TRANSPORT AND WORKS ACT 1992
TOWN AND COUNTRY PLANNING ACT 1990

PLANNING (LISTED BUILDINGS AND CONSERVATION AREAS) ACT 1990

PROPOSED LONDON UNDERGROUND (NORTHERN LINE EXTENSION) ORDER

PROOF OF EVIDENCE

OF

Jonathan R A Gammon

ENGINEERING

FOR

TRANSPORT FOR LONDON (TfL)

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Contents

S1 INTRODUCTION

S1.1 My name is Jonathan Robert Arthur Gammon. I am the Technical Director, Tunnelling and Earth Engineering, at Halcrow Group Limited, which is a CH2M HILL company. I am based at the company's offices in London and currently also hold the position of Design Project Manager for the upgrade of London Underground's Bond Street station.

S1.2 I have a Bachelors of Science Degree in Civil Engineering, a Master of Science Degree in Soil Mechanics, and the Diploma of Imperial College, University of London. I am a Chartered Civil Engineer, a Chartered Geologist, and a Registered Engineer.

S1.3 I am an active Member of many professional institutions, societies, and related organisations and these are listed in my full Proof of Evidence which follows this Summary.

S1.4 I have been involved with tunnelling and ground engineering projects for almost forty years. In connection with underground railways, I have led teams carrying out design work at locations as diverse as London and Hong Kong. I have held senior positions as a member of Resident Site Staff during the formation of tunnels and the construction of underground stations.

S2 SCOPE OF EVIDENCE

S2.1 My Proof of Evidence addresses the engineering implications of the proposed Northern line extension (NLE) and encompasses both its engineering design and construction. I commence with an introduction to the scheme and a description of the main features of the NLE. I describe the basis of the engineering design of the NLE in broad terms and introduce the constraints on the engineering of the NLE.

S2.2 I present the tunnelling techniques relevant to the NLE and then describe the main features of the NLE, I follow the alignment of the NLE by commencing at its western end, at Battersea, and ending at its eastern end, at Kennington station. I describe each of the features of the NLE in terms of their design configuration and in terms of their construction and related matters.

S2.3 I then address the specific issue of ground movement resulting from the tunnelling and excavation works, before introducing the Code of Construction Practice which will be applied to the NLE to safeguard the interests of all those involved with, and potentially affected by, the NLE.

S2.4 The engineering of the NLE involves contributions from a wide range of disciplines including Civil and Structural Engineering, Tunnel Engineering, Mechanical, Electrical and Public Health Engineering and Fire and Life Safety Engineering. Engineers worked closely with Architects, Town

Planners, Traffic and Transport Planners, Cost Consultants, and other professionals during the process that led to the application for the Transport and Works Act Order.

S2.5 The engineering of the NLE has taken account of a large number of often inter-related or inter-dependent factors in establishing the alignment of the NLE's tunnels and the locations of its underground stations and ancillary features. It has also taken account of the findings of a comprehensive process of consultation with interested parties, ranging from individuals to multi-national corporations.

S2.6 The NLE has been engineered to the high standards required, and expected, of a modern underground railway and it has drawn on the vast experience that already exists of creating such railways in London.

S3 THE SCHEME AND PROPOSED WORKS

S3.1 The scheme consists of a 3.2km extension of the existing underground Northern Line (Charing Cross Branch). The extension involves twin bore tunnels running between the existing Kennington Loop and Battersea and the introduction of new stations at Nine Elms and Battersea; trains will terminate at Battersea, where a track crossover facility is also to be provided. Both stations are to be located below ground with the provision for over site development (OSD).

S3.2 Also constructed along the route are two permanent shafts, at Kennington Park and Kennington Green, and cross passages between the running tunnels at various locations and with varying functions. Additional cross passages are to be formed at platform level at Kennington station to enhance the use of, and safety at, that station.

S3.3 To connect the new underground extension to the existing Northern line at Kennington Loop a technique involving a step plate junction is to be used in order to minimize disruption to the existing Northern Line services.

S3.4 At an earlier stage in the development of the design of the NLE, a requirement for one additional permanent shaft and two temporary shafts was envisaged. The permanent shaft was removed prior to the Order application, leading to an increase in tunnel diameter and ventilation requirements. The two temporary shafts have been removed as a result of design development since the Order application, with an alternative approach now adopted for effecting the connection of the NLE to the Kennington Loop.

S3.5 Worksites to enable the scheme to be constructed will be required at Battersea station, Nine Elms station, Kennington Park and Kennington Green. Related features include the provision of a conveyor from the Battersea station worksite to a jetty adjacent to the River Thames to enable its use for the transportation of excavated materials away from the worksite.

S3.6 I consider that the sizes of the various worksites represent pragmatic solutions to the problem of accommodating the necessary site personnel and operations and at the same time minimizing their impact on the areas in which they are located.

S3.7 The NLE works also include accommodation works for a number of existing landowners including Battersea Dogs and Cats Home (BDCH, to the west of Battersea station) and the Beefeater Gin Distillery (in the vicinity of the Kennington Green shaft).

S3.8 The scheme is to be constructed using the latest tunnelling techniques and the fire safety and ventilation strategies are designed to current standards. There are particular requirements arising from the need to ensure that the proposed NLE is safe in the event of an emergency and appropriately ventilated in the event of fire below ground. I have provided a detailed description of fire and life safety considerations and the strategy adopted for the NLE in an appendix to my Proof of Evidence. I have provided a detailed description of the Flood Risk Assessment as an appendix to my Proof of Evidence.

