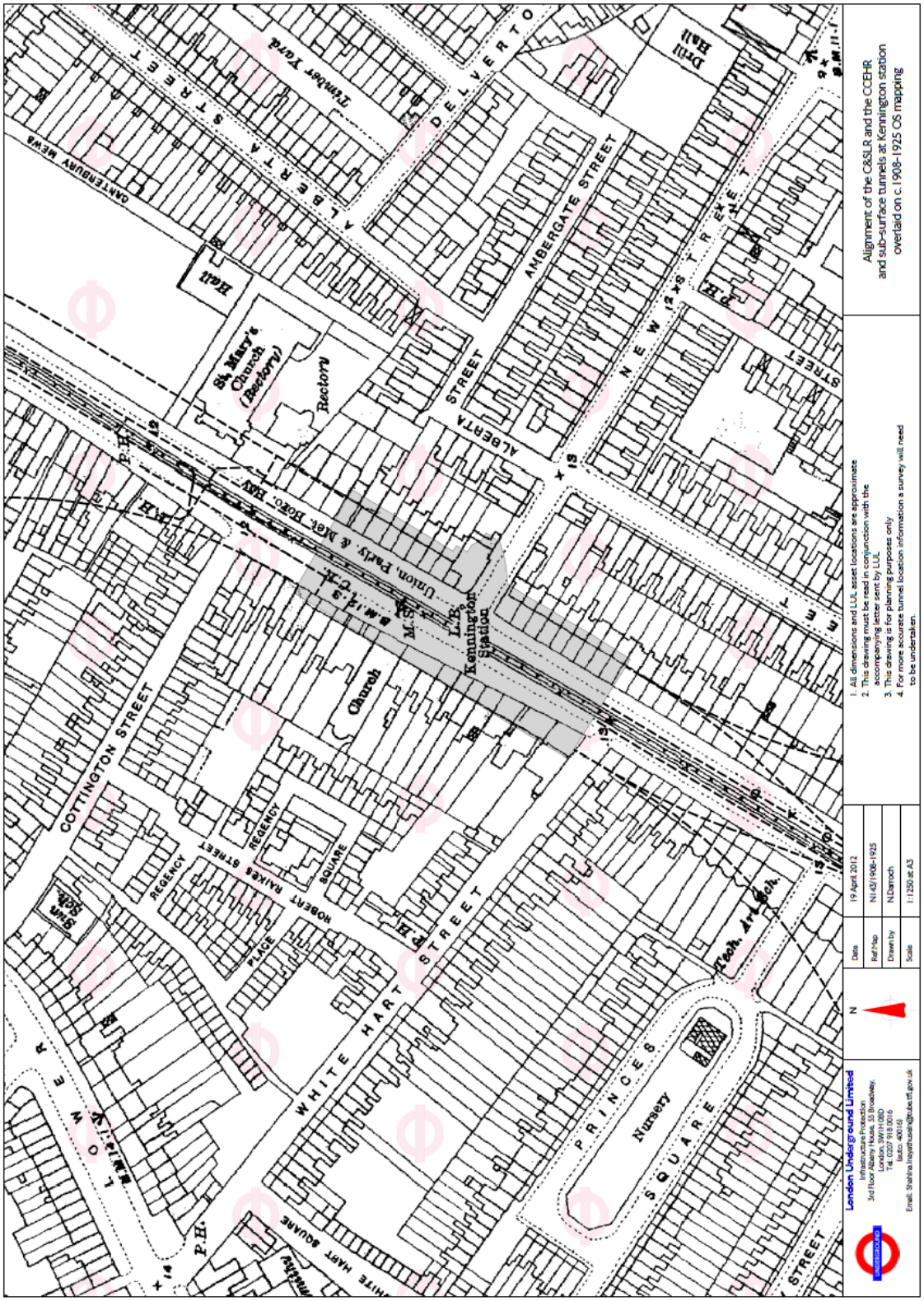

Fig.4.8

1:1250@A3 plan showing the alignment of the C&SLR and the CCEHR (both dashed black) and sub-surface tunnels (shaded grey) at Kennington station overlaid on c.1908-1925 OS mapping.

Source: London Underground, Ref.Map.1908-1925.

the boring of new shafts[100]. Whereas lifts require minimal use of sub-soil due to their being located within a vertical shaft, previously utilised for the construction of the railway, an escalator needs an angled shaft. The depth of the railway dictates the length and number of escalators, where surface facilities are to be located and what the interface between railway and private land will be.

When escalators were first introduced, the main issue regarding property was the purchase of an easement through the sub-soil. In many cases the escalators were projected under the roads thus obviating the need to pass under adjacent property, such as those at Oval installed in the 1920s as part of the widening of the running tunnels on the original section of the C&SLR. In the long term, such construction was to prove beneficial not only for the railway company but also for the adjoining property owners. As we shall see in chapter 5 until the 1950s buildings were limited in size, tending to be only one basement level deep and up to four or five storeys high, depending on location and need. As such, the foundations for the buildings were shallow, about three feet deep. Post 1950s, however, buildings started to become taller, the sub-soil becoming utilised for deeper basement levels and foundations. If a property - such as those at Angel - had an escalator shaft beneath (fig.4.9), it would have imposed limits on what development could be undertaken. For example, if the owners of the public house on the corner of City Road and Islington High Street wished to re-develop the property for a high-rise building with two or three basement levels they would have to design around the escalator shaft passing under their property. This could increase the costs of design and construction that would need to be calculated against anticipated income from the re-development. In the end, it may turn out to be too expensive for this and as such, the property owner would lose profitability on the land.

4.2.1 The effect of escalators on use of land

An example of the interface between sub-surface railway assets and private property is South Wimbledon station on today's Northern line (fig.4.10). This station is located at the junction of Merton High Street and Morden Road. It was opened with the Morden extension of the C&SLR in 1926 to serve the developing Merton area of south London. From the outset, the station was provided with escalators taking passengers from the surface ticket hall and station building, which had been designed and constructed as a standalone building rather than one that could be developed above. The escalator shaft

[100] Follenfant, *Reconstructing London's Underground*, 25-36.

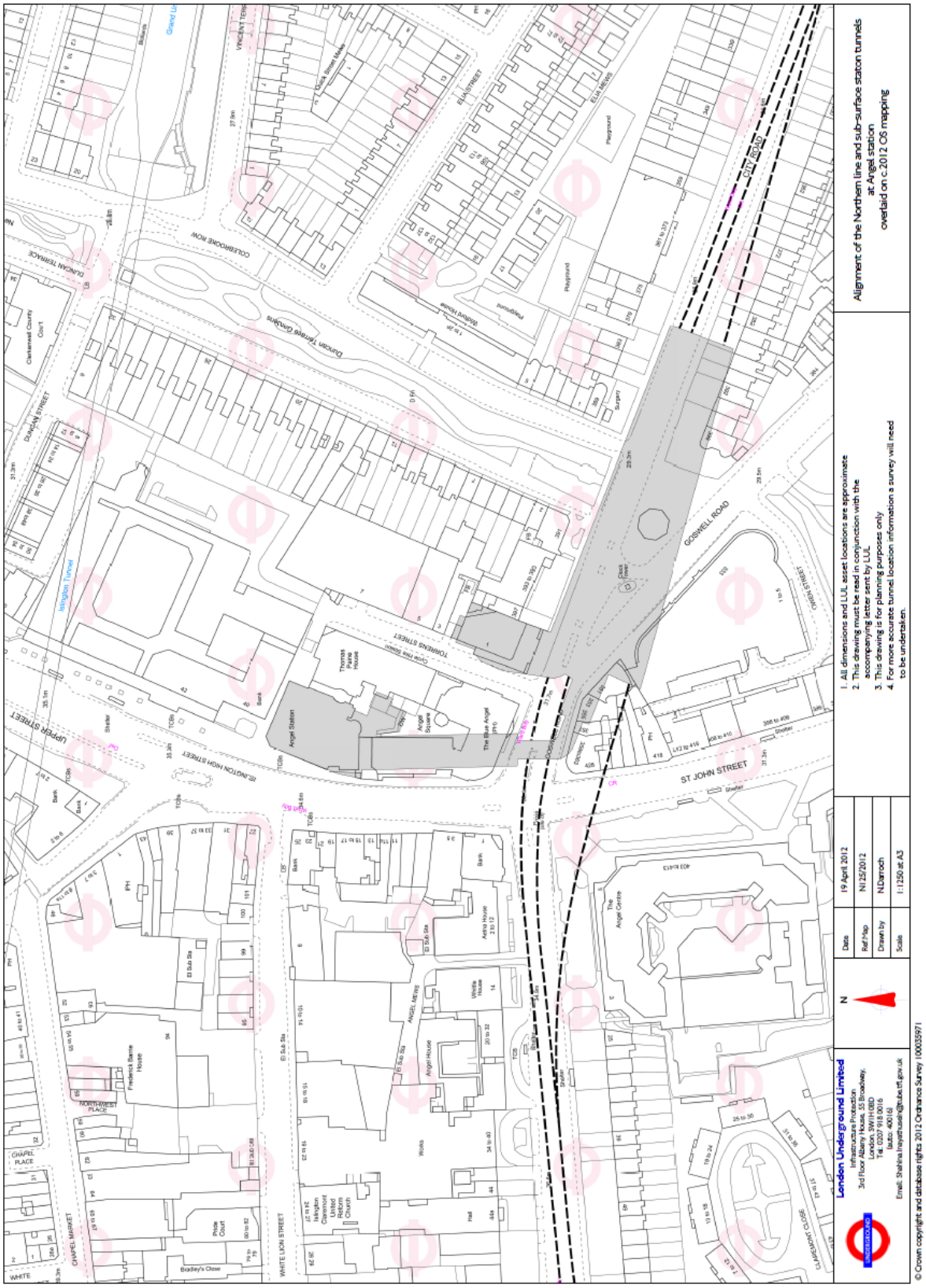

Fig.4.9

1:1250@A3 plan showing the alignment of the Northern line (dashed black) and sub-surface station tunnels (shaded grey) at Angel station overlaid on c.2012 OS mapping.

Source: London Underground, Ref.Map N125/2012.

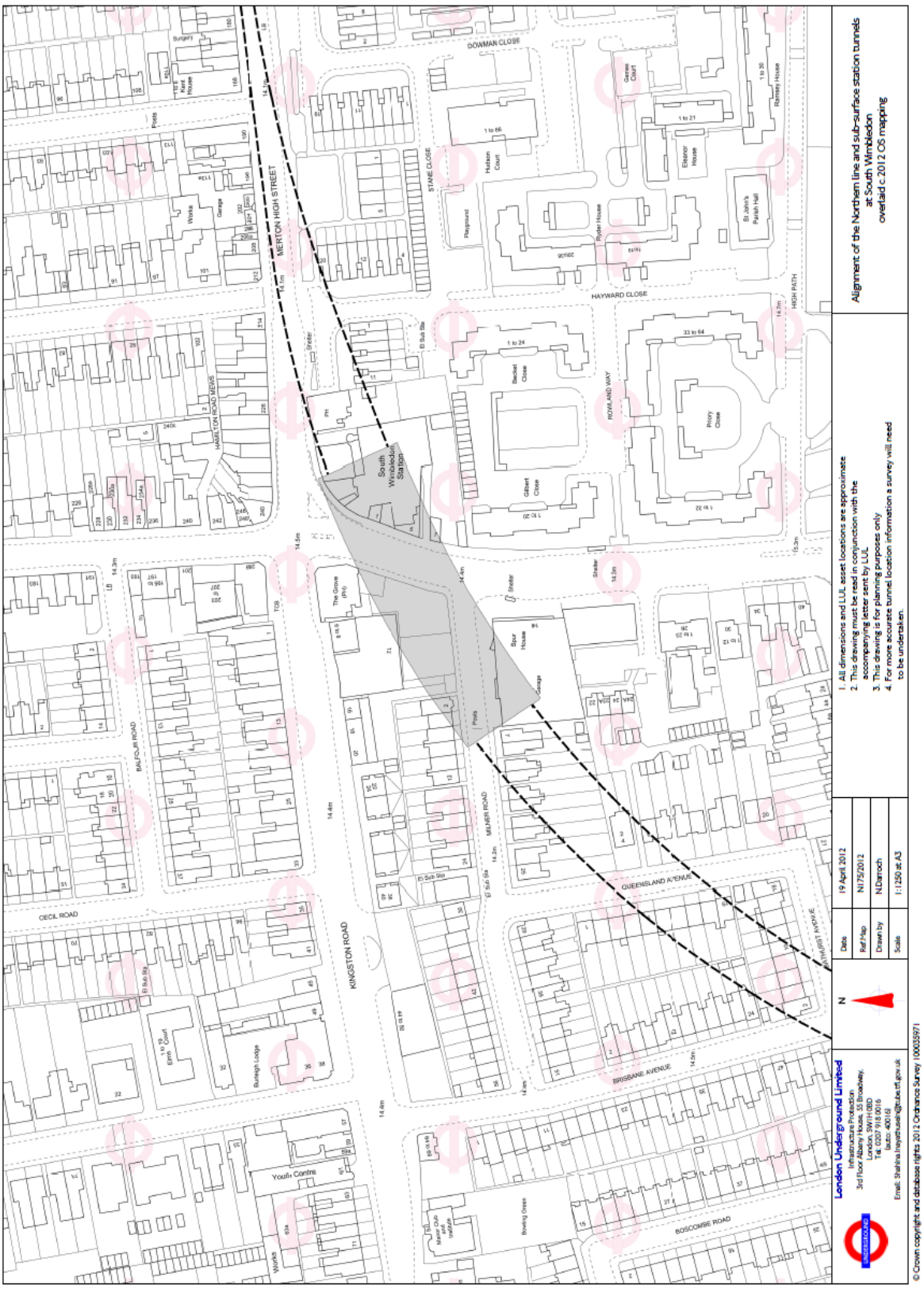

Fig.4.10

1:1250@A3 plan showing the alignment of the Northern line (dashed black) at South Wimbledon station (sub-surface levels shaded grey) overlaid on c.2012 OS mapping.

Source: London Underground, Ref.Map N175/2012.

descended under Morden Road and under a number of terrace houses that were purchased for the construction of the railway and related sub-surface tunnels and shafts[101] (fig.4.11). Whether the works required the demolition of the properties is not clear, however, we do know that by the time of the 1931-1941 mapping of the area, the terrace houses had been removed (fig.4.12). In 1933 the Cannon Brewery Company, owners of the adjacent public house, purchased the land for £6,000. The conveyance included covenants stating that the designs and foundations for any proposed development of the site would need to be agreed to by the railway company before any work could commence, these covenants are still applicable today[102]. Though the brewery submitted their designs for consultation and approval the result of the consultation has not been able to be determined, as there are no references to it in the corporate archives[103]. However, we can see from later OS mapping that no development has been undertaken on the site since the railways construction.

The most feasible explanation for the lack of development is the presence not only of the escalator shaft, but also the station tunnels beneath. Any additional load imposed above the shaft, such as by the presence of a building, is likely to cause some displacement of the ground and thus create a potential risk to the safe operation of the escalator. The very design of escalators, with their tight tolerances, means that if the shaft containing it moves at any one point without the remainder moving by the same amount the escalator can become jammed, thus requiring expensive repair and disruption to the flow of traffic through the station.

4.3 Under highway ticket halls

A common thread passing through this dissertation is the area beneath the public highway. Although owned by adjoining properties this is sparsely used for development purposes, except for the provision of utilities, though these are to a limited depth. In some cases, the utilities are located within pipe subways for ease of access and to minimise disruption to the highway when replacement or other works are required[104]. As such, the sub-soil beneath the public highway is also the most beneficial location for the placing of station facilities. This was recognised early on. In 1846, Charles Pearson gave

[101] Conveyance, dated 3 June 1925, between Frederick Daniel Halsey, Trustee of the will of James Bowyer and the City & South London Railway Company. TfL Muniments Archive: 1004058.
[102] Conveyance, dated 1 March 1933, between the City and South London Railway Company and the Cannon Brewery Company. TfL Muniments Archive: 1004181.
[103] Plan of the Grove Hotel, P.H. Merton, SW19 - Proposed Extensions, 01 March 1933. TfL Miniments Archive: 1040920.
[104] Follenfant, *Reconstructing London's Underground*, *45-46;* Harry Hall, "The new Piccadilly Circus station", Institution of Civil Engineers *Minutes of the Proceedings* 2, Vol.228, (January 1929): 157 – 180.

Fig.4.11

1:1250@A3 plan showing the alignment of the Northern line (dashed black) at South Wimbledon station (sub-surface levels shaded grey) overlaid on c.1908-1925 OS mapping.

Source: London Underground, Ref.Map N175/1908-1925.

Fig.4.12

1:1250@A3 plan showing the alignment of the Northern line (dashed black) at South Wimbledon station (sub-surface levels shaded grey) overlaid on c.1931-1941 OS mapping.

Source: London Underground, Ref.Map N175/1931-1941.

evidence to the Royal Commission inquiring in to the location of Metropolitan railway termini, with regard to the construction of two sub-surface terminal stations either side of Farringdon Street covering 500,000ft[105]. The commission felt that such a loss of land would not be of benefit to the city as a whole[106]. We can only speculate on the scale of disruption to property and the function of the City that this would have imposed, as it provided for multiple main line railway services, all of which utilised steam traction. With the use of electricity and the engineering ability for the railway to be located, some considerable depth underground the principle of a sub-surface station became feasible. The advantages included minimising of property purchase by reducing the need for widened roads or the demolition of property to be put over to non-rental income, as use as station facilities for example.

Whereas the 1846 committee rejected a central station, the 1892 committee and the associated report of Colonel Haywood and John Wolfe Barry, consultants to the Corporation of London, seemed merely indifferent[107]. The latter appear to be more interested in the obstruction of already congested pavements by entrances to the proposed station, and how the station would be constructed[108]. They also seem more interested in the provision for pedestrians to cross the road[109]. As such, the committee left the decision whether to allow the construction of the station to the Corporation.

The WCR terminus at Bank, located under Queen Victoria Street and opened in 1898, was the first station to be located wholly underground, though construction of the CLR station was already under way[110]. The terminus station at Waterloo was located within the basement of the station; a very good example, along with King William Street on the C&SLR, of how stations could be incorporated within existing buildings. Passenger access to the WCR was via the CLR station subways that surfaced in the public footpath. Jackson and Croome state that lifts had not been provided out of 'pinchpenny unfairness'[111]. This is rather unfair given what we have seen so far of the cost of property purchase in the city, as we saw with King William Street station a short distance away from Bank. It is also a very good example of how tube railway historians have failed to

[105] House of Commons Parliamentary Papers, Online, House of Commons Papers; Reports of Committees, (215), "Report of the commissioners appointed to investigate the various projects for establishing railway termini within or in the immediate vicinity of the metropolis, 1846". 13. http://parlipapers.chadwyck.co.uk/marketing/index.jsp. [Accessed August 11, 2011].
[106] Ibid, 13.
[107] "Report of the Joint Select Committee of the House of Lords and the House of Commons on the Electric & Cable Railways (Metropolis), 1892", [V-VI], 8-9.
[108] Ibid, 83-99.
[109] Ibid, 9.
[110] Harley Hugh Dalrymple-Hay, "The Waterloo & City Railway", Institution of Civil Engineers, *Minutes of the Proceedings* 1, 139, (January 1900); Croome & Jackson, *Rails through the clay*, 31.
[111] Croome & Jackson, *Rails through the clay*, 31, 507.

recognise the importance of the relationship between the tube and land use. Generally from a land use perspective the WCR use of another railway companies entrances minimised any further use of the surface in a very busy location, as well as providing interchange and joint facilities, benefitting the companies as well as their passengers who would not need to come to the surface and back down again. The Corporation doubtless also finding this beneficial as it would lessen the pedestrian traffic at surface level. The argument that use of the sub-soil for ticket halls is enhanced by Greathead's reasoning for the construction of the CLR station in the sub-soil, which had 'no value'[112]. This is because it was the only location, in the densely developed and highly priced central zone of the City that was not already *directly* affected by development, if one ignores the vast number of utilities placed under the highway.

Under-highway stations had and have an additional benefit. Whereas the expansion of surface stations can be restricted due to the densely built up areas within which they are located, under-highway facilities can either enlarge or replace existing surface assets without the requirement to purchase additional surface land or property. The original building can then be sold for re-development or utilised for operational purposes such as ventilation, as we saw in chapter 3.

Though under-highway ticket halls reduce surface area usage, it increases the interface between the tube and land-use. The scale of the sub-surface area posing a risk to adjoining properties that, in turn, poses a risk to the railway. For example, the provision of a sub-surface ticket hall, ancillary rooms, escalators etc. requires a large subterranean area such as that shown in fig.4.13, an indicative plan showing Bank LUL and Docklands Light Railway (DLR) stations, the grey shading representing the three dimensional sub-surface structures as shown by the axonometric view in fig.4.14. The excavation of so much earth would have required the railway companies to ensure that the buildings were not damaged during or after construction. This often resulted in adjacent buildings having to be underpinned, such as at Leicester Square, on the GNPBR, when that station was enlarged in the 1930s[113]. If the neighbouring buildings were to be redeveloped, the developer and their engineers would then need to ensure that the railway's assets were not affected and that access to the station was maintained at all times.

[112] "Report of the Joint Select Committee of the House of Lords and the House of Commons on the Electric & Cable Railways (Metropolis), 1892", 22.
[113] Follenfant, *Reconstructing London's Underground*, *46*.