S4 TUNNELLING TECHNIQUES

S4.1 After a description of the ground conditions and groundwater regime of relevance to the NLE, I describe the three tunnelling techniques that will be used in the construction of the NLE; namely: Tunnel Boring Machine (TBM); Sprayed Concrete Lining (SCL); and Spheroidal Graphite Iron Lining (SGI).

S4.2 The running tunnels of the NLE will be constructed using TBMs. There are a number of different types of TBM and the type used for any given project depends mostly upon the nature of the ground and the groundwater regime through which the tunnel passes.

S4.3 The nature of the ground in the NLE project is such that a closed-face earth pressure balance type of TBM (named an EPBM) will be used to form the running tunnels. This means that the machine is designed so that at all times the ground through which it is cutting is supported.

S4.4 A cutter head, with a diameter corresponding to the required internal diameter of the tunnel plus the thickness of the tunnel lining, sits within a cylindrical steel skin. As the EPBM name suggests, at the cutting face the ground is kept under pressure to provide ground support. The soil (and water, where present) produced by the cutter head come through into a chamber behind the cutter head under a pressure dictated by controlling the

rate of the discharge from the cutter head chamber by means of a screw conveyor. At all times the earth around the tunnel boring machine is supported by the TBM's steel skin. Behind the cutter head and chamber, but within the steel skin, pre-cast reinforced concrete lining segments are then put into place as the TBM moves forward. The segments form a ring and support the earth once the TBM has moved forward. In essence the concrete lining segments take over the role of providing support to the ground that was initially provided by the steel skin of the TBM.

S4.5 EPBMs are currently in use to form tunnels for London's Crossrail project and they have been used in numerous projects in the UK and worldwide. For the NLE running tunnels a 5.2m internal diameter is proposed.

S4.6 Whilst the long sections of tunnel between stations are designed to be constructed using TBMs there are other parts of the works underground that are to be constructed using SCL.

S4.7 SCL involves excavation to form an opening in the ground followed by the rapid spraying of a concrete lining, usually called a primary lining, onto the sides or walls of the opening. The essence of the process is that the concrete goes hard extremely quickly. It contains special additives that mean that within a matter of minutes after being sprayed onto the ground surface it starts to go hard. A secondary lining is applied to provide the tunnel with long-term integrity and to provide the required internal diameter.

S4.8 This technique can be used to form openings in the ground that are not circular in cross-section and openings which are horizontal, vertical, or inclined. SCL has been used extensively on major underground works in London for many years. Notable examples of such works include the Jubilee line extension (Waterloo and London Bridge stations), Heathrow Express (Terminal 4 station), the shafts and junctions for the Heathrow Baggage Transfer tunnel, shafts for London Electricity cable tunnels and on the Channel Tunnel Rail Link for the entire 3 km long North Downs tunnel and for the ventilation shaft connection in the London tunnels. SCL was also used as the primary tunnel lining support for the construction of the passenger circulation tunnels for the redevelopment of Kings Cross station for London Underground and has been used during upgrades to Tottenham Court, Bond Street, and Victoria Underground stations.

S4.9 The adoption of the SCL technique is dependent on the nature of the ground conditions and in London, for example, is best-suited to excavation through clay soils where conditions are "dry". Where granular or mixed soil conditions prevail, and in situations where groundwater can freely enter the excavation, then a means of immediately applying support to the ground and limiting the ingress of groundwater is required.

S4.10 Under such conditions, and supported by a wealth of experience gained during the construction of London Underground, spheroidal graphite iron (SGI) linings are adopted. These are placed in bolted rings, made up of

segments formed of SGI. Although similar to precast concrete rings by way of their appearance inside the tunnel, their strength and their weight place them at an advantage where access or the use of equipment is limited or where the geometry of the lining is complicated.

S5 GROUND MOVEMENTS

S5.1 The approach to the prediction of settlement for the NLE has been developed through work on projects such as the Jubilee Line Extension (JLE), Channel Tunnel Rail Link (CTRL), and Crossrail. The process allows the nature of the likely building response to be assessed and allows measures to protect the building to be identified where necessary. The NLE project has adopted the same phased approach as used and approved by both Houses of Parliament during the passage of the Crossrail Bill.

S5.2 The primary form of mitigating the risk of settlement is through the use of best practice in the tunnelling operations, including continuous working, erecting linings immediately after excavation and providing tight control of the Tunnelling process to reduce the magnitude of settlement.

S5.3 Defect surveys will be undertaken on all properties predicted to experience 10mm or more settlement as a result of the assessment process I have described above. This is a written and photographic record of the existing cracking and deterioration of finishes and structures and will be carried out by an appropriately qualified engineer or surveyor working jointly for the promoter of the works and the owner of the building. Owners of properties where defect surveys are required will be contacted in advance to arrange access but the survey will not be undertaken until shortly before the start of construction activities that could affect the building.

S5.4 Generally, all buildings in the highest predicted risk categories will be monitored during tunnel construction. Monitoring for lower risk categories will be covered by the general background surface monitoring undertaken to confirm ground movements are within the magnitude of those predicted.

S5.5 In addition to this, general settlement monitoring will be carried out over the whole area potentially affected by settlement. TfL is prepared, at a landowner's request, to enter into TfL's standard form of settlement deed with any landowner who is concerned about settlement at their property and who has a property within the limits of deviation of the NLE scheme.

S6 CODE OF CONSTRUCTION PRACTICE

S6.1 The management of the construction process is a crucially important component of any large construction project such as the NLE. It is vitally important that best practice is implemented from a safety and an environmental perspective. In my evidence I outline the construction management proposals. However, at this stage of the project no contract has been awarded and no contractor chosen to implement the works. The precise details of the construction management process will thus be defined at a point in time in the future. What can be offered now is a commitment to

a framework that the contractor awarded the Design & Build Contract will be required to follow.

S7 RESPONSE TO STATEMENT OF MATTERS AND OBJECTIONS

S7.1 My Proof of Evidence provides my responses to the Statement of Matters (in Chapter 20) and my responses to the Objections that have been received and that raise issues that are relevant to my evidence (in Appendix 3).

S8 CONCLUSION

S8.1 The engineering of the Northern Line Extension has had regard to all relevant constraints. The worksites are required in order to construct the tunnels, stations and shafts that form the NLE. It has been established that the strategy to use the River Thames for the removal of excavated material is viable. The permanent shafts at Kennington Green and Kennington Park are required to provide necessary ventilation and for safety-related reasons. The procedures to identify, mitigate, monitor, and respond to ground movement represent best practice; they are appropriate to ensure that any potential impacts will be adequately controlled and mitigated.

S8.2 There is a comprehensive framework for the management of construction in the form of the draft Code of Construction Practice which will ensure that best practice is adopted in the construction of the NLE project.

S8.3 I conclude that the engineering of the proposed NLE is both appropriate and justified.

1 QUALIFICATIONS AND EXPERIENCE

1.1 My name is Jonathan Robert Arthur Gammon. My academic and professional qualifications are:

BSc(Hons) Degree in Civil Engineering;
MSc Degree in Soil Mechanics;
DIC, Diploma of Imperial College

Chartered Engineer (CEng)
Member of the Institution of Civil Engineers (MICE)
Chartered Geologist (CGeol)
Fellow of the Geological Society of London (FGS)
Fellow of the Institution of Professional Engineers, New Zealand (FIPENZ)
Member of the American Society of Civil Engineers (MASCE)
Member of the Hong Kong Institution of Engineers (MHKIE)
European Registered Engineer (EurIng, FEANI)

1.2 The professional societies and related organisations of which I am a Member include the British Tunnelling Society (BTS), the British Geotechnical Association (BGA), and the Railway Civil Engineers Association (RCEA).

1.3 I am the Technical Director, Tunnelling and Earth Engineering, at Halcrow Group Limited (Halcrow), a CH2M Hill Company. I am based at the company's offices in London.

1.4 I have been involved with the design of the Northern Line Extension since commencing employment at Halcrow in October 2012.

1.5 I have been involved with tunnelling and ground engineering projects for almost forty years. In connection with underground railways, I have led teams carrying out preliminary, reference, tender, and detailed design work. I have been responsible for underground railway projects at locations including London, Dublin, and Hong Kong. I have held senior positions as a member of Resident Site Staff during the formation of tunnels and the construction of underground stations.

1.6 My experience of tunnelling projects in London includes the Jubilee Line Extension, Thames Tideway, Crossrail, and London Underground's station Upgrade programme. I am currently the Project Manager for the design work being carried out for the contractors undertaking the Bond Street Station Upgrade.

2 SCOPE OF EVIDENCE

2.1 My Proof of Evidence addresses the engineering implications of the proposed Northern line extension (NLE) and encompasses both its engineering design and construction.

2.2 I commence with an introduction to the scheme and a description of the main features of the NLE. I describe the basis of the engineering design of the NLE in broad terms and introduce the constraints on the engineering of the NLE.

2.3 To assist with an understanding of the more-detailed descriptions of the works that follow, I introduce the tunnelling techniques relevant to the NLE and describe, in more detail, the development of the initial scheme design.

2.4 In describing each of the features of the NLE, I follow the alignment of the NLE by commencing at its western end, at Battersea, and ending at its eastern end, at Kennington station. I describe each of the features of the NLE in terms of their design configuration and in terms of their construction and related matters. Thus the sequence of my descriptions is: Battersea; Battersea to Nine Elms; Nine Elms station; Nine Elms to Kennington; Claylands Road Shaft; Kennington Green Shaft; Kennington Park Shaft; Connection to Kennington Loop; and Kennington station.

2.5 I then address the specific issue of ground movement resulting from the tunnelling and excavation works.

2.6 I follow an introduction to the Code of Construction Practice with an explanation of the use of the River Thames during the construction of the NLE.

2.7 The Statement of Matters and Objections receive my attention before I provide my conclusion and Witness Declaration.

3 INTRODUCTION TO SCHEME AND PROPOSED WORKS

3.1 The scheme consists of a 3.2km extension of the existing underground Northern line (Charing Cross branch). The extension [Figure 1] is to be constructed underground in twin bore tunnels running between the existing Kennington Loop and Battersea. The scheme is to be constructed in three London boroughs, namely Wandsworth, Lambeth and Southwark.

3.2 New stations on the underground extension line are to be provided at both Nine Elms and Battersea, with the trains terminating at the latter. Both stations are to be constructed below ground with the provision for over site development (OSD).

3.3 Also constructed along the route are two shafts, at Kennington Park and Kennington Green, required for Tunnel Boring Machine retrieval, emergency intervention, ventilation and fire safety purposes. Cross passages are to be formed between the running tunnels at various locations.

3.4 To connect the new underground extension to the existing Northern line at Kennington Loop a technique involving a step plate junction is to be used in order to minimise disruption to the existing Northern Line services. To enable construction of the step plate junctions associated temporary works will be required.