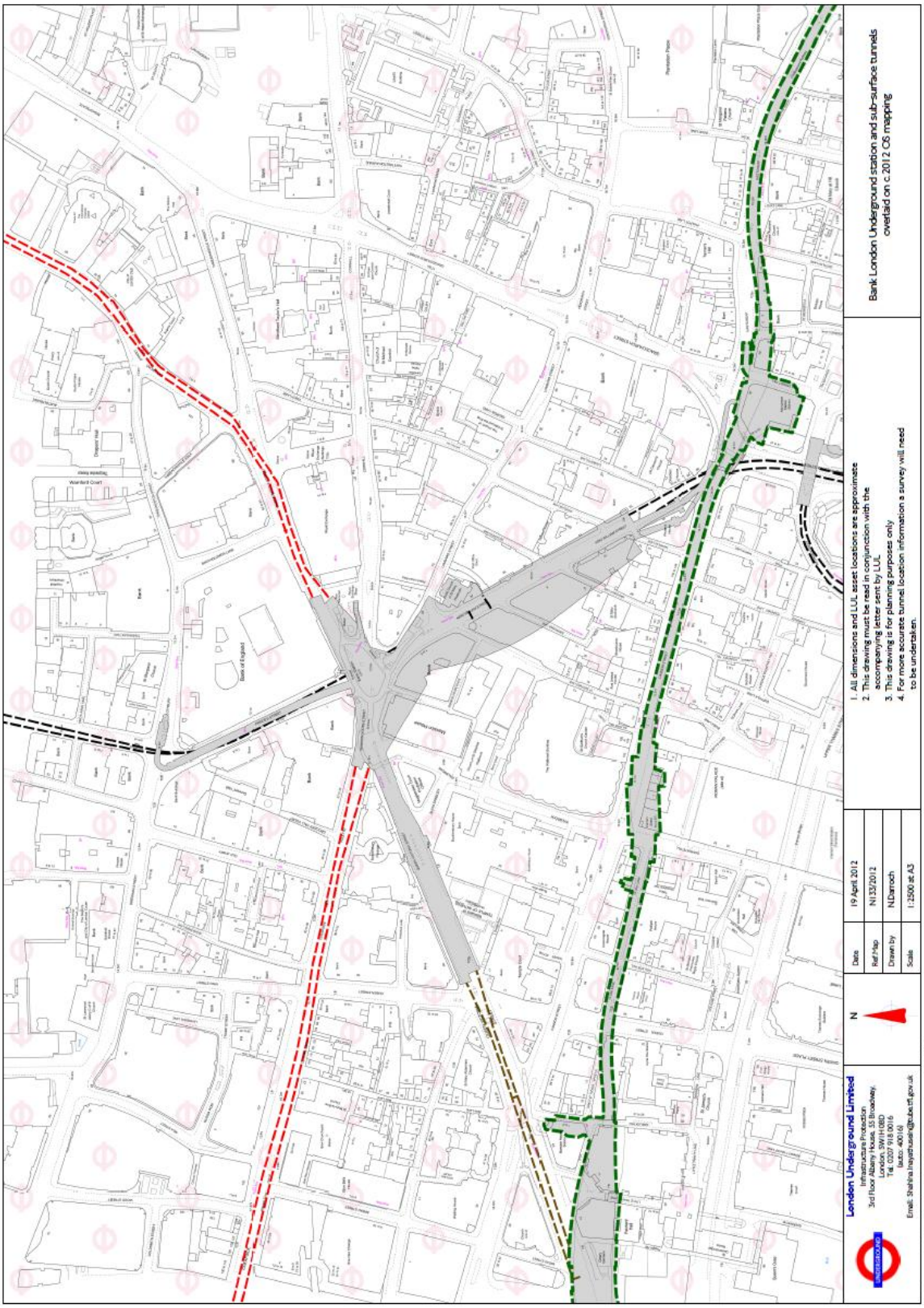

Fig.4.13

1:2500@A3 plan showing Bank London Underground station and sub-surface tunnels (shaded grey) overlaid on c.2012 OS mapping.

Source: London Underground, Ref.Map N133/2012.

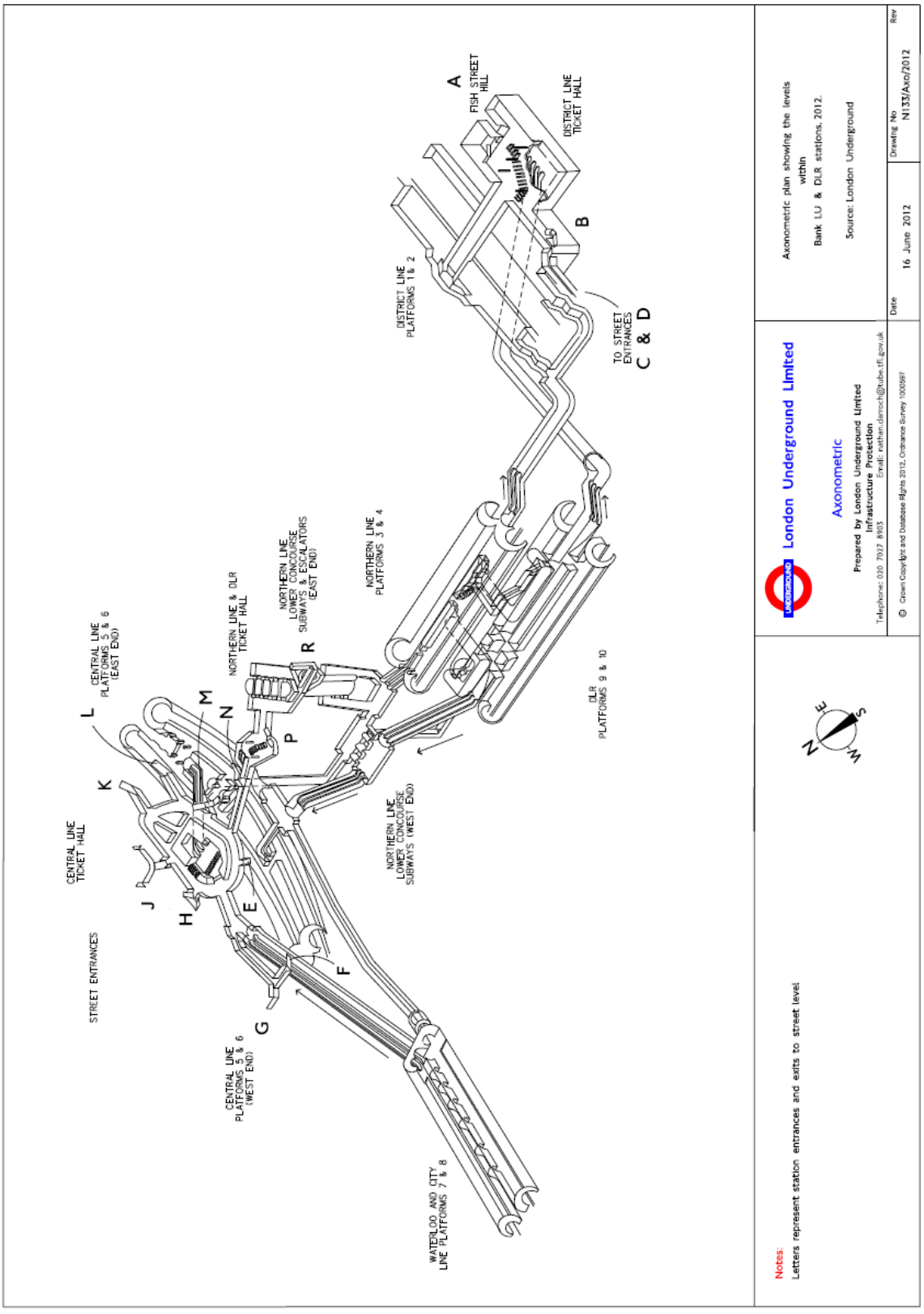

Fig.4.14

Axonometric plan showing the levels within Bank LUL & DLR stations, 2012.

Source: London Underground, Ref.Map N133/Axo/2012.

4.4 Station entrances within non-railway buildings

In 4.3 above, we saw that the Corporation of London appeared to be more interested in the location of entrances to the proposed Bank station than they were about its presence under the highway, their main concern being the vehicular and pedestrian traffic. As part of the construction of the station, the CLR and the Corporation agreed that the entrances from the footpath down to the station were to act as public subways, constructed paved, lit, cleaned and maintained at the company's expense[114]. These very same entrances are still in use today.

There are alternative options for accessing stations, such as the provision of entrances within existing buildings or new developments. Both Follenfant and Jackson and Croome describe how the LER enlarged the original Leicester Square station by constructing a sub-surface ticket hall[115], the works authorised by acts of Parliament in 1929 (the 1929 Act) and 1931 (the 1931 act)[116]. The original station was opened in 1906 to serve the GNPBR, becoming an interchange with the CCEHR in 1907. By 1934 passenger usage of the station had reached 27 million. As the station was becoming incapable of catering for the flow of traffic the decision was taken to provide an under highway ticket hall whilst retaining parts of the original building as one of five station entrances[117]. One of the new entrances located within the Hippodrome Theatre on Charring Cross Road. Fig.4.15 shows the current sub-surface area of Leicester Square station with the Hippodrome entrance marked 'A' and fig.4.16 is a photograph of it at street level.

The two acts enabled the company to purchase an easement for the use of parts of the Hippodrome Theatre to be utilized as a new entrance to the enlarged station facility[118]. The easement, including compensation for the freeholder and leaseholder, cost the company £28,150; interestingly the leaseholder gained the greater quantity of the purchase and compensation fee[119]. This sum did not include the cost of reconstructing the theatre's lower levels for the provision of the entrance, which was at the company's cost. Fig.4.17 shows the areas that were subject to the agreement and re-structuring. Because of the works the long-term need for a conventional subway entrance in the footpath, where the width of the road could not accommodate the flow of passengers

[114] 55 & 56 Vict., Central London Railway Act 1892, Ch.CCXLI, Sct.28, (3).
[115] Follenfant, *Reconstructing London's Underground*, 45-47; Croome & Jackson, *Rails through the clay,* 198-199.
[116] 19 & 20 Geo.5, London Electric, Metropolitan District and City and South London Railway Companies Act 1929. Ch.XXV; 21 & 22 Geo.5, London Electric Metropolitan District and South London Railway Companies Act 1931, Ch.XXXIII.
[117] Follenfant, *Reconstructing London's underground,* 45-47.
[118] Agreement, dated 30 June 1933, between the Right Honourable Robert Arthur James Gascoyne Cecil M.P and the London Electric Railway Company. TfL Muniments Archive: 1002105.
[119] Ibid.

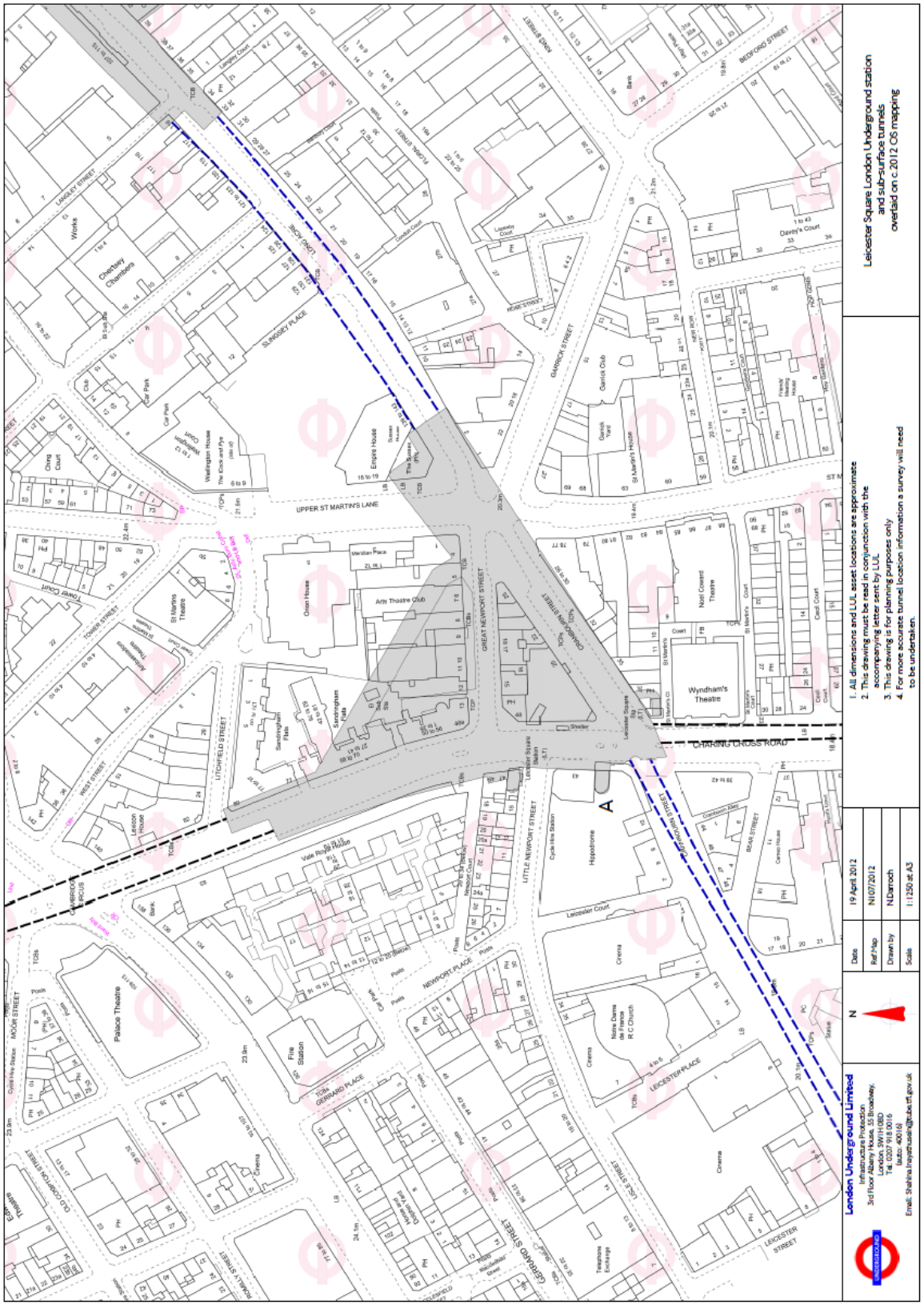

Fig.4.15

1:1250@A3 plan showing Leicester Square London Underground station and sub-surface tunnels (shaded grey) overlaid on c.2012 OS mapping.

Source: London Underground, Ref.Map N107/2012.

Fig.4.16

Leicester Square, Hippodrome Entrance, 17 June 2012.

Source: Author’s Collection.

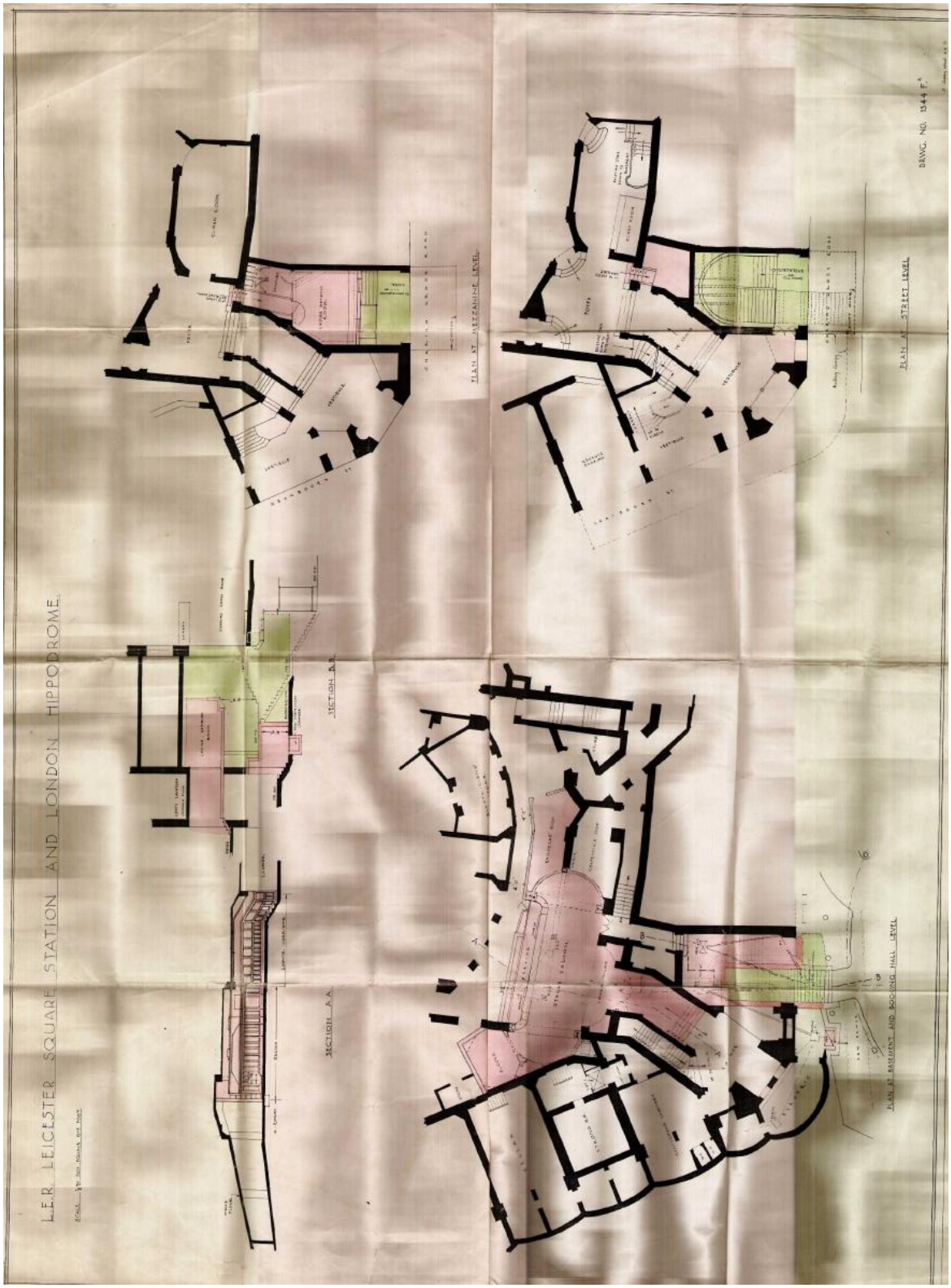

Fig.4.17

Extract from Agreement, dated 30 June 1933, between the Right Honourable Robert Arthur James Gascoyne Cecil M.P and the London Electric Railway Company.

TfL Muniments Archive: 1002105.

from the busy station as well as the existing pedestrian and vehicular traffic, was obviated. However, anyone wishing to re-develop the property would need to incorporate the station entrance within their designs, potentially limiting the design of the new building.

4.5 Case study – Piccadilly Circus station

Piccadilly Circus station was constructed as a joint venture between the BSWR and GNPBR in 1904, the original single-storey station building located at the junction of Jermyn Street, Haymarket and Piccadilly Circus (fig.4.18). The land for the station leased from one J.F.F. Horner Esq. (representing the Crown's Woods and Land Revenues) for a period of 999 years at a cost of £89,830[120], the term essentially granting a freehold status of the land to the railway companies. The site accommodated the ticket hall, four lift shafts and a stair shaft. Opened in 1906, it served one and a half million passengers; by 1929, the station was catering for approximately 25 million a year[121].

As any future enlargement of the existing station was 'almost impossible'[122] it was decided to 'abandon the site and to build an entirely new station beneath the open Circus'[123] able to cater for 50 million passengers[124]. The new works were authorised under the London Electric Railway Act 1923[125], the cost of the new station being in the region of £500,000[126]. Work commenced in 1924 and was completed during late 1929 (fig.4.19). Within the station environment, five sets of escalators in two shafts were provided descending from the 16,000sq.ft oval ticket hall area the floor of which was 15 feet below street level. From a lower concourse level measuring 90ft by 32ft and 72ft below the ticket hall six further escalators were provided to take passengers down to the Piccadilly line platforms (102ft below ground level) and the Bakerloo line (86ft below ground level)[127]. Worthy of note is that the majority of the escalator shafts remained under the public highway, though the northern most shaft, leading to the Bakerloo line concourse level, did pass under property (fig.4.20). Due to the presence of a large quantity of utilities under the public highway at this location, a new subway was constructed specifically for water mains and cables to be diverted around the new ticket

[120] Agreement, dated 14 July 1903, between J.F.F. Horner Esq. and the Baker St and Waterloo Railway Company & the Great Northern Piccadilly and Brompton Railway Company. TfL Muniments Archive: 3376.
[121] Hall, "The New Piccadilly Circus Station", 157.
[122] Ibid, 184.
[123] Ibid, 157-158.
[124] Follenfant, *Reconstructing London's Underground,* 23.
[125] 13 & 14 Geo.5, London Electric Railway Act 1923, Ch.CIII.
[126] Croome & Jackson, *Rails through the clay,* 195.
[127] Hall, "The New Piccadilly Circus Station", 157-192; Follenfant. *Reconstructing London's underground,* 23-25.

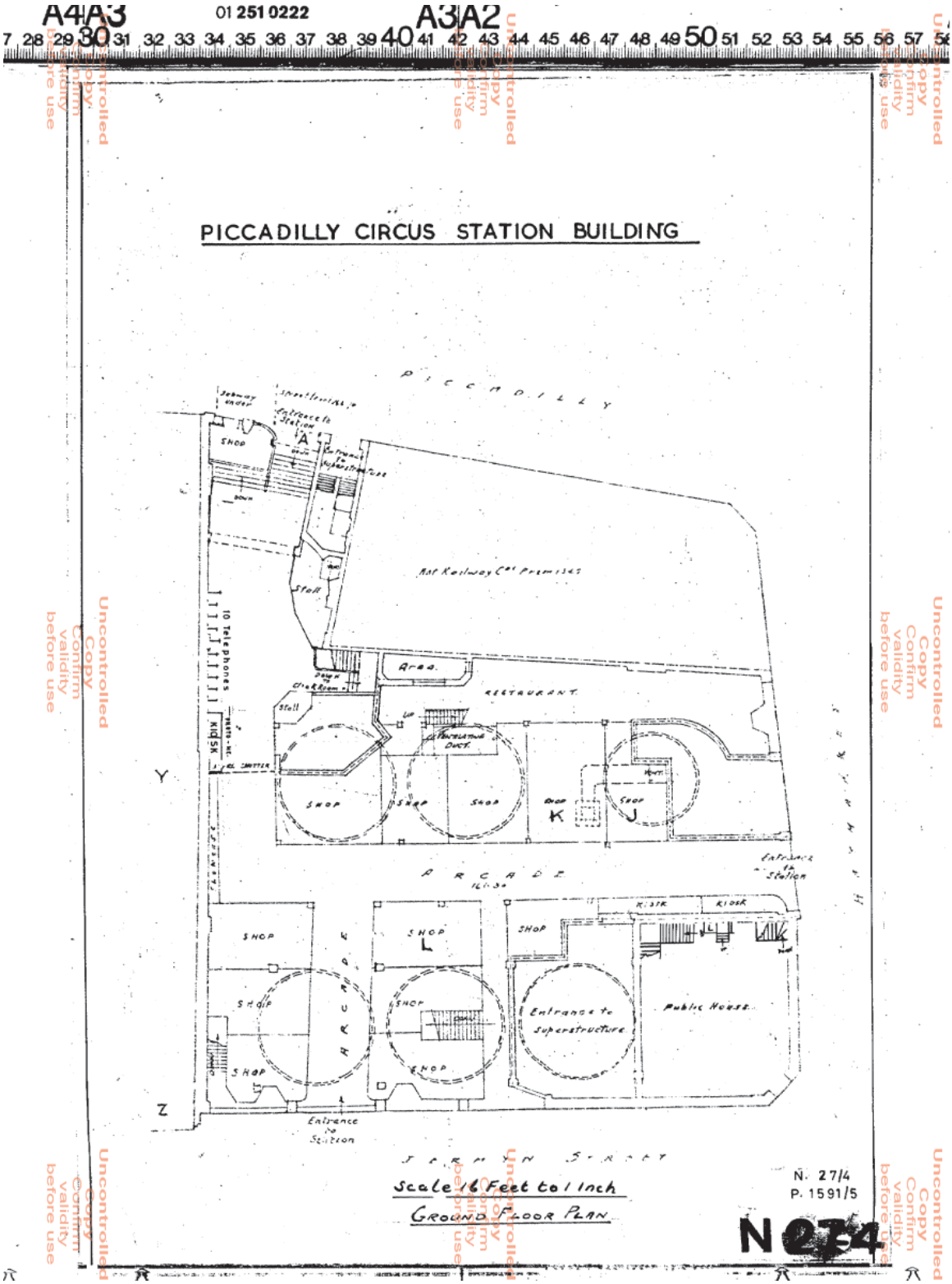

Fig.4.18

Drawing showing the Ground Floor plan of the original Piccadilly Circus Station, Undated.