3.5 Worksites to enable the scheme to be constructed will be required at Battersea station, Nine Elms station, Kennington Park and Kennington Green. This includes the provision of a conveyor from the Battersea station worksite to a jetty adjacent to the river. Works are also contemplated in the vicinity of the jetty to enable its use for the transportation of excavated materials away from the worksite by river.

3.6 Ancillary and mitigation works will also take place within the limits of deviation including (but not limited to) providing power supply, additional cross passages at platform level at Kennington station and works related to highways, footways and utilities.

3.7 The NLE works also include accommodation works for a number of existing landowners including Battersea Dogs and Cats Home (BDCH, to the west of Battersea Station) and the Beefeater Gin Distillery (in the vicinity of the Kennington Green Shaft).

3.8 The scheme is to be constructed using the latest tunnelling techniques and the fire safety and ventilation strategies are designed to current standards.

3.9 The current design has been taken to a sufficiently detailed state that it can identify the impact of the works in terms of, for example, land requirements and construction activity. It also provides sufficient detail for contractors to bid to implement the works on the basis of a Design & Build Contract, whereby the contractor awarded the works carries out the additional design

work required to permit construction to commence. The present state of the design for the NLE under these circumstances can also be termed the "Reference Design".

3.10 The construction of the NLE is expected to commence in 2015 and be completed in 2020.

3.11 The ground conditions along the alignment, of significance to the scheme, comprise of the solid geological formations of the Lambeth Group overlain by the London Clay which in turn is overlain by a sequence of superficial deposits comprised of River Terrace Deposits, Alluvium, and Made Ground. Figures 2, 3 and 4 illustrate the ground conditions, in section, along the alignment of the NLE as inferred from investigation work carried out prior to the Order Application. The groundwater regime in the superficial deposits is significantly influenced by proximity to the River Thames (to the north), whereas the groundwater regime in the underlying formations is influenced by the aquifer in the Chalk formation at greater depth and which underlies the entire alignment.

3.12 The different formations within the overall ground conditions are described more fully in the Environmental Statement **[NLE/A19/1]** and a summary of typical ground conditions inferred by past investigations is provided by Table 1.

3.13 Around the areas of Battersea and Kennington there are localised scour features in the surface of the London Clay which are infilled with superficial deposits. These result in the top of the London Clay occurring at a greater depth than at locations where such scour features are absent. It is probable that these features relate to the natural conditions which existed prior to the development of London, at a time when the tributaries to the River Thames ran at the ground surface and would have incised valleys, now buried, into the topography.

3.14 The development of London over many centuries has gradually led to the masking of the natural setting of this portion of London. Tributaries to the River Thames have become "hidden" and natural water courses now run in culverts or pipes. Natural ground levels have been modified and in the main have been raised using a wide range of materials that are now captured by the term "Made Ground". Industrialisation has, in some instances, resulted in the presence of contaminated ground.

3.15 The pumped abstraction of groundwater from deep wells penetrating into the Chalk drew down groundwater levels significantly at the peak of London's industrialisation and as the City's population grew. These water levels are in the process of recovering as the volumes of water abstracted have reduced markedly in recent decades.

3.16 Detailed attention to the setting of the NLE is provided in the Environmental Statement. Investigation of the ground conditions and the groundwater regime has been carried out in stages and is still in progress.

4 SCHEME DESIGN AND CONSTRAINTS

4.1 In my evidence I describe the nature of the scheme design from an engineering perspective. It is important to understand that the engineering design of an underground railway system such as that proposed for the NLE involves the detailed consideration of a number of factors and constraints. The design of one feature will have a consequent effect on another. This means that the design of a scheme from an engineering perspective is inevitably an iterative process.

4.2 There are particular requirements arising from the need to ensure that the proposed NLE is safe in the event of an emergency and appropriately ventilated in the event of fire below ground. I have provided a detailed description of fire and life safety considerations and the strategy adopted for the NLE in Appendix 4.1 to this Proof of Evidence. The Office of Rail Regulation (ORR) has provided guidance and has no objection to the NLE.

4.3 In addition, any design has to address the potential for flooding to occur. The main flood risk to the NLE is the River Thames, which is tidally influenced. The NLE project has been designed (for example by raising entrance levels at stations) to accommodate a flood event as approved by the Environment Agency. I have provided a detailed description of the Flood Risk Assessment as Appendix 4.2 to this Proof of Evidence.

4.4 In developing a route alignment for running tunnels, a number of aspects have to be considered including:

i. The presence of existing sub-surface infrastructure, such as utilities (in the form of pipes, tunnels, and shafts) and existing underground railways, as well as potential obstructions such as deep basements and/or piles associated with buildings.

ii. The proposed locations and alignment for proposed stations;

iii. The proposed locations for ventilation and intervention (emergency services access) shafts;

iv. The need to accommodate cross-passages between the running tunnels as part of the fire intervention and evacuation strategy;

v. The constraints in connecting to the existing Northern Line;

vi. The nature of the Northern Line rolling stock which limits the curve radius that can be adopted. In that regard, the most efficient route would be a straight line as that alignment reduces journey times, makes for a more comfortable journey and is easier to construct.

4.5 The running tunnel diameter has to be designed so that it is large enough to allow for a train to pass through the tunnel at the design speed, taking account of the curvature of the track alignment and the overall “envelope"

swept by the train at all points in the tunnels. To reflect the lateral movements of the train carriages that have to be accommodated within the tunnel, the critical tunnel cross-section dimensions are determined from the Dynamic Kinematic Envelope.