LUL Electronic Archive No.: P063 15372.

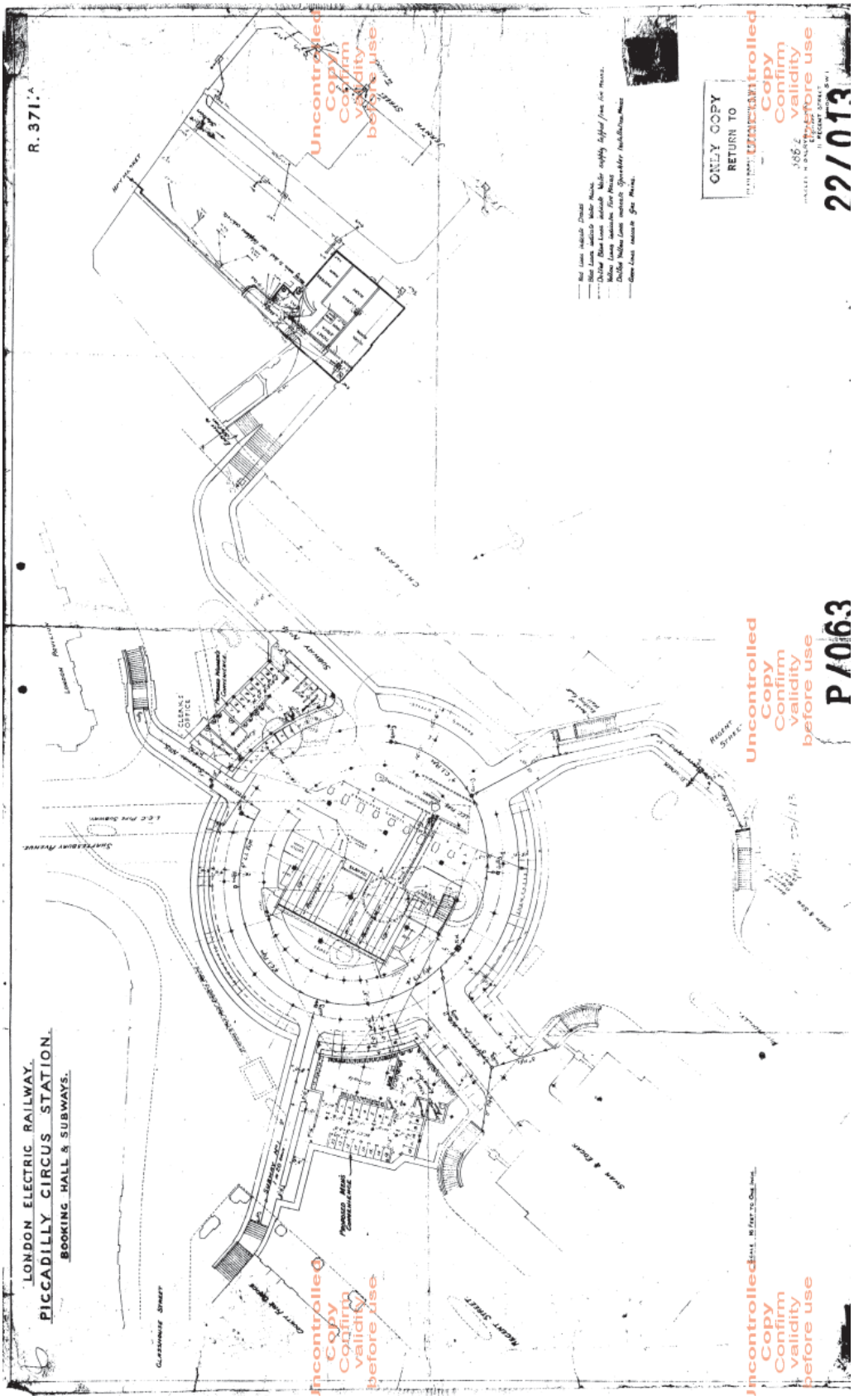

Fig.4.19

London Electric Railway plan showing the New Piccadilly Circus Ticket Hall, 1929.

LUL Electronic Archive No.: P063 22013.

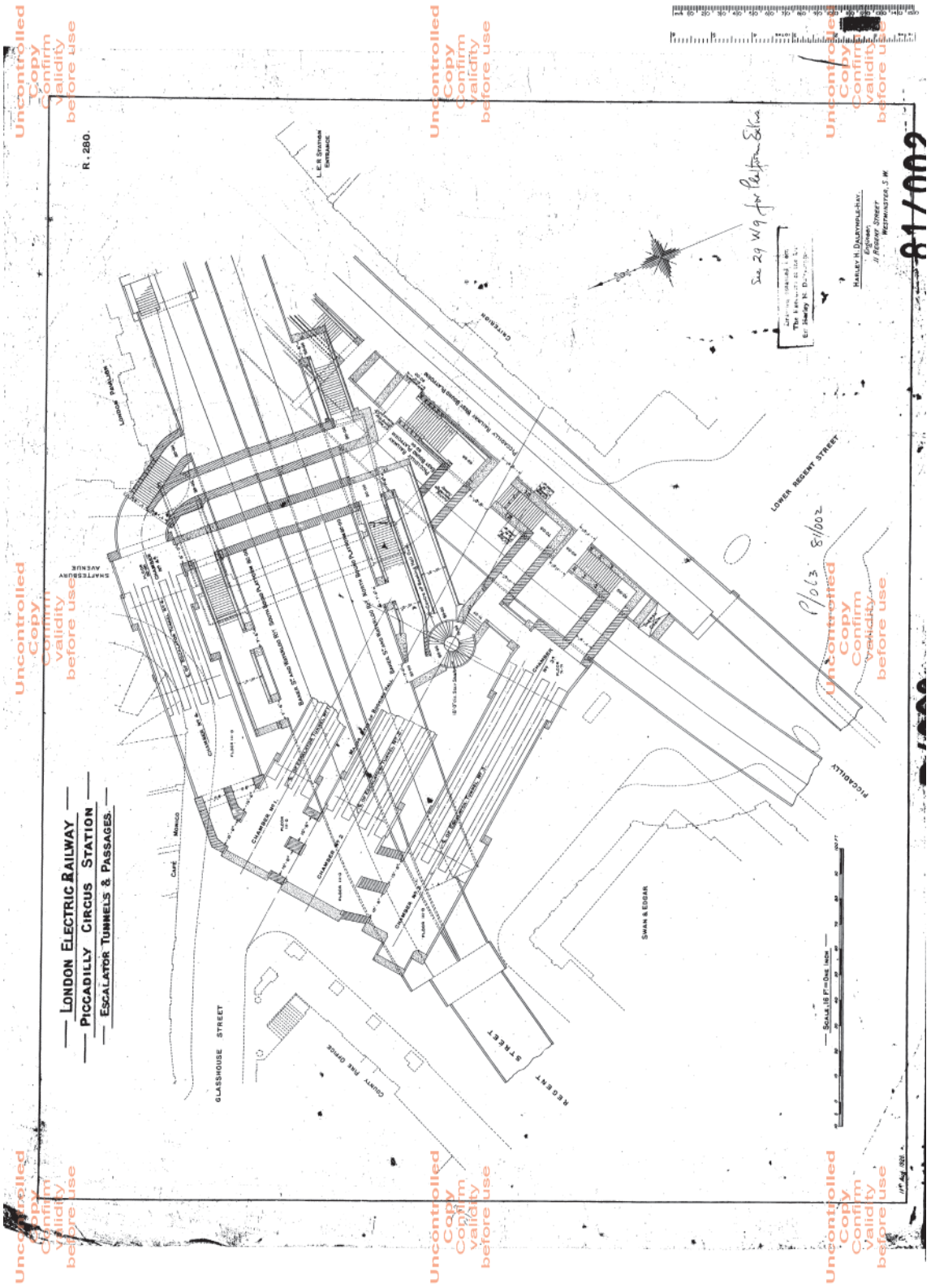

Fig.4.20

London Electric Railway drawing showing escalator tunnels and passages at Piccadilly Circus, 1 January 1926.

LUL Electronic Archive No. P063 81002.

hall. The construction and diversions had to be commenced and completed before work began on the station. The opening of the new station did not see the original building fall entirely out of operational use, the basement levels and the former lift shafts were put over to the purposes of ventilation and the locating of electrical equipment. As the railway's needs were limited, the company leased the property interest, including the original station building, to the Union Surplus Lands Company Ltd. for a sum of £57,820[128]. This company was comparable in status to the Metropolitan Surplus Lands Company of the MR. Both companies managed the properties of London's underground railway companies for which there was either limited or no operational use. Today, the original station site forms the location of the Criterion building erected in the late 1980s. Figs.4.21 and 4.22 show the sub-surface station area and the Criterion building on the site of the former station. To accommodate the railway's requirements this building had to incorporate not only ventilation facilities but also the presence of the railways sub-surface structures beneath. As with other sites, any future re-development of the site will require the agreement of London Underground, successor to the London Electric Railway, as to what can and cannot be undertaken.

4.6 Conclusion: the tube and the urban environment

This chapter has considered some of the uses that London's sub-soil has been put to for the use of the tube railways. It has shown how station sites were utilised for construction purposes and how that benefited the railway company by their not having to purchase additional lands. We have seen how initially the station tunnels were laid out in the same manner as the running tunnels, under the road to minimise incursion on property, and how enlargement or replacement of older stations had been undertaken under the highway to minimise property purchase, and also because private property was affecting the development and enhancement of station facilities. But this chapter also shows the greater scale of some later sub-surface stations, especially at locations such as Piccadilly Circus and Leicester Square when compared with the earlier C&SLR stations at Kennington and Oval. Historians must think beyond 'what was built when' and consider more fully how the railway was built, on what scale and why. Although the tube was constructed in a three-dimensional environment, our thinking must be four-dimensional, as we take in to account changes over time.

Part one of this dissertation shows a distinct change in the relationship between the tube

[128] Lease, dated May 1931, between the London Electric Railway Company and the Union Surplus Lands Company Limited. TfL Muniments Archive, 1026030.

and land use in the metropolis. Whereas the early tubes (1884-1907) were designed and constructed to avoid property, later extensions, improvements to access and the requirement for operational necessities such as ventilation, saw the tube start to pass under property from the 1920s onwards, through the purchase of easements, as recommended by the 1892 committee. Whether the way the railway developed between 1892 and 1939 was entirely what Greathead had in mind in 1892, when giving evidence to the committee, is questionable. However, his thinking did, in the long-term, prove prescient. Today's tube passes under property in the manner suggested by Greathead. It is argued that it did so to such a degree that the passing of the British Transport Commission Act in 1955 included the right for the *taking* of that sub-soil required for the construction of a new tube railway across London, because of the cost of purchasing easements, one of the key aspects of part 2. The only additional cost being the payment of compensation for loss of property value[129]. Note must be made, however, that this had also been a factor in the London Transport act of 1936, to a much lesser degree. The LPTB having been permitted to take lands without payment for purchase or easement, but only for the purposes of improving stations of the sub-surface railways (Metropolitan, District lines) and the provision of new electrical sub-stations[130].

However, the increased interface between the railway and private property posed concerns regarding the safety of the railway and the development of property. It introduced a requirement not only for the railway companies to ensure the protection of property, when they were constructing new assets, but for property owners and developers to ensure the safety of the railway, especially when buildings were to be re-developed, another of the key issues of part 2.

[129] 4 Eliz.2, British Transport Commission Act 1955, Ch.XXX.
[130] 26 Geo. 5 & 1 Edw.8. London Passenger Transport Act 1936, Ch.CXXXI.

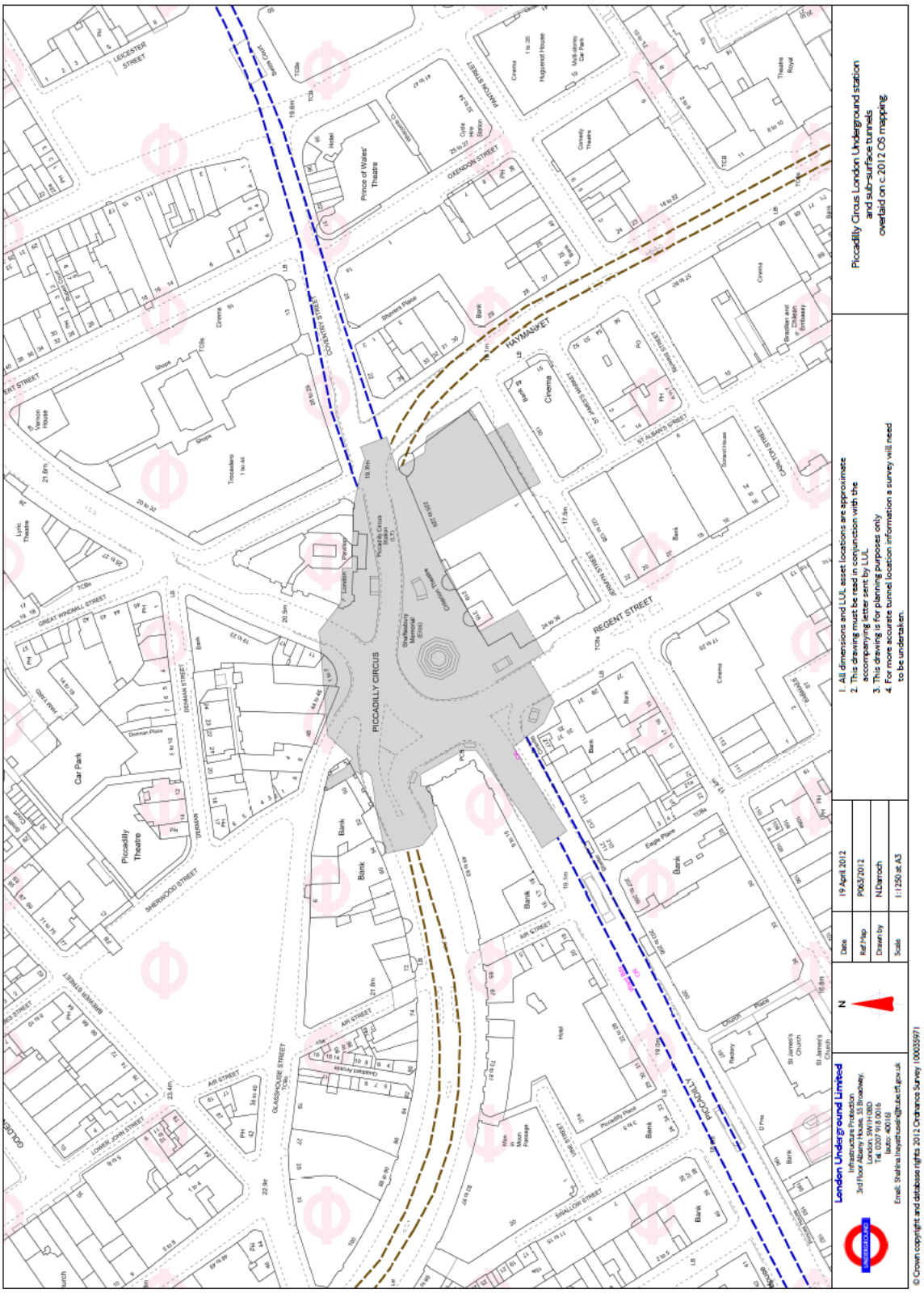

Fig.4.21

1:1250@A3 plan showing Piccadilly Circus London Underground station and sub-surface tunnels (shaded grey) overlaid on c.2012 OS mapping.

Source: London Underground, Ref.Map N107/2012.

Fig.4.22

Criterion Building Piccadilly Circus, 17 June 2012.

Source: Author’s Collection.

Part 2 The need for protection

Chapter 5: Bigger, taller, deeper

Part one of this dissertation considered the development of the deep-tube system in London, reviewing the legislation that affected its construction, the requirement to minimise its impact on land use and the need for the railway to be constructed in such a way as to minimise property purchase. This section takes a different turn as it studies how, since the 1920s, property interests must take in to account the presence of the tube.

The following chapters therefore consider changes to urban development; changes to legislation, which enabled the tube to pass where it would, and the construction of the latest major extension of the tube, the JLE opened in 1999. These have an even greater interface with property, not just by their passing under private property but also due to the inclusion of a protective zone around the railway assets as a means of protecting the infrastructure. In a city such as London property development is an ever-present factor providing the population with housing, work and leisure, just as the tube provides transit to and from these. As such, it is essential that those undertaking works are aware of the presence of the railway and the potential interface between them and its assets. This chapter therefore looks at the requirements for consultation with LUL to ensure the safety of the railway.

5.0 Tunnelling under property

By 1907, when the core tube network was complete, tunnels only passed under property when necessary. This was, after all, Greathead's intention when he had petitioned the 1892 committee for the ability to purchase an easement under property, instead of having to purchase the property as a whole. But changes in attitude and thinking were to take place from the 1920s onwards seeing an increasing interface between private property and the tube.

By the 1920s, the privately owned tube companies had merged in to three groups. The MR incorporating the Great Northern & City Railway, and, along with the CLR, remained independent. The remainder, excluding the WCR, which belonged to the Southern Railway, formed the London Electric Railway (LER), which also had an interest in tram

and bus operation across the capital. Extensions to the tube network had been ongoing for some years between 1907 and the CCEHR extension to Kennington, opened in 1926, such as the Bakerloo from Edgware Road to Paddington (1913) and from Paddington to Watford Junction (1917). Though the section of Bakerloo between Edgware Road and Paddington passed under private property it did so for only a relatively short distance under the Regents Canal and Paddington Basin. This area was not affected by new development until the early twenty-first century; the development of the area above the Bakerloo lines is currently LUL project for the protection of the railway today[131]. However, it was only with the Kennington extension that a change to the alignment of the tubes was undertaken, seeing them pass for the majority of their length under private property (fig.5.1).

As we have seen so far in this dissertation, the alignment of the tubes primarily followed the alignment of the major public highways, in an effort to not only to tap in to trunk traffic but also to minimise the effect of property on the cost of constructing the railways. However with the provision of interest free loans from the government under the Trade Facilities Act 1921[132] improvements were made to stations and the alignment of the railways, thus creating greater revenue for the companies and their shareholders[133]. One such advantage was the availability of cash to construct the railways under property. Where previously the companies had minimised additional costs on the shareholders purse by avoiding expensive negotiation and purchase of easements under property, cash was now available from the public purse for the first time. What we see from this point on therefore, is a change in philosophy from one of minimising incursion on property to one of public funds paying for improvements to public services, the availability of funds enabling the tubes to pass under property without utilising private finances to do so. After all, any company given the benefit of free cash to improve their coffers is doubtless going to take advantage of the situation and make full use of the opportunity. As such, the CCEHR extension to Kennington, authorised by the London Electric Railway Act 1923[134], took full benefit from the availability of the government loan to purchase easements by agreement or compulsorily. The line being constructed with the intention of opening up new traffic flows from south of the river to the west end, such as Leicester Square and Tottenham Court Road, and to relieve congestion on the existing CSLR from Kennington and the BSWR from Elephant & Castle, the new alignment doubtless much too costly to be constructed without public funding. The

[131] London Underground Infrastructure Protection Project File, B072, 1813011.
[132] 11 & 12 Geo.5, Trade Facilities Act 1921, Ch.65.
[133] Barker and Robbins, *A History of London Transport: the Twentieth Century,* 202-214.
[134] 13 & 14 Geo.5, London Electric Railway Act 1923, Ch.CIII.

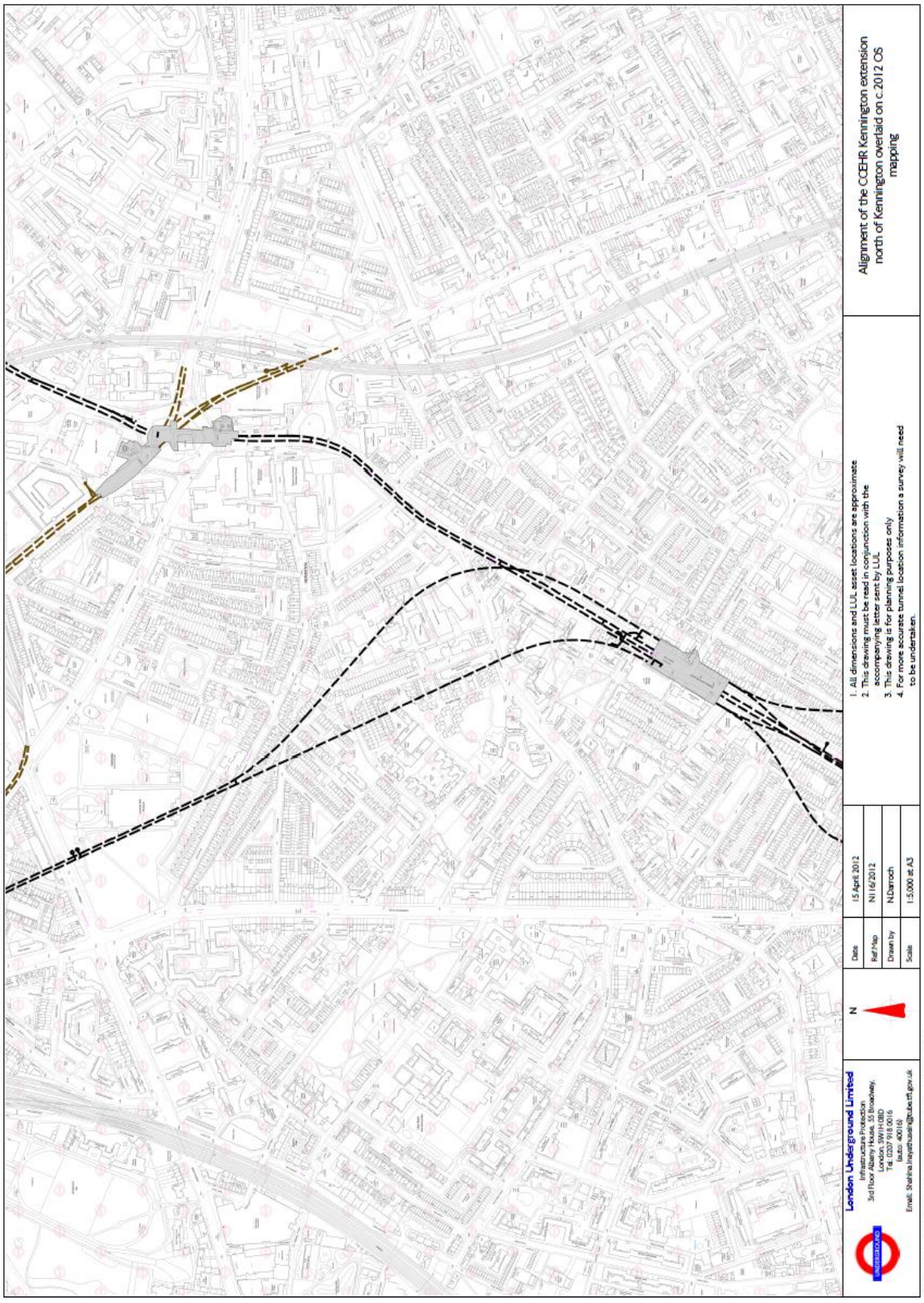

Fig.5.1

1:5000@A3 plan showing the alignment of the CCEHR Kennington extension (dashed black) north of Kennington overlaid on c.2012 OS mapping.

Source: London Underground, Ref.Map.N116/2012.

construction of the CCEHR extension appears to have set the precedent for other future schemes under the London Passenger Transport Board (LPTB).

In 1933, London's local public transport was integrated under the banner of the LPTB, established by the London Passenger Transport Act 1933[135], the board taking over control of the previously independent underground railways, buses and trams in the metropolis. To improve London's transport network, it undertook extensions and continued upgrading the railway and stations begun by the private companies. One such extension, authorised by the London Transport Act 1936[136], was that between Liverpool Street and Stratford that, as with the CCEHR extension to Kennington, tunnelled under property. The easements purchased through either agreement or compulsory purchase. This was not expensive: the purchase of six easements near and on Globe Road, Bethnal Green, E2 (fig.5.2) costing the board £124 in total[137], though it must be borne in mind that the cost of properties in this area were much cheaper when compared to the central zone or other more popular areas of the city.

These examples suggest the beginnings of a change in design philosophy. Where the tubes of 1884-1907 had avoided property where possible, despite having the same compulsory purchase powers as the extension railways of the 1920s and 1930s, the new extensions took advantage of their statutory powers to purchase easements, whether through agreement or compulsorily. Not only was there the concept of attracting new sources of traffic, thus creating greater revenue for the shareholders, but there was the principle of public benefit requiring public funds, the works being heavily funded by the tax payer through government loans or through a public body (the LPTB).

With the greater availability of funding and the potential for new direct routes, a closer interface between private property and the tubes was taking place; whereas the early tubes had previously had a minimal effect on those properties along their alignment, due to their being predominantly located under the public highway, their presence under property now had a long-term effect[138]. Landowners now had to take account of and accommodate the presence of the tunnels under their property, whereas previously the tube had largely accommodated the interests of private property owners.

[135] 24 & 25 Geo. 5 London Passenger Transport Act 1933, XCVI.
[136] 26 Geo.5. & Edw.8., London Passenger Transport Act 1936, Ch.CXXXI.
[137] Agreement, dated 18 January 1938, between R Joslowite and the London Passenger Transport Board. TfL Muniments Archive: 1068627; Agreement, dated 18 January 1938, between Cecil Vernon Barker and others and the London Passenger Transport Board. TfL Muniments Archive: 1013984.
[138] Barker and Robbins, *A History of London Transport: the Twentieth Century*, 344.

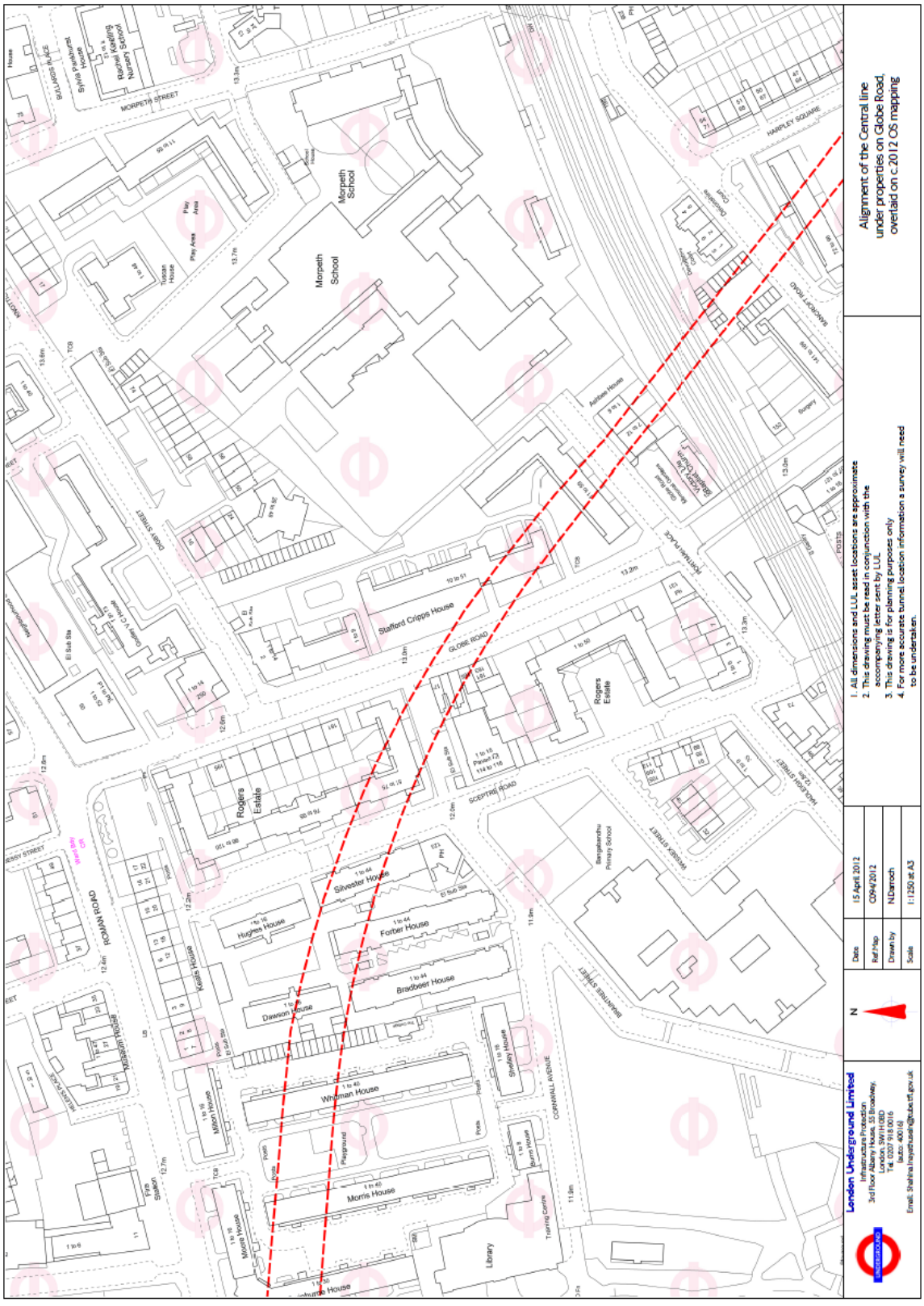

Fig.5.2

1:1250@A3 plan showing the alignment of the Central line (dashed red) under properties on Globe Road, overlaid on c.2012 OS mapping.

Source: London Underground, Ref.Map.C094/2012.

5.1 Changes to building design

Until the mid 1950s, buildings were generally of low-level construction[139], the tallest in London for many years being 55 Broadway, the headquarters of the Underground Group, at ten storeys once it was completed in 1929[140]. It is located above the MDR St James's Park station and utilises the air space above the sub-surface railway, the building supported on piles to transfer its weight beyond the retaining walls of the former railway cutting, the design based on American practices for tall buildings. Before the development of larger buildings, foundations were minimal, not extending below a few feet in to the sub-soil, hence the term 'footings'. Generally, the only time they extended deeper was when basement levels were included. The main interface with tube railways was if there was a void under the surface such as a ticket hall or an escalator shaft, as discussed in the previous chapters. The reason for the smaller scale buildings across the metropolis was that the city was free to expand outwards as demonstrated by the growth of the suburbs in the 1920s and 1930s[141].

Towards the end of World War 2, government drew up plans to determine the pattern of development for Britain's towns and cities. Within the Greater London area the green belt, approximately the area within the alignment of today's M25 Motorway, was already established having first been proposed to be generally around the city in 1935, though it had been barely enforced. It was not until 1955 and the requirement for re-housing and re-development of the city that it came in to full force limiting suburban development and restricting London's outward expansion[142]. Therefore, alternative development had to be undertaken to cater for the ever-increasing population and demand for office space: namely to build upwards[143]. As White points out 'during the 1950s [the London County Council] aspirations for London were emboldened by advances in construction technology, which could now overcome the problems of building high on pliable London clay'[144]. The mechanism for supporting the new buildings, in the form of reinforced concrete piles, relied heavily on the same geological conditions as those found beneficial for the boring of the tube tunnels; its cohesiveness allowing equally for the excavation of tunnels and piled foundations with relative ease when compared to non-cohesive soils

[139] Barker and Robbins, *A History of London Transport: the Twentieth Century*, 1-14;
[140] London Transport Museum Website. "55 Broadway" http://www.ltmcollection.org/museum/glossary.html?IXglossary=55+Broadway [accessed: 31 Jun 2012]; Nathan Darroch, "55 Broadway". Author's Collection, London, 17 June 2012.
[141] Alan A. Jackson, *Semi-Detached London: Suburban Development, Life and Transport, 1900-1939*, (London: Allen & Unwin, 1973); David Levinson, "Density and dispersion: the co-development of land use and rail in London", Journal of Economic Geography 8, 1, (2008): 55-77; Haywood, *Railways, Urban Development and Town Planning in Britain*.
[142] White, *London in the Twentieth Century*, 49.
[143] Ibid, 36-45; Haywood, *Railways, Urban Development and Town Planning in Britain*. 83.
[144] Ibid, 47.

such as sand and gravel or water-bearing strata.

5.2 New development and underground railway infrastructure

The design of the early tube lines, mostly in the un-developed sub-soil of the streets of the central zone of the city, posed little threat to new development at surface level or in the sub-soil, despite the need for certain engineering factors to be taken in to account especially when undertaking excavation or designing foundations. With those sections of railway or related infrastructure in close proximity to or under property however, the interface became more complex. As such, developers and railway engineers needed to discuss and agree what work can be undertaken and how to minimise any adverse effect on the railway.

5.2.1 Building load and ground heave

Any structure applies weight or 'load' to the ground; the pressure compressing the soil below it, which in turn compresses any other structure contained within the ground[145]. As the tube tunnels, which are circular in cross-section, are held in compression by the surrounding sub-soil, the load is transmitted around them (fig.5.3). If the compression of the sub-soil is relieved, by excavation or demolition of a building, the ground beneath can, over time, start to swell due to the stratum absorbing water[146]. The resulting ground movement can cause the tunnel, generally formed of cast iron, concrete or steel segments, to move and deform. This poses serious risks to the safe operation of the railway as, in a worst-case scenario, the trains can contact with the deformed internal diameter of the tunnel[147].

5.2.2 Foundations and the underground railway

As a property owner, the railway company has a right of support from not only the sub-soil but also adjoining properties, just as surface properties have a right of support from one another. The foundations of a building must therefore be designed to minimise any adverse effect on railway structures, whether a tunnel, box or wall. The stratum upon which buildings are located can be an issue with regard to subsidence or settling of the

[145] N.E Simmons & B.K Menzies, *A Short Course in Foundation Engineering,* (London: Newnes Butterworths, 1977), 49.
[146] Ibid, 42.
[147] BBC News website. "Bakerloo Line Train Hits Bulge in Tunnel" http://www.bbc.co.uk/news/uk-england-london-17853428 [Accessed 27 June 2012].

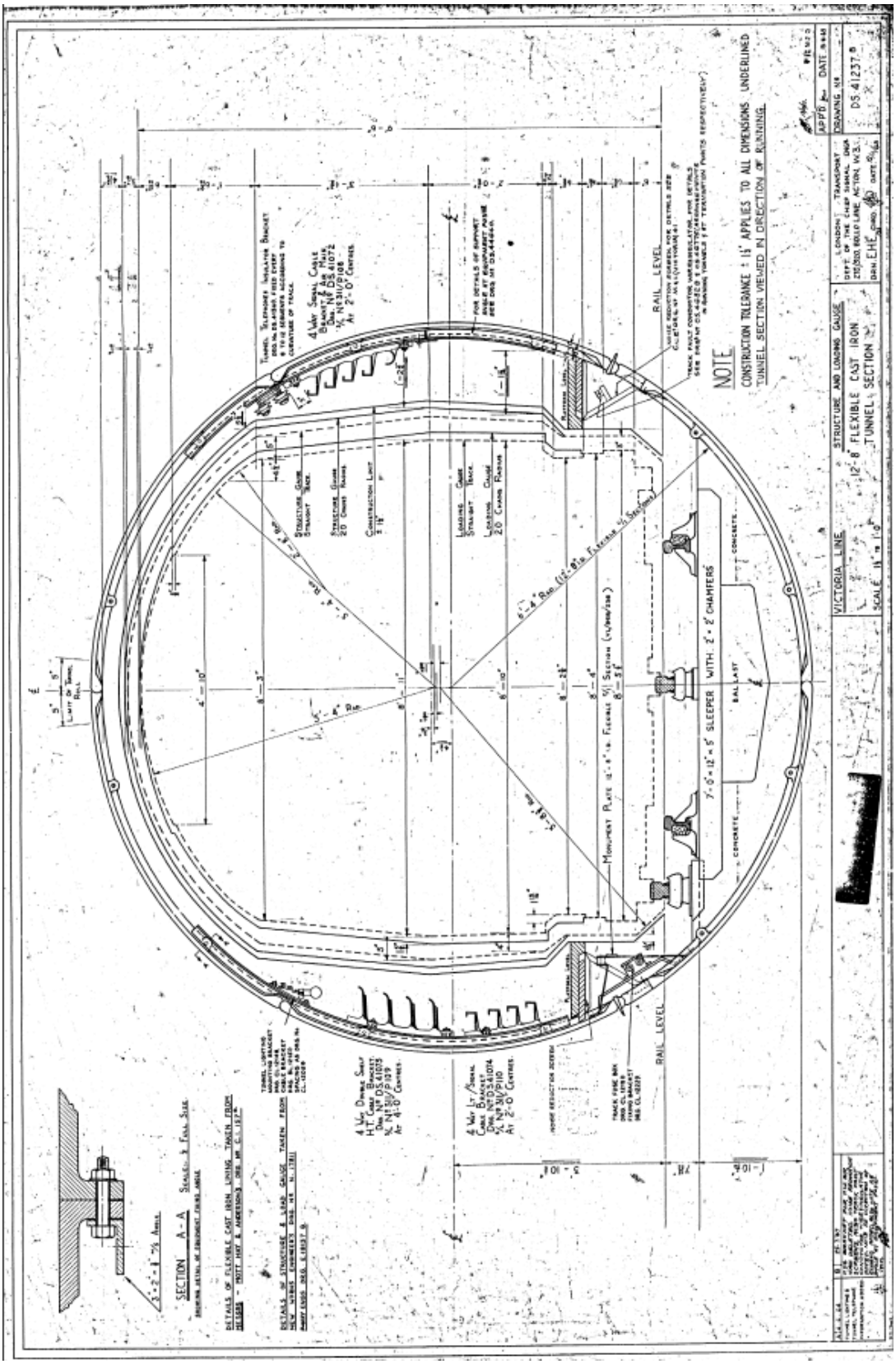

Fig.5.3

London Transport drawing showing a typical 12’ 8” flexible cast iron tunnel lining section as used on the Victoria line, 13 August 1963.

LUL Electronic Archive No.: V001 464120.

building as it compresses the ground beneath[148]. Depending on the scale of the building, and the nature of the sub-stratum, the engineer must decide what form the foundations will need to be: whether strip foundations, where the brick walls extend to just below ground level and are supported on a concrete strip; a raft, a flat concrete surface spreading the load over a greater area; or piles which are long columns of concrete or other material that allow the engineer to transfer loads to a greater depth than those methods above. These can be used on their own or as a combination, depending what is required, each development being different. For example if there is a tube tunnel under a property and the weight of that building may injuriously effect the tunnel, piles can be sunk either side and a raft constructed over the top to carry the building.

For the first two foundation types, there is minimal risk to the railway. This is because not only their relatively shallow depth but because of the way the building's weight is carried and support is given. However, piles by their very nature extend deeper in to the sub-soil to gain the greatest support for erections above.

5.2.3 Piles and their relevance to the tube

As piles have perhaps the greatest influence on the running tunnels of the railway, it is important to gain a greater understanding of how they work and how they can affect the tunnels.

Piles act as a column, 'which transmit the weight of the structure from an upper level through an intervening stratum of soft ground to a harder stratum'[149], though there are other means of the pile offering support, such as skin friction piles, which draw on the ground around their circumference. Piles can typically range in size from 150mm to over 2m in diameter; the latter used at Mansion House and Monument stations where large office developments were undertaken above the sub-surface railway, for example. The building loads have not only to pass the tunnels but also extend down to the solid stratum below the riverbed. The largest piles are dug by hand but smaller ones are augured (drilled) and then filled with concrete, or are pre-cast and driven in to the ground[150]. Though piling is not a new method of construction, having been in use for thousands of years, the ability to support large-scale buildings upon them was, having been first used on a large scale for offices in America.

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148 Simmons and Menzies, *A Short Course in Foundation Engineering,* 30-48.
149 Carill Sharpe, ed., *Kempe's Engineers Year-Book, Vol.II* (Tonbridge, Kent: Benn, 98th ed., 1993). 12/15-12/16.
150 Simmons and Menzies, *A Short Course in Foundation Engineering,* 107-140.

Piles and related foundations need to be designed so as not to adversely affect any underground railway structures. For example, if piles are driven in to the ground, the vibration and movement of the soil can cause displacement of the surrounding ground[151] and ultimately in the potential distortion of the railway tunnel. LUL's current recommendation for driven piles in proximity to tunnels is therefore no closer than 15 metres[152]. For augured piles, the developer must demonstrate that no load or damage will be imposed on the tunnel structure. As such, the structural engineer must provide calculations and method statements to the company's engineers to demonstrate that their work can be undertaken without affecting the railway. All being well this allows them to construct their foundations close to the tunnels; but the larger the building the greater the separation distance. If piling is required on a site limited in size, alternative foundations may be required. This ensures that the tunnels beneath are not affected, for example by using a raft foundation to spread the load of the structure over a larger area potentially resulting in alternative foundation design and construction costs or even a re-design of the building itself, including its size.

5.3 Other areas of consultation

In addition to consultation on the designs of the building, the foundations and any potential effects on the railway, developers must follow other procedures to protect the railway. These include tunnel-movement monitoring, surveys of the tunnels, and representatives of the company being on site during certain types of works[153]. These few examples are an essential factor in understanding the relationship between the tube and land use in the metropolis as they demonstrate the complexities involved, all of which have implications for the financial viability of redeveloping properties above or adjacent to underground railway structures. These are clearly important factors for the historian researching the relationship between the urban environment and the tube in the metropolis.

5.4 Case study – improvements to property

To gain a greater understanding of these points, the following study examines a current

[151] Ibid, 109.
[152] London Underground Category 1 Standard, S1023, Infrastructure Protection, May 2012; London Underground Guidance Document, G0023, Infrastructure Protection Special Conditions for Outside Parties Working On or Near the Railway, July 2011, Sct.3.13.
[153] Ibid.

project involving London Underground and a developer[154]. Due to the commercial sensitivity of the consultation process, some details about parties involved or the location of the development have to remain confidential. However, the remainder are actual details. In addition, as this is an ongoing project, only the initial stages can be reviewed, used here to highlight some of the aspects relating to the tube and land use.

5.4.1 The Tube in relation to the property

The site in question is located between Green Park and Bond Street stations on the Jubilee line. The railway between Bond Street and Green Park was authorised by the London Transport act 1969[155] as part of the proposed Fleet line but was opened in 1979 as the Jubilee line. Fig.5.4 shows the alignment of the railway (dashed grey) in this area which passes under relatively medium-scale terrace housing dating from the mid-nineteenth century, most of which will have shallow strip foundations. The depth of the tunnel is approximately eleven metres below Ordnance Datum and thirty-three metres below ground level.

The property under review is rectangular and spans an area fifteen metres by forty metres between two parallel streets. One tunnel is located directly underneath running its full length. The site is formed of a five-storey terraced house with basement on the northern side and a three-storey plus basement mews house at the rear, the two separated by a courtyard.

5.4.2 Consultation with London Underground

In March 2012, the consultant civil and structural engineers for the project, representing the property owner, contacted the Infrastructure Protection department of LUL[156]. Their proposal was for the demolition of the existing mews house; construction of a six metre deep basement under the courtyard and a twelve metre deep basement on the footprint of the original mews house which would be replaced by one of a similar size and build. The five-storey building would be unaffected by the demolition and excavation works but would undergo internal refitting. To support the buildings either side of the excavation a secant piled wall would be constructed to take lateral loads whilst a slab would be used on the lower basement floor to balance the ground heave from the removal of the ground

[154] London Underground Infrastructure Protection Project File: F044, 1813577.
[155] 1969, London Transport Act 1969, Ch.1.
[156] Email dated, 13 March 2012, from civil & structural engineer to LUL engineer. London Underground Infrastructure Protection Case File: F044, 1813577.