4.6 The tunnel diameter is also influenced by evacuation and ventilation requirements. Changes to these latter requirements can affect the diameter of the tunnel as occurred in the development of the NLE design. As explained in more detail below the decision not to have a ventilation/intervention shaft at Claylands Road resulted in the need to provide a walkway within the running tunnels for evacuation purposes, which in turn resulted in a larger diameter running tunnel.

4.7 In developing the engineering design of stations numerous matters have to be taken into account including:

i. The need to locate stations in proximity to other public transport to enable easy access and interchange for passengers;

ii. The need to locate stations in accordance with ventilation constraints;

iii. The need to locate stations in accordance with other fire risk and safety constraints;

iv. The proposed horizontal and vertical alignment of the proposed running tunnels;

v. The presence of existing sub-surface infrastructure and other assets;

vi. The need to ensure that the risk of flooding is reduced to an acceptable level;

vii. The need to minimise construction and operational impacts upon existing and proposed residential and commercial properties;

viii. The need to accommodate potential future over station development (OSD);

ix. The presence of sufficient land in proximity to accommodate the worksite in order to be able to construct the station.

4.8 In developing the design of permanent ventilation and intervention shafts from an engineering perspective again there are numerous factors that have to be taken into account. These include:

i. The need to provide appropriate ventilation and comfort within tunnels when the railway is operating and in the event of a fire;

ii. The need to provide for appropriate means of intervention and evacuation in an emergency in accordance with the requirements of the Office of the Rail Regulator (ORR);

iii. The need to locate shafts in close proximity to the running tunnels and at a distance acceptable to the London Fire and Emergency Planning Authority (LFEPA);

iv. The proposed horizontal and vertical alignment of the proposed running tunnels;

v. The presence of existing sub-surface infrastructure and other underground assets;

vi. The need to ensure that the risk of flooding is reduced to acceptable levels;

vii. The need to minimise construction and operational impacts upon existing and proposed residential and commercial properties;

viii. The need to accommodate above-ground structures and any internal plant or staircases e.g. head house, ventilation fans, and emergency staircase access;

ix. The presence of sufficient land in proximity to accommodate the worksite in order to be able to construct the shaft;

x. The need to accommodate the tunnelling strategy; for example, to permit the removal of the tunnel boring machines (TBMs) at the end of their drive;

4.9 When all these factors are considered, the iterative nature of the design process and the inter-relationship of the various considerations becomes clear.

4.10 By way of example, the choice of location of a station would have an impact upon the alignment of the running tunnels. If the running tunnel alignment is changed this may in turn result in a longer distance between stations potentially requiring a different ventilation/intervention strategy. This in turn may result in the need to identify different alternative/additional locations for ventilation/intervention shafts.

4.11 Similarly a change in tunnel alignment to avoid a particular constraint may give rise to the need to alter the design of a station, affect the location or design of ventilation/intervention shafts and/or of cross-passages.

5 TUNNELLING TECHNIQUES

5.1 In this section I described the three tunnelling techniques that will be used in the construction of the NLE. These are

i. by tunnel boring machine (TBM);

ii. by sprayed concrete lining (SCL); and

iii. by using bolted and grouted segmental Spheroidal Graphite Iron linings (SGI)

Tunnel Boring Machine

5.2 The running tunnels of the NLE will be constructed using tunnel boring machines or “TBMs”. There are a number of different types of TBM and the type use for any given project depends mostly upon the nature of the ground and the groundwater regime through which the tunnel passes.

5.3 The nature of the ground in the NLE project is such that a closed-face earth pressure balance type of TBM (named an EPBM) is expected to be used to form the running tunnels. This means that the machine is designed so that at all times the ground through which it is cutting is supported.

5.4 The various components of an EPBM are shown on Figure 5. A typical modern closed face earth pressure balance machine is made up of a number of elements.

5.5 A cutter head, with a diameter corresponding to the required internal diameter of the tunnel plus the thickness of the tunnel lining, sits within a cylindrical steel skin. As the EPBM name suggests, at the cutting face the ground is kept under pressure to provide ground support. The soil (and water, where present) produced by the cutter head come through into a chamber behind the cutter head under a pressure dictated by controlling the rate of the discharge from the cutter head chamber by means of a screw conveyor. The screw conveyer comprises of a steel cylinder, typically about a metre in diameter, within which there is an Archimedean screw (rather like a tight fitting corkscrew). The pressure in the chamber is regulated by controlling the rate of rotation of the Archimedes screw. The cuttings emerging from the screw conveyor, at ordinary atmospheric pressure pass on to a conveyor belt and are taken off down the tunnel for disposal.

5.6 At all times the earth around the tunnel boring machine is supported by the TBM’s steel skin.

5.7 Behind the cutter head and chamber but within the steel skin, pre-cast reinforced concrete lining segments are then put into place as the TBM moves forward. The segments form a ring and support the earth once the TBM has moved forward. In essence the concrete lining segments take over the role of

providing support to the ground that was initially provided by the steel skin of the TBM.

5.8 EPBMs are currently in use to form tunnels for London's Crossrail project and they have been used in numerous projects in the UK and worldwide.

5.9 For the NLE running tunnels, as a result of design development which I describe later, a 5.2m internal diameter is proposed.

Sprayed Concrete Lining

5.10 Whilst the long sections of tunnel between stations, called the running tunnels, are designed to be constructed using Tunnel Boring Machines (TBMs) there are other parts of the works underground that are to be constructed using a technique known as sprayed concrete lining (SCL) [Figure 6].