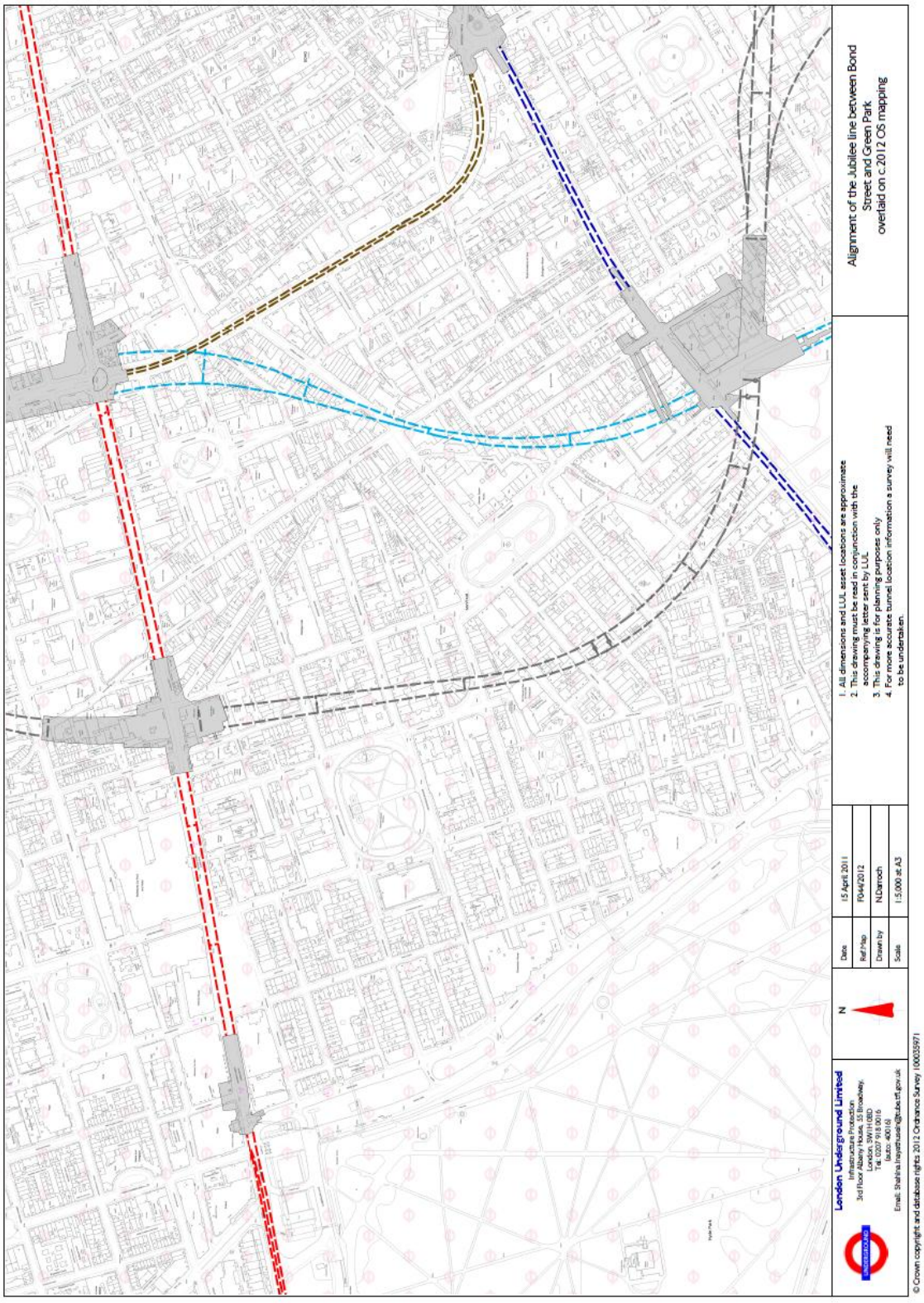

Fig.5.4

1:5000@A3 plan showing the alignment of the Jubilee line (dashed grey) between Bond Street and Green Park and the Victoria line (dashed blue) between Oxford Circus and Green Park overlaid on c.2012 OS mapping.

Source: London Underground, Ref.Map.N115/2012.

for construction of the basement. These would form the basement walls and floor respectively[157]. The overall excavation was to be to a depth of 11-12 metres below ground level bringing the vertical depth between the base of the lower basement slab and top of the tunnel to approximately twenty-one metres. The response of the LUL engineer was a cautious one, the initial considerations being the nature and magnitude of the predicted impact of the works on the tunnels below, especially any demolition, piling, excavation, unloading, reloading and long-term settlement. These have to be clarified by the developer as the scheme progresses, but initial requirements were for an assessment of the ground movement impact[158]. Once the engineer had received this, he was able to determine the additional information and level of involvement required.

As part of the ground assessment, the developer intended undertaking twenty-metre deep boreholes on the property using a cable percussive method[159], which as we saw above has a potential effect on the tunnels. As such, the engineer recommended that the boreholes were located as far from the tunnel as possible, and that once the distance had been confirmed work could begin on that phase[160]. While this work was underway communication between the developer and the LUL engineer continued with an application for a topographic survey of the tunnel under the property to determine the relationship between the two.

5.4.3 The impact of the property on the tube and vice versa

With regard to the effect of the new development on the tunnel, the 'Report on Effects of Ground Movement on London Underground structures'[161] suggests that the ground movement around the tunnel would be about 4mm in the short term and 6mm in the long term and as such the longitudinal distortion of the tunnel would be negligible[162].

Though this project is still ongoing the LUL engineer was able to estimate that the overall cost of the consultation process was approximately £21,000, for engineering reviews, the presence of an inspector on site during the works, arranging tunnel access and

[157] Civil & structural engineer sketch 2 of 2, dated February 2012. London Underground Infrastructure Protection Project File: F044, 1813577.
[158] Email, dated 22 March 2012, from LUL engineer to civil & structural engineer. London Underground Infrastructure Protection Project File: F044, 1813577.
[159] Email, dated 11 April 2012, from civil & structural engineer to LUL Engineer. London Underground Infrastructure Protection Project File: F044, 1813577.
[160] Email, dated 19 April 2012, from civil & structural engineer to LUL Engineer. London Underground Infrastructure Protection Project File: F044, 1813577.
[161] 'Report on Effects of Ground Movement on LUL Structures', Revision 1, May 2012. London Underground Infrastructure Protection Case File: F044, 1813577. Accessed: 2 May 2012.
[162] Ibid.

monitoring[163]. If the tunnels were not present, the developers' engineers would only have needed to take in to account their requirements for the reconstruction and adjoining properties. The presence of the tube, however, necessitates a design that will not affect the tunnels in either the short or long term. This example highlights how the presence of the tube under a property can add additional costs to re-development of a property, to ensure the safety of the railway. With this figure in mind, the property owner must determine what the overall costs of the re-development are, especially when taking in to account the architect's and consulting engineers' fees as well as the cost of the works.

Though this sum may seem modest, for the average homeowner wishing to undertake improvements to their home this sum is likely to cause some second thought as to whether they could undertake the works, despite the financial gain if they were to sell the house at a later time. However, as this sum is proportional to the scale of the works and the involvement of the company's engineers, a developer will no doubt take on board the cost as a typical overhead. Though it would be beneficial to be able to indicate how often the presence of the tube has required the re-design of a new building or stopped the development of land, no records are kept outlining this. This is because records are only kept of those projects that are undertaken. However, Kellet's observation that 'there is no physical obstacle which could not be overcome by engineering skill; the difficulty is simply one of money'[164], is highly pertinent, after all, most large development projects that may have an impact on the tube will have the financial backing to undertake the works. As such the £21,000 quoted above would be, for major developers, a reasonable cost to undertake their development.

This case study demonstrates that even when the tube tunnels are located some depth below the ground they can have an impact on property, not only from a legal perspective but also from an engineering one. However, as we shall see in Chapters 6 and 7, just because the tunnels are located beneath property it does not necessarily mean that they have an adverse effect.

5.5 Conclusion: understanding the engineering aspect

This chapter has demonstrated that there is a more complex relationship between the tube and land use than most historians believe. Along with the analysis of the previous

[163] Letter, dated 14 June 2012, from LUL engineer to civil & structural engineer. London Underground Infrastructure Protection Project File: F044, 1813577.
[164] J.R, Kellett, *The Impact of Railways on Victorian Cities*, 395.

chapters, the brief overview of civil engineering technologies and especially the case study have shown that the relationship between surface development and the underground railways of London has changed over the years. Where once the tube railways largely accommodated the rights of property owners, from the 1950s property developers have had to accommodate the railway in the design of buildings.

The passage of the tube and locating of assets such as escalators and stations, under property raises certain issues with regard to the safety of the railway however, as we saw above. What if the developer had not contacted the LUL and undertaken boreholes or piling that would have come very close to the tunnels? Though the Underground's engineers can recommend where piles or related foundations are located, they do not have any statutory right to stop the developer locating their infrastructure on their own land[165]. Though any damage incurred to the railway and its assets would ensure a financial cost and penalty for any damage to the railway and any service suspension, these do not stop works from being undertaken that can affect its safety. Indeed, it is preferable to deter this from happening rather than responding to an incident. The best way to protect the railway therefore, is for the company to own additional sub-soil around its structures. In instances where foundations or structures need to be located within the sub-soil adjacent to LUL structures, the property developer would have to purchase an easement from the railway company. This will be discussed in the following chapters.

[165] London Underground Category 1 Standard, S1023, Infrastructure Protection, May 2012.

Chapter 6: A change in philosophy

Whereas chapter 5 considered the changes to the alignment of the tubes from the 1920s, this chapter continues the discussion by considering the changes in legislation that enabled the Victoria line to be constructed across the London street pattern for the whole of its length. It also discusses how the provision of facilities within existing stations encroached on property and how requirements for ventilation saw the loss of land to residential and commercial development. The provision of an annulus around the tunnels for the protection of the railway will also be reviewed.

6.0 Changes to Legislation

Though London's passenger transport was combined under public ownership in 1933, other aspects of Britain's transport network were not amalgamated and brought in to public ownership until 1948, under the Transport Act 1947[166]. This brought under one umbrella – the British Transport Commission (BTC) - all assets relating to main line and underground railways and certain other transport operations; the control of London's public transport coming under the London Transport Executive (LTE). On 1st January 1963, the Transport Act 1962 came in to force splitting the former BTC in to five boards, two of which were the BRB and the London Transport Board (LTB)[167], the importance of this act the topic of discussion in chapter 7.

One of the projects that spanned the LTE and the LTB was that for the construction of a new tube railway across London. Since the 1920s, consideration had been given to the construction of a new tube to cater for the rising demand on the existing network and ease pressure on other lines[168]. The result was the 13¾ mile long Victoria line, authorised under the British Transport Commission Act 1955 (the 1955 Act)[169], running from Walthamstow to Victoria. This line, tunnelled predominantly under densely developed land, is perhaps most well known for being the first fully automated railway in the world. But it is also important as the first tube railway to be constructed under legislation that varied the 1845 act by permitting the London Transport Executive (LTE), as part of the British Transport Commission (BTC), to take that subsoil it required for the

[166] 10 & 11 Geo., Transport Act 1947, Ch.49.
[167] 10 & 11 Eliz.2. Transport Act 1962.
[168] Frank Stephen Powell Turner, "Preliminary Planning for a New Tube Railway Across London", Institution of Civil Engineers Proceedings 12, No.1, (January 1959): 19; H.G Follenfant, "The Victoria Line", Institution of Civil Engineers Proceedings, Supplementary Volume, paper 7270, (1969): 337.
[169] 4 Eliz. 2, British Transport Commission Act 1955, Ch.XXX.

tunnels[170] with only payment of compensation. Whereas the earlier tube authorising acts had only varied section 92 of the 1845 act, as we saw in chapters 3 and 4, by allowing the companies to purchase easements for only that sub-soil or land that they required and not the whole of a property under which they tunnelled[171].

The reasoning behind the change in legislation for the compulsory *taking* of land for construction of the tube was in recognition that public benefit had to take precedence over private property. The effect on the city if the new railway was not built potentially leading to the requirement for new higher buildings and new roads to cater for people not being able to live further afield[172]. In addition the new tube was to serve areas of the city separated by the central zone, Walthamstow in the northeast and Victoria and Brixton from 1971, in the south. To enable the line to reach these locations and to relieve existing lines and travel patterns it had to pass under private property along its entire route. As the new railway was to be paid through government grants because the LTE could not afford to pay for the new line, and as it was anticipated never to make a profit, it is feasible that this was the reason why easements were granted permission to be taken rather than purchased[173]. What is of interest here is that *neither* Barker and Robbins nor Croome and Jackson make note of this in their descriptions of the railways history, thus leaving the reasoning behind the change to legislation open to speculation, especially when no other information on why there was this change has been found.

The strength of this consensus is suggested by the fact that out of 3,300 properties referenced as being passed under by the new tube, only 26 petitioned against the proposals. Furthermore terms were agreed with all of the petitioners before the bill went to parliament[174]. Assurances and heads of terms agreements were made guaranteeing that the railway would have little to no effect on their property and is instances where it did they would be re-housed; in other cases, a larger sum of compensation for use of their subsoil was made[175].

6.1 The Victoria line and property

At first glance, it may seem likely that the construction of the Victoria line under so much

[170] Ibid, Part IV, Sct.23, (3).
[171] 8 Vict., Land Clauses Consolidation Act 1845, Ch.18, Sct.XCII.
[172] Barker and Robbins, *A History of London Transport: the Twentieth Century,* 207, 344-350.
[173] Ibid*,* 206.
[174] Powell Turner, "Preliminary planning for a new tube railway across London", 22.
[175] Undertakings and Assurances given by or to London Transport, combined file with multiple dates and locations. TfL Muniments Archive: 1093747/1004604.

property had a dramatic impact on the use of surface and sub-surface land, especially when we consider the discussion in chapter 5. But in fact the tube also has a minimal impact on the properties it runs beneath, suggesting why there was so little objection to the scheme.

The technical advantage of tunnelling underground, as we saw in chapter 4, is that no complicated expensive structures needed for a surface urban railway are required. The sub-soil does the work of a bridge or viaduct at ground level by supporting the structure, in the instance of the running tunnels at least. This enabled the Victoria line to follow as direct an alignment as possible under property, and at such a depth as to minimise any disruption to it. For instance, the tunnels between Green Park and Oxford Circus are approximately twenty to twenty four metres in depth, for the north and southbound tunnels respectively (see fig.5.4). Most of the properties in this area, north of Green Park are terraced housing with foundations that only extend a few feet in to the ground except where properties have basements. As such, the presence of the tube does not affect and is not affected by the building. Where properties had deep foundations, it was a simple matter for the tunnels to diverge and pass around them at little additional cost. Despite this, there was still of course, very much a surface interface in the shape of modifications to existing stations to include the new tube, and the provision of ventilation.

6.2 Making provision for new facilities in old stations

In chapters, 3 and 4 mention was made of the provision of new facilities for stations when surface structures, constructed with the first tubes, became unable to cater for the traffic flowing through them. In many cases, this involved some reconstruction of the stations or the provision of under-highway facilities. This might include incorporating entrances within existing private property or the public highway as well as the excavation of ground in front of buildings. As the Victoria line shared facilities at older stations in the central zone, much reconstruction had to be undertaken[176]. This could either include provision of new passages, escalators or ventilation facilities. To fully discuss what was undertaken at each station would constitute a separate dissertation, so this section gives an overview and pinpoints some of the effects of the station enlargements on property.

As the Victoria line was intended from the outset to establish new traffic flows and relieve

[176] Follenfant, *Reconstructing London's Underground*, 52.

pressure on other lines, inter-connection with these was an essential factor in station design. The most beneficial means of interchange between lines followed the principle established by the CCEHR and CSLR model at Kennington namely cross-platform interchange, where passengers alighted one train and walked straight on to the platform for the adjoining line. A benefit of such a station layout was the reduction in ground use by the railway due to the minimal need for connecting passages from one line to another, in addition to the new station tunnels. However, other considerations had to be taken in to account when designing the stations. This included the requirement for additional facilities to cater for the increased passenger traffic, including the installation of escalators. Though this did use more sub-soil it was still less than if the station had not had cross-platform interchange. We have already seen that the presence of station structures under property can have an adverse effect on new development. Therefore, by reducing the requirement for additional sub-soil for connecting passages within the station, the railway minimised any adverse effect it would have on land-use in the central zone where buildings were being designed to be higher, deeper, and requiring piled foundations for support. However, it was not only future development that was affected by the new station facilities as the works also had an interface with existing buildings.

Oxford Circus station, opened in 1900 as one of the original CLR stations, required not only the reconstruction of the original station but also its expansion under the public highway. Prior to the construction of the Victoria line Oxford Circus station was still a single storey building, typical of the 1892-1907 design with facility for development above. Despite the CLR being joined by the BSWR in 1906 and the increase in traffic the station had not been re-built and it still employed lifts for access to and from the trains. When the Victoria line was being constructed, it was not only necessary to redesign and expand the station for the new traffic but because it was overdue[177]. The addition of a third line needed careful design to make provision for greater traffic flows in to and out of the station as well as between lines, especially as the Bakerloo and Victoria had cross platform interchange but were at right angles to the older Central line. This was facilitated by the addition of new passages at the lower levels, and by the provision of a new ticket hall under the road. However, the original building was retained as part of the means to minimise surface use for entrances and exits in the public footpath. This enabled a greater flow through the station. It is worth noting the congestion that takes place at surface level at this location today with the four entrances on each corner of the busy vehicular and pedestrian junction of Oxford Street and Regent Street. This congestion

[177] Ibid.

not only caused by the popularity of the west end but by the presence of the station entrances and those wishing to enter or leave, thus minimising the area of available footpath for those wishing to pass by, one of the key concerns of the Corporation of London when considering the construction of Bank station in 1892. Though this may at first seem remote from the topic of this dissertation, it is another contributing factor to understanding the relationship between the tube and land use. The tube has a direct interface with use of land that could be put to alternative use, namely the passage of people, the station entrances hindering the free flowing use of the public footpath just as the tube has an effect on property development. Another highly pertinent issue is the effect of the works to create the under highway ticket hall on adjoining properties.

One such building was the Peter Robinson building on the northeast corner of the Circus (fig.6.1). Follenfant describes how under this building were located a new passage and escalator shaft from a low level area of the station under Regent Street North, entering in to the second basement level of the building and leading to the Central line. For this to be undertaken, the BTC entered in to 'undertakings, assurances and agreements' with the building's owners in the preparation of the 1955 act[178]. They also entered in to an under lease in 1966 to carry out the works, the cost of the latter being in the region of £26,525 for a period of 5 years[179]. To facilitate this work the building also had to be underpinned at the cost of the London Transport Board, successor to the BTC and LTE. But it was not only the stations which saw necessary works undertaken to buildings along the new railway's alignment, as there was the essential need for provision of adequate ventilation facilities.

6.3 Ventilating the Victoria line

Whereas the early tubes had accommodated ventilation facilities within their station structures, by the 1930s purpose-built facilities began to be constructed[180]. This saw the locating of forced air ventilation facilities between stations, especially on the Bakerloo and Northern lines, as these were the warmest on the network. With the Victoria line this principle was continued, especially as the distances between stations were increased to about a mile apart. At stations, draught-relief shafts were provided to ease airflow through the station corridors and passages, worked by the passage of the trains, whilst

[178] Undertakings and assurances given by or to the British Transport Commission and agreements entered into in connection with the following (A) British Transport Commission Act 1955 (B) British Transport Commission Order Confirmation Act 1955 (C) private Acts 1955 (D) miscellaneous orders and schemes. TfL Muniments archive: 1006840.
[179] Underlease, dated 7 March 1955, between Montague Burton Limited and Peter Robinson Limited and the London Transport Board. TfL Muniments Archive: 1080462.
[180] Croome & Jackson, *Rails through the clay,* 254; Follenfant, *Reconstructing London's Underground*, 38-41.

mid-section vents saw the provision of forced air provided by reversible fans[181]. As the LTE were granted permission under the 1955 act to purchase those plots of public land required for the construction of the railway, it was only natural that these sites were utilised for ventilation purposes once construction of the railway was complete[182]. For example, one construction shaft on the Brixton extension, completed in 1971, was converted to draught-relief due to its proximity to a station. Looking at fig.6.2 it is apparent that it does not merge in to the environment of the park, arguably using land that could have been used for an alternative facility for the local residents, such as a place to sit and relax. But alternatives were limited. Open spaces in a city such as London, though numerous, are not located for the benefit of the railway; nor is it beneficial to divert a railway to pass under them just for the purposes of ventilation. Indeed airflow mechanics does not allow air to be transferred over a prolonged distance, the resistance from the tunnel walls and the power of the fan limiting the distances that the air can pass. It was therefore necessary for the engineers of the Victoria line to place air shafts as near the railway as possible; in several cases this required the locating of the shaft within a residential area, as was the case with one located between Victoria and Pimlico.

The 150-year leasehold of the affected property had been purchased in 1951 from Central Estates (Belgravia) Ltd. as a private residence for an annual rent of £120, by the couple who were to have the leasehold compulsorily purchased from them in 1968[183]. The site was considered the most beneficial for the dual purpose of sinking a construction shaft and its conversion to use as forced air supply shaft once the railway was built[184]. The leaseholders were therefore handed a 'notice to treat'[185] in August 1967 which stated that their property was to be purchased. The outcome was that the vendors were paid £2,050 by the LTB; as payment for vendors surveyors fees (£237.6.0) and Solicitors fee (£92.18.0), in addition £2,050 of the total was given for the deposit on the purchase of a new property[186]. Also included were rates such as water and ground rent. The completion of the purchase took place in 1968. For the purposes of ventilating the railway a new building, incorporating a fan, was erected. The new facade, unlike the vent mentioned above, designed in an effort to blend the building in with the surrounding residential properties.

[181] Follenfant, "The Victoria line", 346-348.
[182] 4 Eliz. 2, British Transport Commission Act 1955, Ch. XXX, Sct.44.
[183] Land Registry Transfer of Leasehold Property dated 22 May 1963. TfL Corporate Archive: LT 664/507.
[184] Letter, undated, from Maurice Holmes to John Smith M.P, House of Commons. TfL Corporate Archive: LT 664/507.
[185] Notice to Treat, dated August 1967. TfL Muniments Archive: 9582.
[186] London Transport Acknowledgement Receipt, dated 26 October 1967. TfL Corporate Archive: LT 664/507.

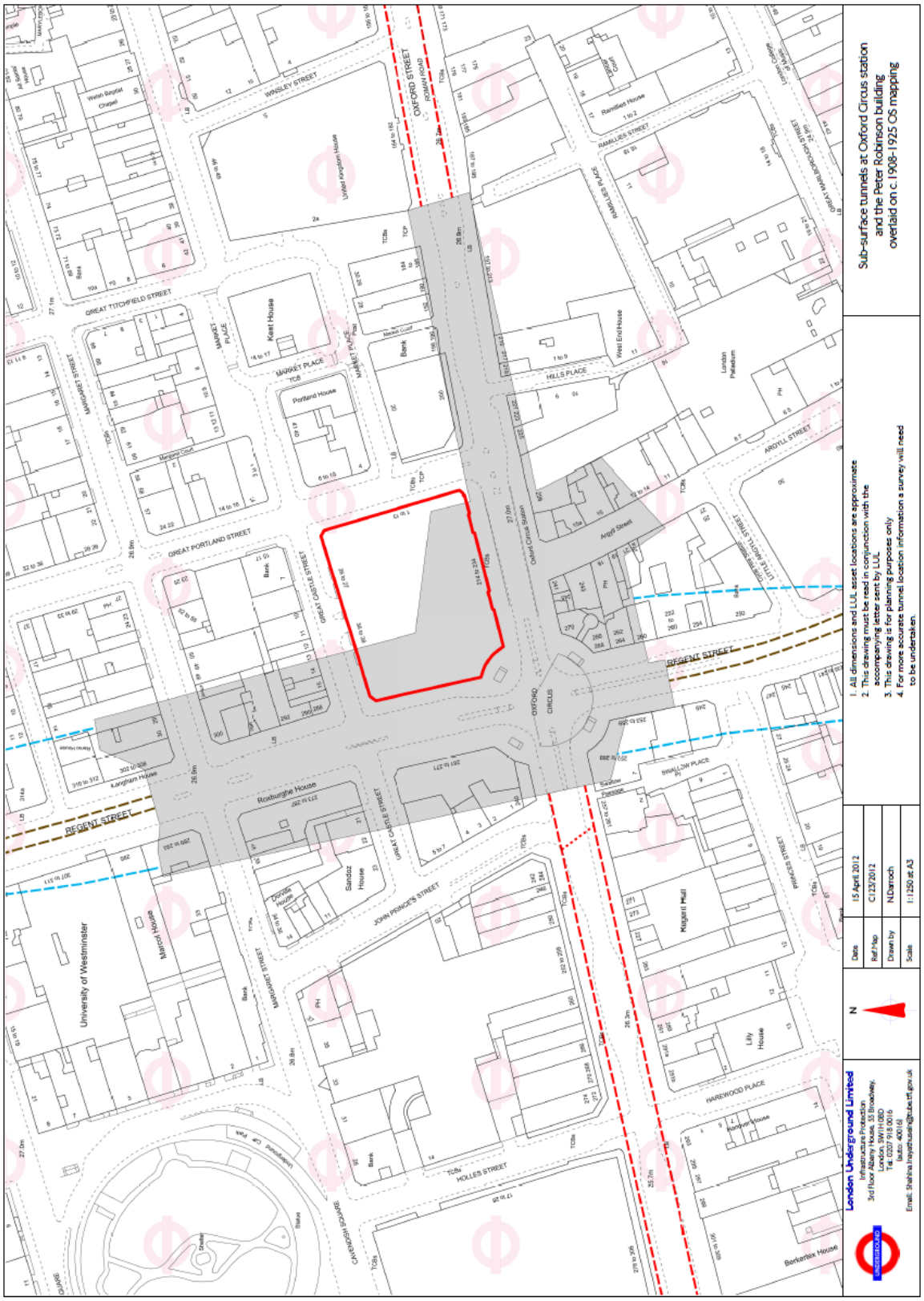

Fig.6.1

1:1250@A3 plan showing the sub-surface tunnels (shaded grey) at Oxford Circus station and the Peter Robinson building (outlined red) overlaid on c.2012 OS mapping.

Source: London Underground, Ref.Map.C123/2012.

Fig.6.2

Vent shaft in a park, 17 June 2012.

Source: Author’s Collection.

Fig.6.3 shows the current facade and fig.6.4 shows the design of the building and the ventilation facilities within. One of the many problems with a site such as this is the upgrading of the equipment within the fan house due to the constrictions imposed by the presence of adjoining residential property. This is becoming increasingly urgent given rising levels of heat within the tunnels across the network. To enable any upgrade the engineers must either work within the confines of the existing property or purchase further property for the additional facilities.

The shorter distances between stations on the Victoria line and its sharing facilities with the older lines in the central zone meant that no new ventilation facilities were required[187]. There was a need for these to be upgraded however, potentially requiring the purchase and demolition of existing property on a limited basis[188]. For example the disused lift shafts in some of the older stations, which were already put over to ventilation use, had higher power fans installed to cater for the additional requirement, the higher frequency of trains also aided air flow. But the provision of ventilation facilities required additional sub-soil to be utilised, once again increasing the interface with private property. The construction of the interchange at Green Park station, for example, required the tunnelling of new passages for ventilation, though they also served as access routes for passengers[189]. In some instances, especially on between station sections, the shafts were located some distance from the running tunnels requiring adits (connecting passages) to be driven from the base of the shaft to the tunnels. One such example is located north of Victoria station. At this location, the fan building is located on the main road between two residential properties, an adit leading from the bottom of the shaft on a gradient allows airflow to the cross passages between the two running tunnels. What is most pertinent about this site is the passage of the adit under the rear gardens of private properties the depth of the adit at its closest point to the vent shaft about 2 metres in depth. This is reflective of Cunningham's comments to the 1905 committee regarding the use of back yards for the provision of ventilation[190].

6.4 Protecting the railway

It has been demonstrated that the presence of the railway under property not only complicates and enhances the legal aspects of property ownership but can also have an

[187] Follenfant, *Reconstructing London's Underground,* 38-41.
[188] Ibid, 63.
[189] Ibid, 38-41.
[190] "Report of the Royal Commission appointed to inquire into and report upon the means of Locomotion and Transport in London, Vol. II, 1905". 813.

Fig.6.3

Facade of Ventilation Shaft Building, 17 June 2012.

Source: Author’s Collection.

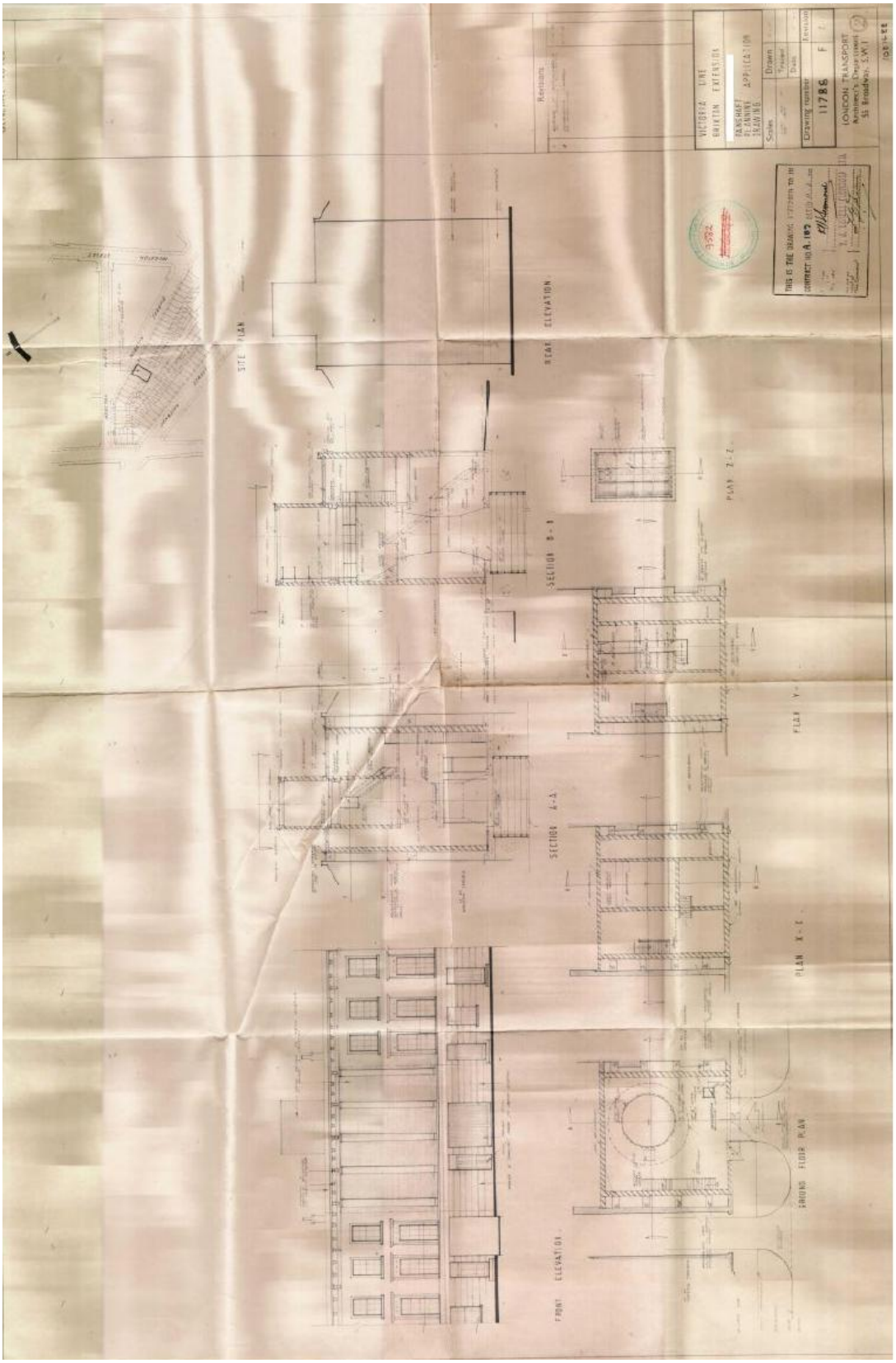

Fig.6.4

LPTB Planning Application Drawing showing Victoria Line, Brixton Extension, Fan Shaft, 17 June 1969. [Address removed for security].

TfL Muniments Archive, 9582/1081488.

engineering impact. To say that every section of the railway located under property has an engineering impact is misleading, as we have seen that many buildings in London are relatively shallow in their depth whilst the tunnels are deep. This scenario is likely in most instances to remain unchanged due to planning considerations and the ownership of private property. For example, it is doubtful that whole scale demolition of a large area of residential housing would be demolished to make way for high-rise buildings. However, there are instances such as in areas that need economic re-structuring, where this is a possibility, especially given the city's expanding population and the requirement for new homes and commercial and corporate office space. But with the construction of new railways it is easier to plan for this than it is to develop protection after the line has been constructed. For example, when the Brixton extension of the Victoria line was granted Royal Assent in 1966[191], the new extension incorporated a protective sleeve or annulus around the tunnels. The requirement for the additional sub-soil was included in the parliamentary bill, and when the sub-soil for the tunnels was bought, suitable compensation was paid for the annulus on top of that for the tunnels. But precisely what is the annulus? As we have seen, historically sub-soil was always purchased (or an easement granted) for the presence of the tube; this included enough for the tunnel through which the trains were to run, varying from 11ft 6in to 12ft 6in depending on the date of construction. The older lines had the narrower bore, whilst the Victoria line had the larger. Added to this would be an additional circumference for the presence of the tunnel rings that form the tunnel. Therefore, the sub-soil required for the tunnel could be in the region of 13ft 6in. This diameter might be even larger at certain locations, depending on additional factors such as the requirement for a larger bore for curves, step-plate junctions or station tunnels. But to ensure that the tunnel was protected from development an extra ten feet (c.3m) of sub-soil was included all around the tunnel for the Brixton extension[192]. When the private property under which the tunnel passed was registered with the Land Registry, or when there were changes made to the registration, the tunnel and annulus were and can be highlighted by London Underground as being excluded from the demise of the private property. A note would then be included in the land registry documentation stating this exclusion. This provides London Underground Limited (LUL) a legal base to restrict what can be placed within the sub-soil around the tunnel by an external party. For example, one property on the junction of South Lambeth Road and Vauxhall Grove has such a protective zone located beneath it (fig.6.5). The tunnel alignment runs through the northeastern corner of the property at a depth of

[191] 1966, London Transport Act 1966, Ch.XXXIII.
[192] Ibid, Sct.11 (1).

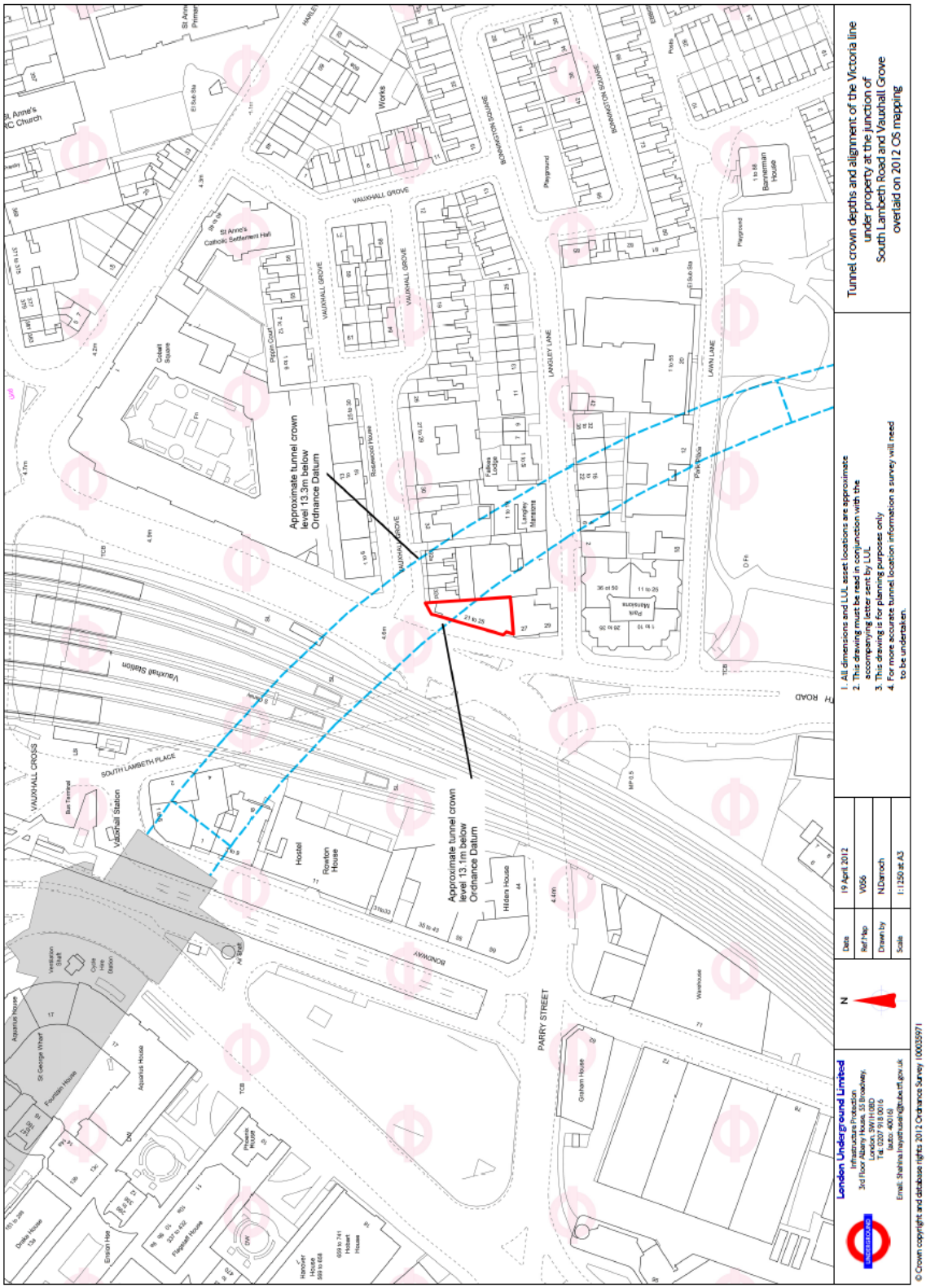

Fig.6.5

1:1250 @ A3 plan showing the tunnel crown depths and alignment of the Victoria line (dashed blue) under a property at the junction of South Lambeth Road and Vauxhall Grove (outlined Red) overlaid on 2012 OS mapping.

Source: London Underground, Ref.Map V056/2012.

approximately 17.8m below ground level. If the tunnel has a 3.7m diameter and the protective sleeve or annulus is an additional 3 metres to the surrounding that, then the LUL ownership of sub-soil would be in the region of 9.7m in diameter, quite a considerable area (fig.6.6). If the property owner wished to construct a five storey building on the site they may intend using piled foundations, based on the ground conditions, which are a mixture of sand and gravel overlaying London blue clay[193]. In addition, they would also need to bridge over the tunnel. If the piles in this corner could not be located within the remaining freehold of their property to support the new building, it is likely that alternative foundation arrangements would be required.

Alternatively, the developer could enter into an agreement with LUL for an easement to pass through the annulus. Within the easement LUL can ensure that there are protective provisions enforcing consultation at all stages of the works, including agreeing to the design of the foundations, load distribution, monitoring and tunnel movement calculations. Alternatively, LUL's engineer may consider that the works might adversely affect the tunnels, the easement could be refused and alternative designs insisted upon. The 1966 act thus further complicated the interface of the tube with property. Whereas the railway at one time had little legal right to property, it now enforced its presence.

6.5 Conclusion: The effects of the new line on land use

So far, part 2 has demonstrated that the passing of tunnels under property has a twofold effect on the way that the metropolis may develop. On the one part, it can potentially affect development if a property owner wishes to undertake works to a deep level within their sub-soil. In practice, this is often not much of a constraint, as wider planning considerations will often prevent such development. For example, much of the Victoria line passes under terraced housing where the local authorities would doubtless refuse large-scale high-rise buildings out of keeping with the surrounding neighbourhood. However, with larger buildings constructed in the central zone, it is clear that the legal and engineering relationship between the tube and land use will continue to develop. The trend towards taller buildings increases the need for protection of the railway. The construction of both the JLE (opened in 1999) and the new Crossrail project, due for completion in 2018, both had the provision of an annulus from the start. It seems highly likely that new extensions or reconstructions of the tube will lead to more restrictions over the rights of neighbours.

[193] London Underground Geological Long Section, Vic.4 of 19, Drg.No.D77407. Dec 1999.

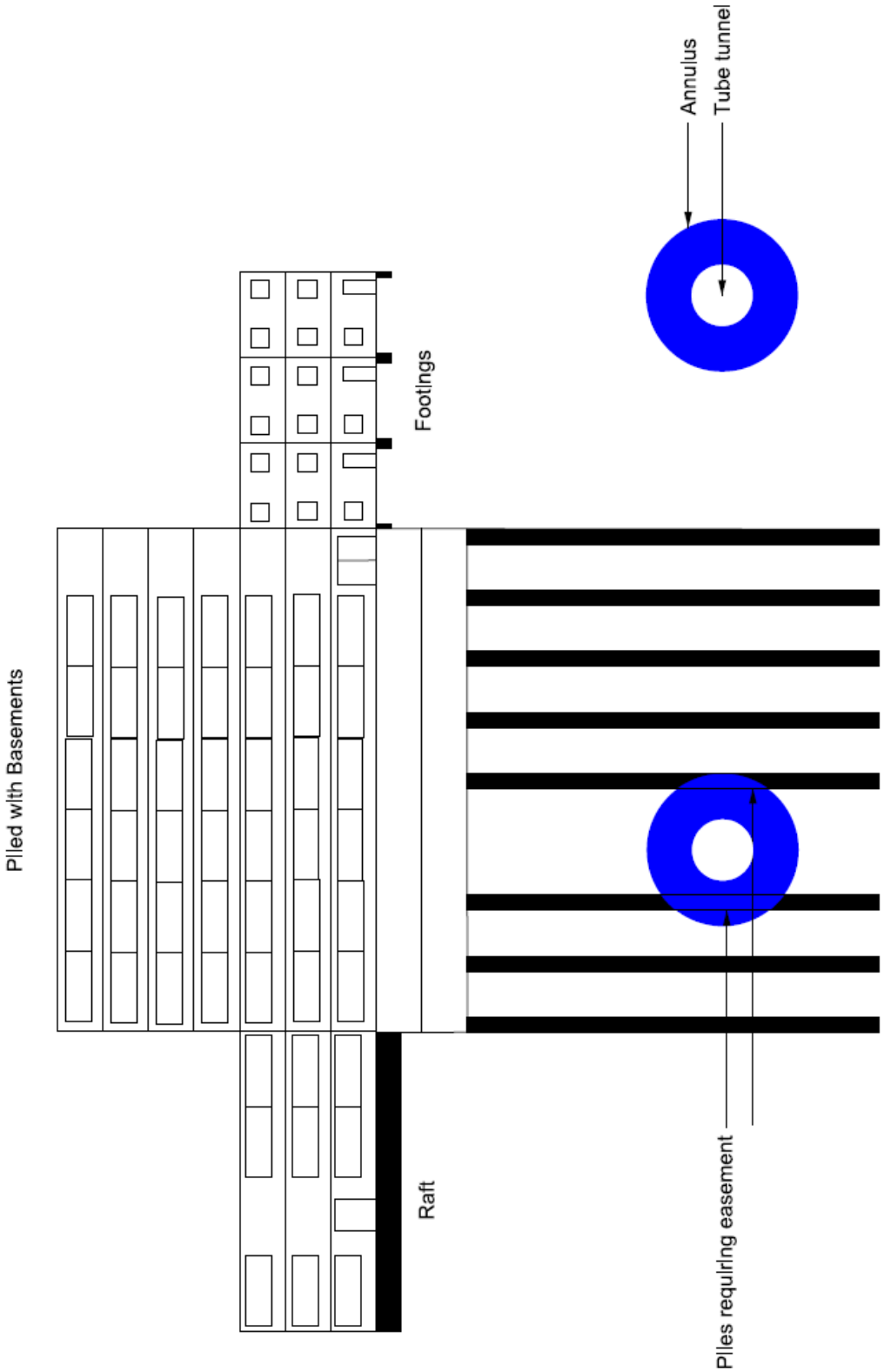

Fig.6.6

Schematic representation of tunnels and annulus under buildings with different foundations.

Chapter 7 Interfacing with national rail

We have seen in this dissertation that the tube tunnels are located under both public highways and private property and that an interface, either legal or physical, is present. However there is another important factor in the design of the tubes and land use that is worthy of some attention. This is their relationship with main line railway property and assets. This chapter will therefore consider the origins of the JLE, the historical property transfer relationship between the tube and British Rail (BR) and its successors, and as a case study, the interfaces with a section of the main line at Southwark.

7.0 The JLE and railway property

Before we consider the topics of this chapter, a point of clarification needs to be made. Whereas the trunk route of today's Jubilee line was opened throughout in 1979 between Stanmore and Charring Cross, the JLE, opened in 1999, ran from Green Park in the west to Stratford in the east. It is only this last section that is under consideration here.