5.11 The sprayed concrete lining technique involves excavation to form an opening in the ground followed by the rapid spraying of a concrete lining, usually called a Primary Lining, onto the sides or walls of the opening. The essence of the process is that the concrete which contains special additives goes hard extremely quickly. Within an hour or two it would be achieving a significant strength compared to concrete used routinely for building works.

5.12 This technique can be used to form openings in the ground that are not circular in cross-section and openings which are horizontal, vertical, or inclined. Conventional TBMs can only form circular openings, such as required for the running tunnels.

5.13 SCL has been used extensively on major underground works in London for many years. Notable examples of such works include the Jubilee Line Extension (Waterloo and London Bridge stations), Heathrow Express (Terminal 4 station), the shafts and junctions for the Heathrow Baggage Transfer tunnel, shafts for London Electricity cable tunnels and on the Channel Tunnel Rail Link for the entire 3 km long North Downs tunnel and for the ventilation shaft connection in the London tunnels. SCL was also used as the primary tunnel lining support for the construction of the passenger circulation tunnels for the redevelopment of Kings Cross station for London Underground and has been used during upgrades to Tottenham Court Road, Bond Street, and Victoria Underground stations.

5.14 All these projects benefited from the lessons learnt from the management failures that lead to the collapse of the tunnels at the Central Terminal Area of Heathrow airport on 21 October 1994. At Heathrow the method of construction employed sprayed concrete to support the tunnel excavations, but insufficient attention was paid to the management of the construction process. The causes of collapse are well understood following investigation by the Health & Safety Executive (HSE) and the Institution of Civil Engineers (ICE). The lessons learnt have been used, and management controls further

developed, in the projects described above, all of which were carried out successfully.

5.15 SCL, in conjunction with a well-managed instrumentation and monitoring regime, is a safe and well-established means of underground construction. Where tunnels or openings of large cross-sectional area are required, then a sequence of smaller cross-section excavations is undertaken. The temporary arches or ribs resulting from the creation of these incremental excavations are removed as the permanent (or "secondary") lining - which might also be formed using SCL - is placed to correspond to the final dimensions required for the tunnel or opening.

Spheroidal Graphite Iron linings

5.16 The adoption of the SCL technique, described above, is dependent on the nature of the ground conditions and in London, for example, is best-suited to excavation through clay soils where conditions are "dry". Where granular or mixed soil conditions prevail, and in situations where groundwater can freely enter the excavation, then a means of immediately applying support to the ground and limiting the ingress of groundwater is required.

5.17 Under such conditions, and supported by a wealth of experience gained during the construction of London Underground, spheroidal graphite iron (SGI) linings are adopted [Figure 7]. These are placed in bolted rings, made up of segments formed of SGI. Although similar to precast concrete rings by way of their appearance inside the tunnel, their strength and their weight place them at an advantage where access or the use of equipment is limited or where the geometry of the lining is complicated.

6 INITIAL SCHEME DESIGN

6.1 As described in the evidence of Mr de Cani **[TFL1/A]**, Ms Rosewell **[TfL6/A]** and Mr Rhodes **[TfL5/A]**, the primary aim of the NLE is to encourage economic growth in London and the wider UK economy by facilitating the sustainable regeneration and development of the VNEB OA.

6.2 The NLE will achieve its primary aim by extending the Northern line between Battersea Power Station (BPS) and Kennington, improving access to the London Underground network in an area which is in part currently characterised by poor access to the existing public transport network and thereby benefitting both new and existing residential and business communities.

6.3 Mr de Cani explains in his evidence that four main route options were considered that connected the existing Northern line loop at Kennington to Battersea Power station.

6.4 Mr de Cani also explains that following initial consideration of a wide range of matters including engineering feasibility, environment and economic viability factors, public consultation, and land acquisition, the decision was taken to proceed with Route 2 as this route was considered to maximise the public benefits.

6.5 Route 2 was an option which provided for a connection to the existing Northern line on each side of the Kennington Loop and proceeded via an intermediate station at Nine Elms to a terminus at BPS. A detailed alignment was not developed at this stage.

6.6 Having identified Route 2 as the preferred route option, the engineering design could be developed in greater detail. The engineering design thus had to accommodate a route from the BPS site to a station at Nine Elms and then on to connect to the existing Northern line at the Kennington loop.

6.7 In the following sections I describe the engineering design of the scheme by reference to each proposed feature or element, beginning with the proposals at Battersea and moving eastwards. In addition I explain the construction of each element of the scheme and the nature and extent of the worksite (if any) required to construct it. At this point I should explain that where a direction of travel is used - for example “southbound” – this relates to the direction of travel dictated by north-south orientation of the existing portion of the Charing Cross Branch of the Northern Line, to the north of Kennington Station, which will feed into and from the NLE. Thus a direction of travel, as used here, may not correspond to a strict geographical orientation once the extended Charing Cross Branch turns westwards and heads across to Battersea. It will be possible to be in the southbound tunnel of the NLE and yet, strictly-speaking, be travelling westwards.

7 BATTERSEA

7.1 There are three significant elements to the infrastructure that has to be accommodated at Battersea [Figures 8 and 9]:

i. the station, including the underground structure and the over-ground structure;

ii. over-run tunnels; and

iii. a crossover.

7.2 The design of these elements was constrained by a number of factors, including:

i. The need for a station to link with the over-ground transport network;

ii. The presence of Thames Water's tunnels to the east;

iii. The presence of a surface running railway system to the west;

iv. The presence of Battersea Park Road to the south;

v. The proposed Battersea Power Station development to the north of, and above the station.