A predominant feature of the JLE is that for approximately half of its length it is located under or on Network Rail assets and land. Between Waterloo and to just west of Bermondsey station the tunnels are located below railway viaducts, (fig.7.1) whilst between Canning Town and Stratford the railway is located on land predominantly leased from the BRB. This is not a new aspect of the tube however; there are many such instances from the earliest days. The GNPBR, for example, was constructed for a substantial proportion of its length under Great Northern Railway (GNR) land between Finsbury Park and Kings Cross (fig.7.2). Though legal, property and engineering interfaces between the tube and national rail are particularly complicated and warrant their own study, a brief overview of this relationship is beneficial to gain a greater understanding of the relationship between the tube and land use. To begin this analysis a review of the Transport Act of 1962, which plays a very important role in the relationship between the former BRB and LUL, must be undertaken first[194].

7.1 The Transport Act 1962

When the BTC was established in 1948, it was a simple matter for the railway board - British Railways (BRB) - and the LTE to share the maintenance obligations for shared

[194] 10 & 11 Eliz.2, Transport Act 1962, Ch.46.

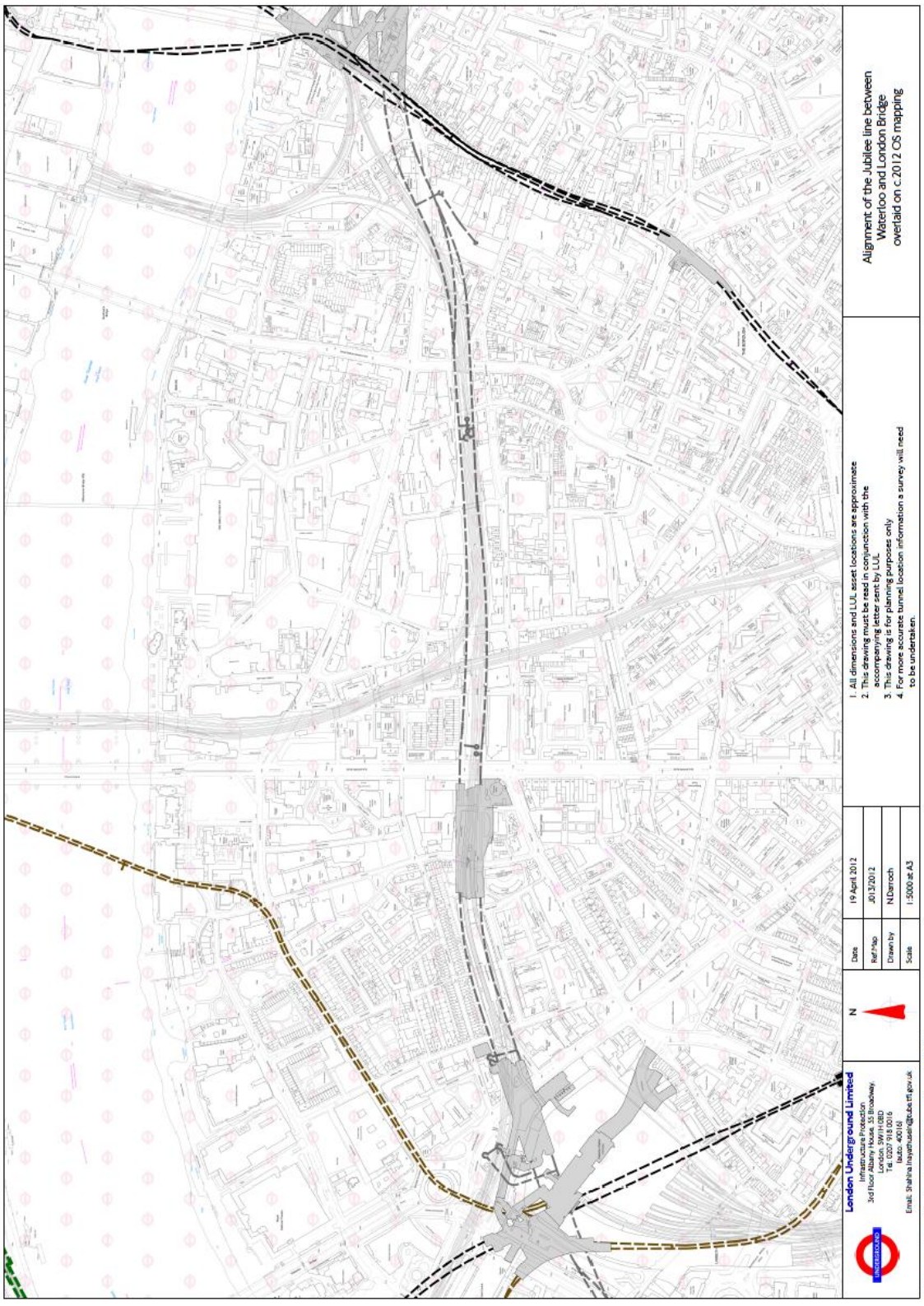

Fig.7.1

1:5000@A3 plan showing the alignment of the Jubilee line (dashed grey) between Waterloo and London Bridge overlaid on c.2012 OS mapping.

Source: London Underground, Ref.Map.J013/2012.

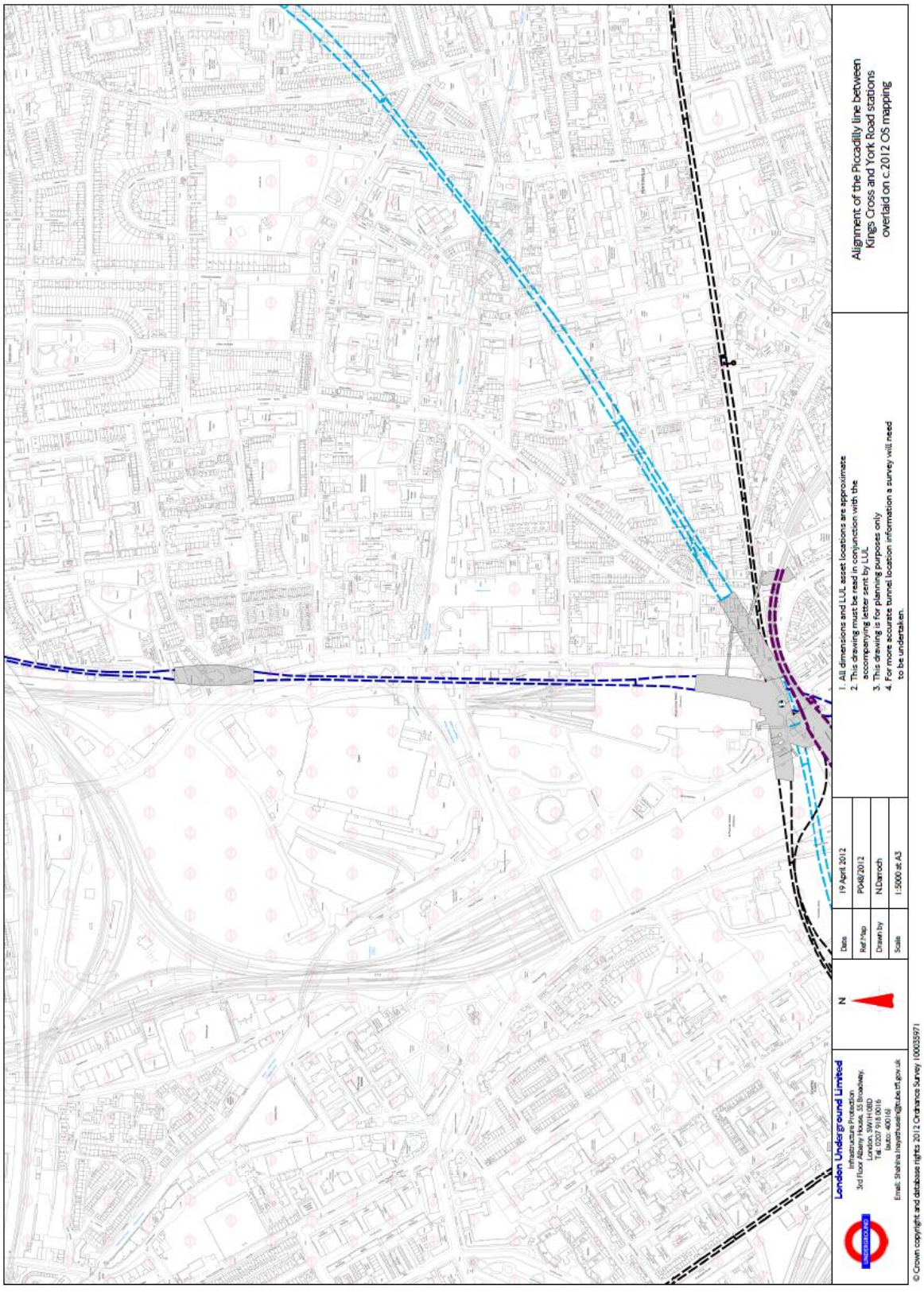

Fig.7.2

1:5000@A3 plan showing the alignment of the Piccadilly line (dashed blue) between Kings Cross and York Road stations overlaid on c.2012 OS mapping.

Source: London Underground, Ref.Map.J013/2012.

assets such as a bridge or a station, the money all coming out of one large pot. However with the disbandment of the BTC under the Transport Act 1962[195], from 1st January 1963 the two boards, the BRB and London Transport Board, successor to the LTE, had to agree which organisation had responsibility for what asset, where said asset was shared or on the land of the other board. For example, if a bridge supported a BR railway over the Underground, which company had responsibility for that bridge and the related structure. To alleviate confusion and to simplify matters the 1962 act allowed for this by enabling the re-vesting or transfer of assets and property between the boards, at no cost to one or the other[196]. The act also allowed for joint vesting of assets, where both subsidised works to an asset. However, the two boards considered this to be, in most cases, confusing. It was therefore decided that each should take a primary role in such an asset whilst allowing the other rights to use it. Because of this, and the inter-connected nature of the railways in London, vesting documents were created specifying areas of responsibility and agreements to rights of access (running rights and running rights with track and equipment)[197]. These take the form of basic drawings coloured to reflect the responsibility of each board/company along with a brief transfer document outlining each asset or area of responsibility.

7.2 The Railways Act 1993

The Railways Act of 1993 privatised Britain's main line railway network establishing Railtrack as the company responsible for them though the British Railways Board remained to manage subsidiary, i.e. non-operational lands[198]. As a private company however, Railtrack could not re-vest assets as BR had done except through lease or purchase[199]. This affected and affects any future proposals for transfer of lands between Network Rail (as a notionally private sector company and successor to Railtrack) and LUL (a private company owned by a public body). For example, consider the JLE/DLR corridor between Canning Town and Stratford station. Although Network Rail no longer has any operational railway interests between these locations, they do still hold a residual property interest stemming from the closure of its North London line in 2006. Along this alignment both LUL and DLR, have track and equipment on land leased from Network Rail. A similar agreement is also applicable to the presence of the JLE tunnels under the main line railway viaduct between Waterloo and west of Bermondsey. In that

195 10 & 11 Eliz.2. Transport Act 1962.
196 Ibid, Sct.31.
197 Ibid, Sct.35 (6).
198 1993, Railways Act 1993, Ch.43.
199 Ibid, Sct.92 (3).

instance a lease of the whole of the sub-soil and lands for the purpose of the tube railway was agreed between LUL and Railtrack, and finalised on 6 January 2009 when LUL paid Network Rail, the sum of £1 for the transfer[200].

7.3 Protection of the railways

As we have seen, structures such as buildings and the underground railways of London have a direct influence upon one another, whether adversely or not. With the tubes directly below a railway viaduct, this interface is no different; it just covers a longer distance. On the other hand, different structures require very particular engineering solutions to protect both parties' assets. This being one of the key factors that make research in to the tube and land use very difficult. For example, the viaduct under which the JLE was located was constructed for the London & Greenwich Railway around 1834-1836 and was added to over subsequent decades as the railway was widened. Not only because of its age but also because of its structural deficiencies it is prone to movement. As such, protective provisions had to be included in the JLE authorising acts, as well as within the transfer document as covenants and restrictions. These were in favour of not only NR but also LUL and specified that any works within the demise of each company must not affect either organisation, and that their respective rights of support must not be affected[201]. Therefore, if the tube were to fall out of use a decision would have to be made as to whether the tunnels would be back filled or left for the main line Company to maintain for the remainder of the life of the viaduct. Alternatively, if the viaduct were to fall out of use, it would need to be maintained to keep the pressure on the tunnels beneath. But the location of the tunnels under the railway was not the only issue regarding the interface between NR and LUL; as there was also a requirement for the locating of other LUL assets within and connecting to NR assets, considered below.

7.4 Case study - Southwark station

A particularly effective demonstration of the interface between the tube and land use is Southwark station, opened with the JLE in 1999 (fig.7.3). Its construction required the demolition of property adjacent to the NR viaduct and the incorporation of the station structure and its related assets, such as ventilation facilities and escalator shafts, within and below it (fig.7.4). The station is located at the junction of Blackfriars Road and The

[200] Transfer, dated 6 January 2009, between London Underground Limited and Network Rail. TfL Muniments Archive: 1141057.
[201] Ibid; 1992, London Underground Act 1992, Ch.III, Sct.33; 1993, London Underground (Jubilee) Act 1993, Ch.IX. Sct.23.

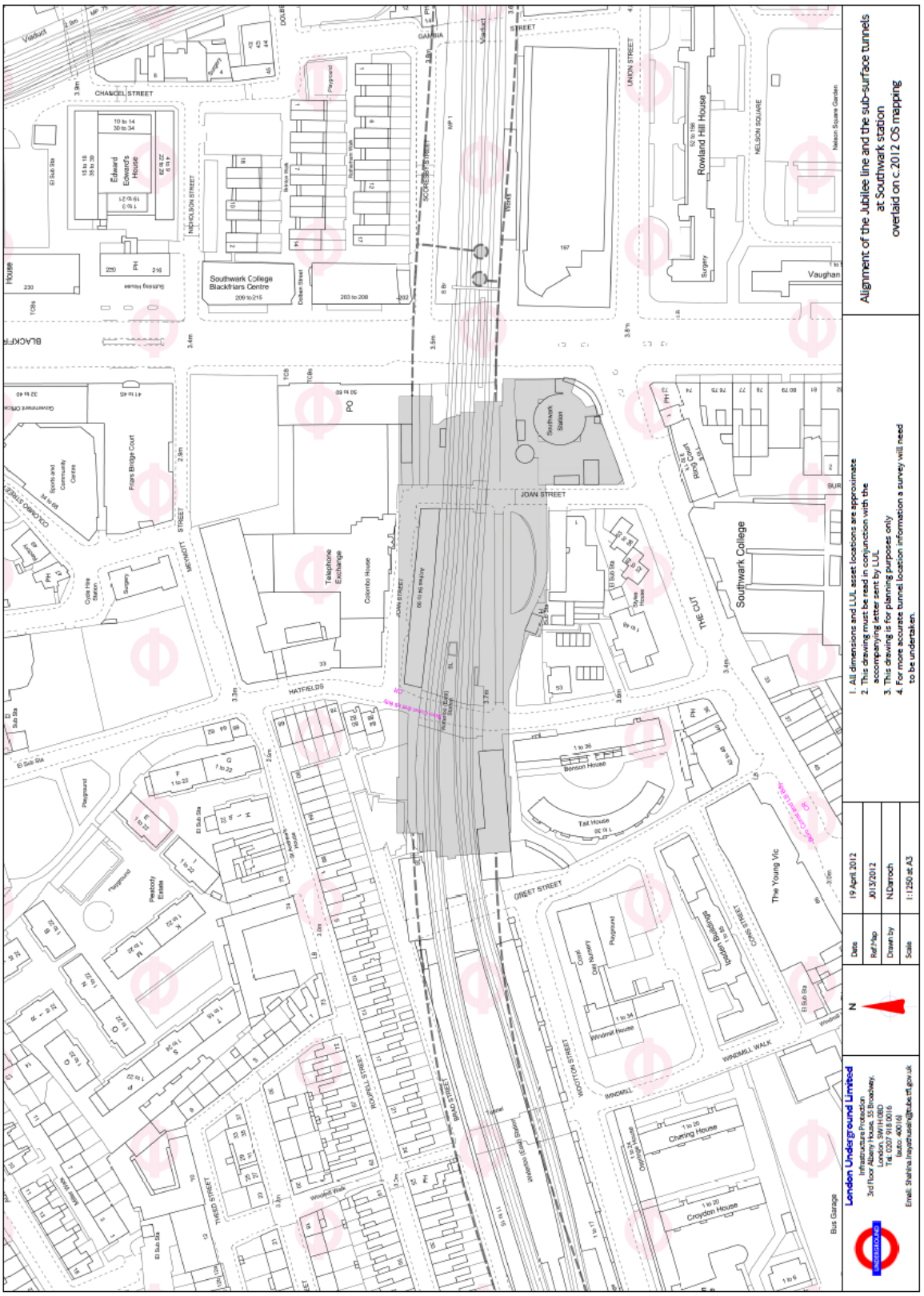

Fig.7.3

1:1250@A3 plan showing the alignment of the Jubilee line (dashed grey) and the sub-surface tunnels (shaded grey) at Southwark station overlaid on c.2012 OS mapping.

Source: London Underground, Ref.Map.J013/2012.

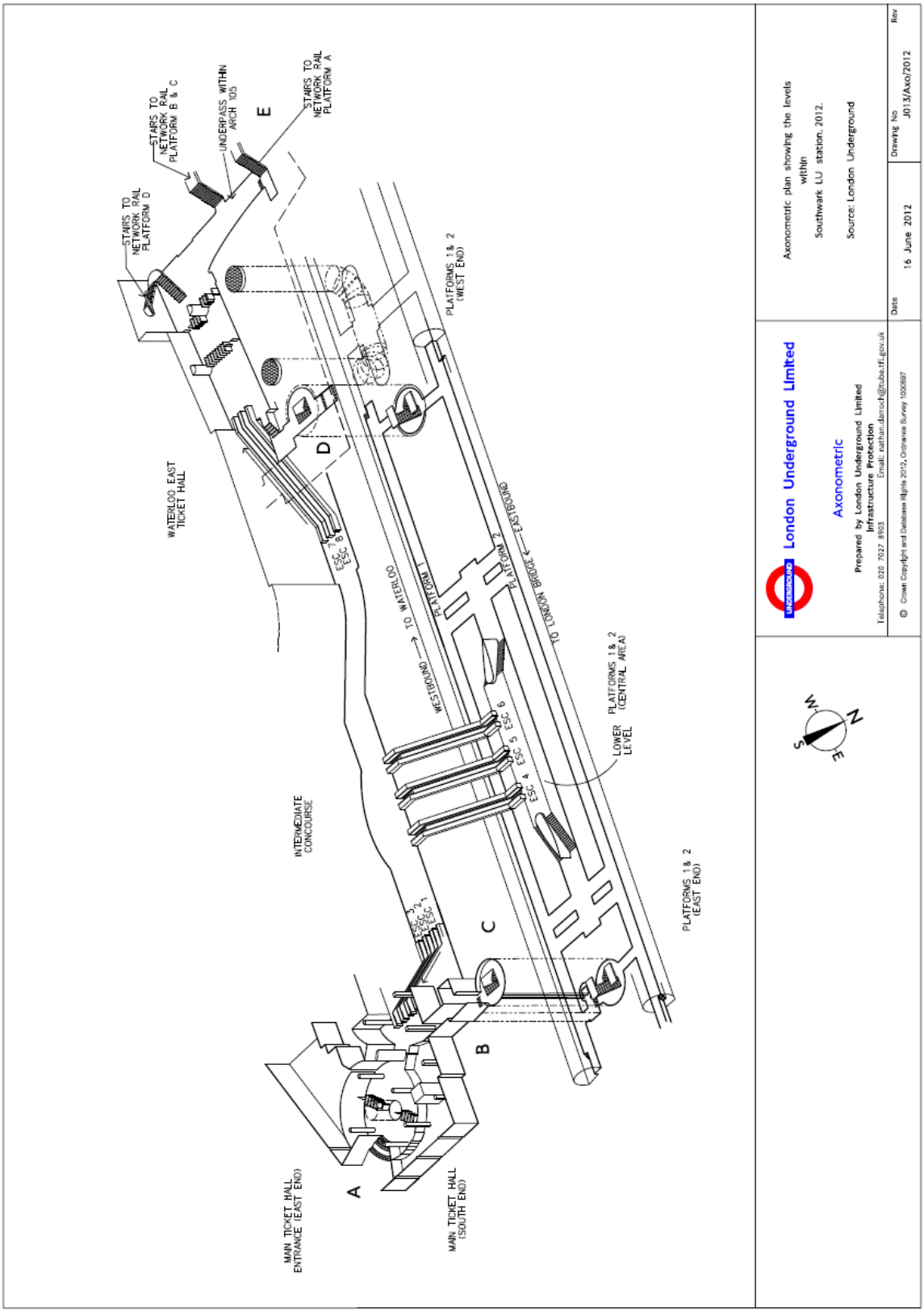

Fig.7.4

Axonometric plan showing the levels within Southwark station, 2012.

Source: London Underground, Ref.Map J013/Axo/2012.

Cut, to the east of Waterloo East (NR) station. When the new tube was being considered this site was the location of vacant offices and disused railway arches. This made it a prime site to locate a new station, despite its proximity to Waterloo LUL station. As Mitchell gives a good overview of the design and location of the station, we shall focus solely on the property interface[202]. Naturally, the vacant offices had to be demolished with all consideration for the presence of NR lines on the adjacent viaduct. The work had to be undertaken in such a way as to protect the operational railway, as were the subsequent excavations and construction work. This would have involved no over-sailing of the air space above the main line railway with plant and equipment, and the monitoring of ground movement. What is of particular interest though is how the station was integrated with its environment.

As can be seen from fig.7.1 the station tunnels are located directly below the viaduct and a surface level building is provided. What the plan does not show however, is that the ticket hall is located below ground level (fig.7.5). From the ticket hall, passengers must pass down to the platforms by way of escalators to an intermediate level that also leads to a corridor adjacent to the viaduct leading to Waterloo East station. Passengers wishing to reach the tube must descend another set of escalators. What is particularly interesting about these is their lay out. Rather than being in a group, as one would normally expect, they are spaced individually. This is because they pass between the arches of the viaduct that had to be supported on a raft over the top of the tube station tunnels and the lower concourse tunnel[203]. To minimise vibration and movement on the slab from the passage of trains or the movement of the viaduct above, a cushion was provided at the base of the viaduct piers, the combination of which also minimised the load on the tunnels beneath. This demonstrates multiple factors of the relationship between tube railways and land use and surface development. There is the need to design new assets, whether tube railway or private buildings, to minimise adverse risk to existing infrastructure, such as the viaduct in this case; new infrastructure could be located within and around existing structures; the tube continued to form part of existing structures such as at Leicester Square, but arguably to a greater degree. Also shown is the great advantage the tube has over other modes of urban transport, such as main line railways or roads, which require greater use of land, demonstrated in chapter 4. Despite the integration of the tube within existing structures at Southwark, there is still a surface interface for the station in the form of the main building.

[202] Mitchell, Robert, *The Jubilee Line Extension: From Concept to Completion.* London: ICE Publishing, 4 Mar 2003,160-163.
[203] Mitchell, *The Jubilee Line Extension: From Concept to Completion,*162.

Fig.7.5

Southwark London Underground station entrance, 17 June 2012.

Source: Author’s Collection.

The surface level building at Southwark may at first look unusual given what has been considered so far about incorporation of stations within other buildings or under the public highway, as it is not either of these, especially with its below ground level ticket and concourse level. It is however similar in principle to the original CLR stations that were designed to incorporate development above. Unlike the earlier tube station buildings where there was a single storey structure that allowed for development above, the building at Southwark only acts as a roof for the ticket hall below. The station, as with the early tube stations designed to be developed above. Unlike the earlier stations however, any new structure will be separate to the existing building though located above enabling the station and above-station development to be independent of one another, in much the same way that the railway viaduct and the station are independent of one another below ground. The reason for this has origins in the engineering and legal aspects of maintenance responsibilities, namely if the above-station structure was part of the station structure, LUL would require sole responsibility for the maintenance and repair of the entire structure to ensure the safety of their station, in much the same way as Network Rail interfaces are dealt with. However, if the two are independent of one another the leaseholder of the air space above the station has sole responsibility for their structure under the terms of the lease, whilst LUL can concentrate on their own structures and enforce the lease agreement as required. To keep the buildings separate the foundations for the new building have already been constructed and are clearly visible passing through the ticket hall, the columns designed to transfer the load away from the tunnels beneath.

Nevertheless, this aspect of the relationship between the tube and future land use is not entirely straightforward. In particular, the foundations are designed to accommodate only a certain load. As such, any future property developer must consider whether they can accommodate the proposed building on the site and gain enough revenue from the letting of office or residential properties to warrant the needs of designing around and accommodating LUL's requirements. It is entirely possible, particularly bearing in mind the need to buy the leasehold of the airspace and consultation fees, that the station air space will remain undeveloped even though it is located in an otherwise densely developed part of the city.

7.5 Conclusion: The tube and other transport modes

It is obvious that the tube and other transport modes within the city are inter-related,

whether because they are competing for traffic or creating inter-change facilities. This chapter has shown that transport infrastructure stands in a similar legal and technical relationship to the tube as private property. For example, the early tubes were located under the public highway as it had a minimal impact upon them: both legally and financially, not having to purchase easements; and physically, as buildings were not located above and thus would not be affected by the tunnels. The locating of tubes under railway assets, such as those demonstrated above, was undertaken for a similar reason. The benefits to London Underground by doing this were not only financial, as they only paid £1 for the lease of the land for the whole length of its railway under the viaduct, but practical as it minimised the impact of adjoining property development on the tube. Both railways anticipated to remain in use and in situ for many decades if not hundreds of years to come.

Chapter 8 Conclusion

Earlier historians have sometimes recognized the relevance of particular legal powers for the tube; for example, consider how Jackson and Croombe reference the Victoria line taking 'full advantage of legal powers to cut across the street pattern'. But they do not explain what these powers were or explore the implications of the presence of the tube under private property[204]. These are essential factors when considering the development of the tube railway system as a whole. This dissertation therefore builds upon and corrects some of these earlier findings by drawing on new, alternative sources made available by London Underground on a privileged basis.

This dissertation has presented evidence from a variety of fields, which relate to the inter-relationship between land use and the deep-tube railways of London between 1884 and 1999. Factors such as property law, authorising legislation, and the physical attributes of the tubes have been analysed in terms of their effect on the engineering design of the tube and its relationship to private property. An historical approach demonstrates the long-term effect on the city of these factors, which will continue for many decades if not centuries to come. They are still as relevant to the railway now as they were when the CLSS was first granted Royal assent.

This research is only an initial exploration of a very complicated subject that seems to have received little consideration from historians. The tube might be (mostly) out of sight but it should not be out of the scholarly mind. The tube network has had an important impact on Britain's economy by keeping London moving for well over a century; as this dissertation shows, the legal and engineering relationship with surrounding property is a key element of this history. As such, the subject of this dissertation deserves further research, to build on this initial understanding of how the tube and property have come to be inter-dependent. In this conclusion, we shall remind ourselves of the complexities of this historical relationship and briefly explore its wider relevance to today's engineer, property developers and those in the legal profession.

8.1 The changing relationship between the tube and land use

Part one considered the early tube railways of London and what affected their design and construction. The principal engineering and legal factor was the sub-soil employed

[204] Croome and Jackson, *Rails through the clay*, 359.

for existing utilities and the foundations of buildings. The tube was a triumph of engineering design in that large complicated structures, such as stations like Waterloo underground station with its several lines, could be constructed with the minimum usage of and loss of land in a densely developed metropolis where land availability, for residential and business use, was at a premium. The particular legal and financial circumstances under which the tubes were constructed were the key factor. Legislation allowed for the purchase of easements under private property. But the private funding of the tube railway schemes and the need to provide a financial return for shareholders limited the tubes from passing under private property. It was too expensive. This was despite the fact the 1892 committee had made recommendations designed to reduce costs. It had advised that the railways should only be required to purchase that sub-soil they needed rather than the whole of a property, as was required by the 1845 act. Part of the problem was the high level of subsidiary fees; the price for the sub-soil was often a fraction of the related fees applied by surveyors and solicitors. The company's shareholders and promoters baulked at such expenditure and hence avoided tunnelling under property where possible.

To gain a greater understanding of the promoters' attitude it was beneficial to clarify and explain some of the more pertinent property law issues relating to the tube. These included the extent of property, the relationship between the subsoil and the public highway and the passage across another's land whether at surface level or below. By considering the rights of property owners, in chapter 2 of this dissertation, clarification of the 1845 act was given, thus enabling an understanding of what the railway companies and property owners or leaseholders could expect from the compulsory purchase of property. The overview in chapter 2 also enhanced the relevance of the 1892 committee report on the tube, explaining why the railway's engineers, such as Greathead, urged the variation of section 92 of the 1845 act so that the tube companies were only required to purchase easements under property, through agreement or compulsorily, rather than the whole. It also goes some way to understanding why with the 1920s the tubes were designed to remain as much as possible under the public highway, where they did not have to purchase easements and thus minimised expenditure for construction of the railways except in the unlikely event of damage to adjoining properties. It also established the foundations for understanding the change in legislation between the 1884-1907 tubes and the Victoria Line (initially authorised in 1955 and completed in 1971) and the JLE (opened in 1999).

Property neighbouring the tube also had its effect. It limited the railways from expanding and providing new facilities of public benefit. It could be argued that the early tube designers were short sighted in their planning of facilities, especially with the provision of single-storey buildings serviced by lifts. But it must be borne in mind they were designing for the traffic at a time when the popularity of the tube could not be foreseen. Moreover, it must be remembered that the stations were designed to accommodate traffic for a city that was a lot smaller than post-1950, and that initially lifts were the only means – other than stairs - of getting to and from the platforms. The introduction of escalators required additional works to be undertaken at stations to accommodate them, with the requirement for shafts to be dug, potentially under adjoining property, and the re-construction of the station building. Therefore, it was only with the government funding of upgrades and extensions in the 1920s, 1930s and 1950s and the funding for the Fleet line in the 1960s that these accommodation works could be afforded. The post-1950s works had the advantage of being able to pay compensation only, for the taking of the sub-soil rather than having to buy it, however.

Prior to the 1920s, the tubes were speculated for private profit rather than a public need. As far as easements were concerned, the companies could *compulsorily purchase* them under private property if they needed, but they tended to avoid doing so. Between the wars, a new philosophy took hold. This was of public money for public benefit, seeing the construction of the tubes under private property in the belief that there was a minimal need for the sub-soil under property. The tubes were considered deep enough not to affect use of that property. As such, easements *were* compulsorily purchased where agreement could not be reached for an easement or purchase of the sub-soil. The construction of the Victoria and Jubilee lines was an expansion of this based on cost of property, potential future use and the benefit to the public of the works. This was during a time that new taller buildings with deeper foundations were being constructed, but were not the norm. As such sub-soil was *taken* for the purposes of the railway with compensation paid, but provision had also been made of safe-guarding the route which entitled the Underground to not only veto works but to not be liable for compensation once the zone came in to force. In both cases however, protective provisions were included in part or the whole for the lines, thus enforcing the Undergrounds right to be there, whereas previously they were there at the sufferance of the landowner.

The railway is not just about the tunnels however; we must not forget the surface and sub-surface structures that it cannot do without. With regard to this aspect, there is little

change except perhaps in how they integrate with one another. For example, when the first tube station buildings were constructed they were not designed to provide facility for development above whilst stations constructed after the original CSLR, incorporated facility for additional development above, though it seems this was little utilised at first. This continues to be the case at Southwark station on the JLE, which still has no development above, despite having been designed to do so, thirteen years after its opening. The reasons are probably similar to those for the earlier stations. In both instances, there was not enough profit for the developer.

Tube railway infrastructure affects surrounding property in other ways. For example, stations have become more closely integrated with other property, whether it is by tunnelling an escalator shaft beneath a building, or the inclusion of an entrance within private property. Indeed Southwark station encapsulates both aspects even though the properties in question are railway assets. Additionally there is also the factor of improving railway assets to cater for increasing demand, whether it is a new ticket hall under the road or the tunnelling of new station tunnels. In both instances, there is some effect on the properties nearby. Whether it is apparent or not is another matter.

With these points in mind then how did the interrelationship between land use and the deep tube develop from the early tubes (1884) to the Jubilee line extension (1999)? The simple answer is that, as public need developed and grew so did the integration of the tube within the urban realm. The tube moved from a position of invisibility, located under the public highway where it was not affected by or did not affect property, to the requirement of land owners and developers to be aware of the railways presence under or adjacent to their property when undertaking new development or sale of their land. The railway has therefore superseded the rights of property owners to ensure its safe operation and presence not only underground but also on the surface in the highly developed and re-developing metropolis. Whilst this inter-relationship is not apparent to the everyday user or person passing along the streets of London, it is essential that property owners and developers must be. On occasions where the tube is present, they must therefore be aware of Kellet's philosophy that 'there is no physical obstacle which could not be overcome by engineering skill; the difficulty is simply one of money'[205]. For many property owners today the obstacle is the presence of the tube: the difficulty is its effect on the financial viability of developing property near or above the railway.

[205] Kellett, *The Impact of railways on Victorian Cities*, 395.

As this dissertation is far from the last word on the subject of the inter-relationship between the tube and land use in London, other aspects of the inter-relationship between the tube and land use must also be considered to fill the gaps on the topic.

8.2 Areas of further research

The following are fields of research that are also highly applicable to the understanding of London's Underground railways and land use, and the further development of the subject of this dissertation. Further topics worthy of research include:

- The developing relationship between the whole of London's underground railways and land use in the central zone, building on aspects of this dissertation which has looked solely at the tube. Consideration could be given to the legislation behind the construction of the sub-surface lines and the ensuing changes granted to the deep tubes, comparing and contrasting what changes have taken place or even what requirements have remained the same. It could also analyse the way that the air space above the railways and related buildings or depots has been utilised. The ultimate aim being to fill the gap in research in the developmental history of the underground and land use in London, complimenting works by Jackson on sub-urban development, Kellett on the railways and Victorian London and Haywood's analysis of railways and urban planning.

- Analysis of the Land and Railway Clauses Consolidation Acts of 1845, and their effect and ongoing affect on the underground and land use in the central and Greater London areas since the first development of Underground railways in London. Of particular interest are the requirements of the railway companies to provide crossings of the railway and their ability to divert roads and watercourses for their own benefit, these latter points shaping much of the geographical and landscape development of London's suburbs. Indeed such a study could even be expanded to consider main line railways across the country.

- A very large but essential topic of research is the relationship between the underground and main line railways in London. Yet another complex study essential to gaining a fuller understanding of the legal technicalities of the Underground and land use. Areas of consideration could include the location of the underground under main line railways, the sharing of assets, land, and the

re-vesting of railways and assets under the New Works Programme of 1935-1940. This could then lead on to an analysis of the effects of the formation under the BTC had on the tube and land use relative to the main line railways and the subsequent allocation of assets after the Transport Act of 1962 had come in to force. Yet again, this could also lead in to the Transport Act of 1993, which saw an end to re-vesting and the complexities that have developed since then with the re-allocation of assets between LUL and the successors to British Rail.

8.3 This dissertation and the expansion of previous knowledge

This kind of historical research finds a very practical outlet. Consideration of the historical, technical and legal standing of infrastructure has to be undertaken for the protection and running of the railway. Research such as reviewing engineering drawings and legal documents, not only from the period of the railways construction but also through to the present day helps assure the integration of the railway within the urban realm and vice versa.

There is, however, a need for caution; the reader and the historian must not presume that just because evidence has been presented demonstrating a greater interface with property, than may at first be appreciated, that there is always an absolute (or physical) interface between property and the tube. After all, it is much easier to show something has an effect than it does not. After all this is why the effect of the tube on suburban development is discussed so much, whilst the relationship between the tube and land use is not. In addition, just because the tube passes under or near property it does not necessarily mean that one has an adverse effect upon the other. There is always a possibility, but this does not necessarily mean that it is realised. For example, a tube tunnel may pass under a property where there is only a requirement for the railway to have an easement, and there is no engineering interface. On the opposite side of the road, the same tube may pass under a property that has deep foundations, the presence of which requires the property owner to gain an easement for the foundations in the company's sub-soil around the tunnel. The property owner must also design the foundations, and perhaps the building, taking in to account the railway beneath. This makes understanding and explaining the relationship between private property, land use and the tube very difficult and complex. Sweeping comments, such as that of Croome and Jackson, that the tube should not or does not affect property, is therefore deceptive.

As has been mentioned above, much of the property under which London's tubes pass in

the developed metropolis are low-rise with shallow foundations, and generally in locations where tall or large-scale buildings will not be permitted. The principal concerns then become the related railway surface structures, such as ventilation shafts or depots, and any large scale voids under the ground such as at stations. What we must do therefore is determine where the railway is at any one location of interest, consider the land-use planning issues, such as local authority guidance on urban development, and what, if any, influence the presence of the railway had or will have on that development. This grants us not only a greater historical understanding of how the tube and the urban environment within the metropolis have developed together and will continue to do so for many decades to come, but also one of importance to developers, engineers and solicitors.

Abbreviations

BSWR	–	Baker Street & Waterloo Railway	(Bakerloo line)
BR	–	British Rail	
BTC	–	British Transport Commission	
CSLR	–	City & South London Railway	(Northern line)
CLR	–	Central London Railway	(Central line)
CLSS	–	City of London & Southwark Subway	
CCEHR	–	Charring Cross, Euston & Hampstead Railway	(Northern line)
DLR	–	Docklands Light Railway	
GNPBR	–	Great Northern, Piccadilly & Brompton Railway	(Piccadilly line)
JLE	–	Jubilee Line Extension	(Jubilee line)
LPTB	–	London Passenger Transport Board	(1933-1947)
LTB	--	London Transport Board	(1963-1969)
LTE	--	London Transport Executive	(1948-1962)
LUL	–	London Underground Limited	(1985-present)
MDR	–	Metropolitan District Railway	(District line)
MoD	--	Ministry of Defence	
MR	–	Metropolitan Railway	(Metropolitan line)
NR	--	Network Rail	
TfL	–	Transport for London	
WCR	–	Waterloo & City Railway	(Waterloo & City line)
WD	--	War Department	

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Drawings

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Axonometric plan showing the levels within Bank LUL & DLR stations, 2012. Source: London Underground, Ref.Map N133/Axo/2012.

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Plans
(Scale and date order)

1:500@A3 plan showing the alignment of the C&SLR (dashed black) and sub surface station tunnel (shaded grey) at King William Street overlaid on c.1862-1895 OS mapping. Source: London Underground, Ref.Map.W004/1862-1895.

1:1250@A3 plan showing the alignment of the C&SLR (dashed black) under Hibernia Wharf overlaid on c.1862-1895 OS mapping. Source: London Underground, Ref.Map.N134/1862-1895.

1:1250@A3 plan showing the site of Stockwell C&SLR depot and environs on c.1862-1895 OS mapping. Source: London Underground, Ref.Map.N147/1862-1895.

1:1250@A3 plan showing the alignment of the Metropolitan District Railway near Elizabeth Street on c.1862-1895 OS mapping. Source: London Underground, Drg.No.D106/1862-1895.

1:1250@A3 plan showing the alignment of the C&SLR and the CCEHR (both dashed black) and sub-surface tunnels (shaded grey) at Kennington station overlaid on c.1908-

1925 OS mapping. Source: London Underground, Ref.Map.1908-1925.

1:1250@A3 plan showing the alignment of the Northern line (dashed black) at South Wimbledon station (sub-surface levels shaded grey) overlaid on c.1908-1925 OS mapping. Source: London Underground, Ref.Map N175/1908-1925.

1:1250@A3 plan showing London Road Bakerloo line sidings on c.1908-1925 OS mapping. Source: London Underground, Ref.Map.BD138/1908-1925.

1:1250@A3 plan showing the alignment of the Piccadilly line (dashed blue) and sub-surface station tunnels (Shaded grey) at Brompton Road Disused LU station overlaid on c.1908-1925 OS mapping. Source: London Underground, Ref.Map.W013/1908-1925.

1:1250@A3 plan showing the alignment of the Central line (dashed red) and sub-surface station tunnels (Shaded grey) under Cheapside overlaid on c.1908-1925 OS mapping. Source: London Underground, Ref.Map.C112/1908-1925.

1:1250@A3 plan showing Stockwell C&SLR depot on c.1908-1925 OS mapping. Source: London Underground, Ref.Map.N147/1908-1925.

1:1250@A3 plan showing the alignment of the Northern line (dashed black) at South Wimbledon station (sub-surface levels shaded grey) overlaid on c.1931-1941 OS mapping. Source: London Underground, Ref.Map N175/1931-1941.

1:1250@A3 plan showing Waterloo London Underground station and sub-surface tunnels (Shaded grey) overlaid on c.2012 OS mapping. Source: London Underground, Ref.Map.N115/2012.

1:1250@A3 plan showing the alignment of the Central line (dashed red) and sub-surface station tunnels (Shaded grey) under Cheapside overlaid on c.2012 OS mapping. Source: London Underground, Ref.Map.C112/2012.

1:1250@A3 plan showing London Road Bakerloo line sidings on c.2012 OS mapping. Source: London Underground, Ref.Map.BD138/2012.

1:1250@A3 plan showing the site of London Road Bakerloo line sidings and environs on c.1895-1912 OS mapping. Source: London Underground, Ref.Map.BD138/1895-1912.

1:1250@A3 plan showing the alignment of the District line near Elizabeth Street on c.2012 OS mapping. Source: London Underground, Ref.Map.D106/2012.

1:1250@A3 plan showing the sub-surface tunnels (shaded grey) at Oxford Circus station and the Peter Robinson building (outlined red) overlaid on c.2012 OS mapping. Source: London Underground, Ref.Map.C123/2012.

1:1250 @ A3 plan showing the tunnel crown depths and alignment of the Victoria line, 2012. Source: London Underground, Ref.Map V056/2012;

1:1250@A3 plan showing the alignment of the Jubilee line (dashed grey) and the sub-surface tunnels (shaded grey) at Southwark station overlaid on c.2012 OS mapping. Source: London Underground, Ref.Map.J013/2012.

1:1250@A3 plan showing Leicester Square London Underground station and sub-surface tunnels (shaded grey) overlaid on c.2012 OS mapping. Source: London Underground, Ref.Map N107/2012.

1:1250@A4 plan showing Piccadilly Circus London Underground station and sub-surface tunnels (shaded grey) overlaid on c.2012 OS mapping. Source: London Underground, Ref.Map N107/2012.

1:1250@A3 plan showing the alignment of the Northern line (dashed black) and sub-surface station tunnels (shaded grey) at Angel station overlaid on c.2012 OS mapping. Source: London Underground, Ref.Map N125/2012.

1:1250@A3 plan showing the alignment of the Northern line (dashed black) at South Wimbledon station (sub-surface levels shaded grey) overlaid on c.2012 OS mapping. Source: London Underground, Ref.Map N175/2012.

1:1250@A3 plan showing the alignment of the Central line (dashed red) under properties on Globe Road, overlaid on c.2012 OS mapping. Source: London Underground, Ref.Map.C094/2012.

1:2500@A3 plan showing the alignment of the District (dashed green, shaded grey) and Piccadilly (dashed blue) lines under Earls Court overlaid on c.2012 OS mapping. Source: London Underground, Ref.Map.D172/2012.

1:2500@A3 plan showing Bank London Underground station and sub-surface tunnels (shaded grey) overlaid on c.2012 OS mapping. Source: London Underground, Ref.Map N133/2012.

1:5000@A3 plan showing the Central London Railway Depot at White City on c.1908-1925 OS mapping. Source: London Underground, Ref.Map.CD143/1908-1925.

1:5000@A3 plan showing Westfield White City with Central Line Sidings (dashed red) overlaid on c.2012 OS mapping. Source: London Underground, Ref.Map.CD143/2012.

1:5000@A3 plan showing the alignment of the Jubilee line (dashed grey) between Bond Street and Green Park overlaid on c.2012 OS mapping. Source: London Underground, Ref.Map.N115/2012.

1:5000@A3 plan showing the alignment of the Jubilee line (dashed grey) between Waterloo and London Bridge overlaid on c.2012 OS mapping. Source: London Underground, Ref.Map.J013/2012.

1:5000@A3 plan showing the alignment of the CCEHR Kennington extension (dashed

black) north of Kennington overlaid on c.2012 OS mapping. Source: London Underground, Ref.Map.N116/2012.

1:5000@A3 plan showing the alignment of the Victoria line (dashed blue) between Oxford Circus and Green Park overlaid on c.2012 OS mapping. Source: London Underground, Ref.Map.N115/2012.

1:5000@A3 plan showing the alignment of the Piccadilly line (dashed blue) and sub-surface station tunnels (Shaded grey) between Kings Cross and Russell Square overlaid on c.2012 OS mapping. Source: London Underground, Ref.Map.P052/2012.

1:5000@A3 plan showing the alignment of the Piccadilly line (dashed blue) and sub-surface station tunnels (Shaded grey) between Knightsbridge and South Kensington overlaid on c.2012 OS mapping. Source: London Underground, Ref.Map.P072/2012.

1:5000@A3 plan showing the alignment of the Piccadilly line (dashed blue) between Kings Cross and York Road stations overlaid on c.2012 OS mapping. Source: London Underground, Ref.Map.J013/2012.

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