7.3 Battersea Station forms an integral part of the proposed Battersea Power Station Master Plan (BPSMP). The new station structure and associated crossover box must be designed with structural consideration given to the OSD proposed in the Battersea Power Station (BPS) development.

7.4 The scheme has been designed so as to be capable of supporting up to 12 storeys and is compatible with the BPS master plan.

Battersea Station

7.5 Battersea Station is to be located at the south-west corner of the BPS site. The station is T-shaped in plan with the main station box adjacent to and parallel with Battersea Park Road. The location for the station was established at feasibility stage and was dictated by several physical constraints. These included: the adjacent main line railway to the west; the Thames Water Ring Main (TWRM) to the east; Battersea Park Road to the south; and the BPS development to the north. Additional constraints consisted of the operational requirement for a railway crossover box immediately outside the station, the need to provide direct pedestrian access from both the BPS development and Battersea Park Road and the need to interface with other forms of public transport using Battersea Park Road.

7.6 The Station will be constructed inside a deep cut-and-cover box, formed using diaphragm walls, with a top slab forming the deck of the basement level car

park just below existing ground level that acts as a transfer slab to carry loads from the over site/station development (OSD) that will be built as part of the Battersea Power Station development. Three intermediate floor levels, formed of reinforced concrete slabs and beams, act as permanent props for the diaphragm walls.

7.7 The Station's location was dictated by the need to provide overrun tunnels to the west and a crossover to the east within the constraints of existing development; namely the mainline railway to the west and the Ring Main to the east. All three elements had to be designed together in order to be accommodated within these constraints.

7.8 Figures 8 and 9 indicate the proposed layout of Battersea Station.

7.9 The overall footprint of the underground station is T-shaped in plan with the main station box, 115m long by 26m wide (excluding the SCL platform extension tunnels at the west end), adjacent to and parallel with Battersea Park Road. The underside of the foundation slab is 21.5m below existing ground level and the top of the station roof slab is 2m below existing ground level.

7.10 At ground level, the station entrance is a single free standing pavilion that faces onto Battersea Park Road. It is unaffected by any OSD. The station entrance, which is set back from the road by approximately 24m, is raised to an elevation of +7.5m OD. This results in a gentle ramp from pavement to entrance. The entrance has been positioned to be clearly visible and to provide ease of interchange with buses and other modes of transport on Battersea Park Road.

7.11 The station entrance comprises an entrance pavilion with lift and escalators serving the basement level ticket hall. Also at ground level are the cores to the east and west ends of the station. These house intervention and escape stairs and lifts along with various ventilation ducts and shafts and are designed to integrate with the facade of any future OSD.

7.12 The upper concourse is the "paid" side of the ticket hall. It provides access to the platforms via two banks of opposing escalators. The escalators, which are heavy duty 'metros', have been set out to ensure an even distribution of passengers along the length of the platform.

7.13 A 26 person lift positioned centrally between the escalators provides step free access to platform level. The lift is designed to operate as a through lift with passengers entering and exiting through opposite doors both at upper concourse level and platform level.

7.14 The upper concourse also provides access to various plant rooms and back-of-house (BoH) accommodation that line the length of the station box. In addition there is access to the cores providing an alternative means of escape in an emergency.

7.15 The largest pieces of equipment at this level are the fans used for over track exhaust and ventilating the overrun tunnels. There are two in total, one to each side of the box acting as duty and stand-by. Due to height constraints imposed by the OSD the fans are set out horizontally and ventilate through ducts in the western core.

7.16 The single defining feature of the station box is the central space which extends the full length and height of the box. Conceptually the platforms sit within a single volume with a height of almost 13m. The ventilation and intervention cores provide focal points at each end of the box and help with passenger orientation.

7.17 The two banks of opposing escalators and a passenger lift provide step-free access from upper concourse level to the island platform below. To accommodate the proposed rolling stock the platform length required is 119m. Due to the presence of the mainline railway to the west and the Ring Main to the east it is not possible to accommodate the full length of the platform and the crossover within the footprint of the box structures. As a result, the length of the station box has been restricted. The required platform length has been achieved by extending the platform within an 8.0m internal diameter tunnel beyond the western end of the rectangular box.

7.18 The platform within the station box is proposed as a 12.2m wide island with a minimum width between structure and platform edge of 3.0m. Cores at each end of the station box provide ventilation, intervention and emergency escape. The location of the escape cores is driven by the need to minimize travel distance for those on the platform in the event of an emergency. The maximum travel distance between escape cores is approximately 90m.

7.19 Accommodation at platform level includes a mess room for train crew, a cleaners store, a Despatch Office and Duty Manager's office.

7.20 In addition to the normal exit route, by escalator, the cores at each end of the platform are a means of escape in an emergency, providing a protected route to surface level. Each core contains two scissor stairs with refuge space on each second flight. They also provide a dedicated fire lift. The east core is the designated fire core; however, both cores are capable of being used for emergency services intervention. In order to minimise the impact of the cores on the proposed OSD at surface level the stairs transfer at basement level.

7.21 The cores are also used to accommodate the ventilation ducts, specifically draught relief and tunnel ventilation, which are generally adjacent to the cores at the ends of the platform.

The Crossover

7.22 To the east of the station box is the crossover box [Figure 10], which maintains train services by enabling trains to arrive and depart from either platform. This will be constructed as part of the Battersea station box. The cross-over box is required to provide a junction that will enable trains to switch

track when either entering or leaving Battersea station for train operational reasons.

7.23 In addition to providing the crossover facility for trains, the crossover box also houses tunnel ventilation fans in a void above the tracks at level around -8m OD. Due to the need to accommodate an OSD, particularly a proposed basement level car park over the top of the box, the fans are horizontal. Two fans are provided for resilience. The fans draw air through a large plenum to the east of the crossover box. Air is then pushed towards a vertical riser adjacent to the east core of the station box where it rises to discharge at surface level.

7.24 The overall dimensions of the crossover box structure are 120m long x 22m wide. The underside of the foundation slab is 20.5m below existing ground level and the top of the box cover slab is 5m below existing ground level (+4m). This is also constructed inside a deep cut-and-cover box formed using diaphragm walls.

7.25 Reinforced concrete slabs and beams act as permanent props for the diaphragm walls. Over track accommodation is also included to allow for the provision of a traction substation.

7.26 The intermediate level, which supports the ventilation fans, also acts as a permanent prop for the diaphragm walls. This intermediate floor level is supported on columns which have been placed between the tracks and designed to withstand impact in the event of an accident.

7.27 The location of the headwall has been dictated by the position of the existing Thames Water Ring Main (TWRM) and the requirements of the switches and crossings arrangement.

The Overrun Tunnels

7.28 Overrun tunnels [Figure 11] are required beyond the end of the station platform extension tunnels at Battersea to provide a safety zone for a train that may not stop in time at the end of the platform. These tunnels are also required for the stabling of trains overnight on a daily basis. Additionally they are required as a stabling facility for a train that needs to be taken out of service following technical difficulties.

7.29 The overrun tunnels will be constructed in such a way that they do not preclude the possibility of the line being extended in the future should any such proposals come forward. However, although they form a passive provision for a future extension if required, that function is not part of the current scheme. The alignment of the overrun tunnels is currently dictated by the alignment of the tracks in the station and by the need to avoid possible underground obstructions due to the presence of gas-holders on land owned by National Grid and developments beyond the end of the Station.

7.30 The overrun tunnels have a 6m internal diameter, which is larger than the 5.2m internal diameter proposed for the running tunnels diameter and is due to ventilation requirements associated with the function and manning of the overrun tunnels. The tunnels will be constructed using SCL techniques, as will be the two cross passages which are required for safety and for drainage purposes [Figure 12]. TBMs forming the running tunnels will be launched from the crossover box at the opposite end of the Station box and will run in the opposite direction to the overrun tunnels.

7.31 The Battersea Dogs and Cats Home (BDCH) is located above the alignment of the overrun tunnels as they pass beyond the Network Rail boundary to the west of the Battersea station site. A review of the foundation details of the BDCH Kent Building, beneath which the overrun tunnels pass, has been undertaken. This review has highlighted the need for a structural solution that minimises disruption to BDCH activities. I describe the options that have been considered, and the proposed solutions, in Appendix 3 of this Proof of Evidence, when I specifically address the objections to the NLE raised by the BDCH.

Construction at Battersea

7.32 The works at Battersea all need to be served by a worksite. The worksite proposed is located within the southern section of the BPS development, adjacent to Battersea Park Road (and lying within the London Borough of Wandsworth). Residential properties lie to the south of Battersea Park Road, with the River Thames directly north of the BPS development area. The Battersea Dogs and Cats Home, Network Rail tracks and National Grid gas holders are located to the west. The worksite is shown on Figure 13.

7.33 Access to the proposed worksite would be directly from Battersea Park Road.

7.34 The worksite will be used in different ways during different phases of the construction process but the facilities that it has to accommodate include:

i. Accommodation and office space

ii. Security entrance points

iii. Two bentonite farms to supply the diaphragm wall works

iv. Materials lay-down areas

v. Materials storage areas

vi. Crawler cranes

vii. Tower and gantry cranes

viii. Hoist facilities to support the station fit out works

ix. Adequate space for vehicle access/egress/turning as well as delivery offloading.

x. Excavated material stockpile

7.35 The direction of the TBM drive means that earth excavated from the tunnel boring process will be removed from this worksite together with the material excavated during in the construction of the station and crossover boxes at Battersea.

7.36 Material excavated from this site and from the running tunnels will be sorted and, where practicable, uncontaminated material removed from the site by barge. The use of barges will assist in minimising the level of heavy goods vehicle (HGV) movement associated with the NLE project.

7.37 Contaminated excavated material, which is expected to form less than ten percent of the volume of material arising at Battersea, will probably be removed by road. Contaminated material arising from maintenance dredging of the River is routinely transported using barges that are expected to bear such material. However, the potential for the contamination of barges normally used to transport uncontaminated material from excavations on land may be unacceptable to the barge operators involved and there might not be a suitable disposal site accessible by river. As a result, although it is desirable to remove such material by barge in keeping with the overall material management strategy, it is prudent at this time to allow for the transport of such material by road.

The Conveyor

7.38 In order to facilitate the use of the River Thames during construction of the NLE, a covered conveyor is proposed to be used to take uncontaminated excavated material from the Battersea site to the jetty. The above-ground conveyor route is from the worksite along the eastern edge of the BPS site before turning west parallel to the River Thames before turning north onto the existing BPS jetty. The route is shown on Figure 14.

7.39 This route of the conveyor has been dictated, in part, by the need to provide a means of gaining access to the conveyor for maintenance purposes. This results in a requirement for a service road along its length. No other route has been identified that can accommodate the service road that is required.

7.40 The conveyor route, its service road and the access to the jetty all impinge to some extent upon the BPS development site but this has been minimised as far as possible.

The Jetty

7.41 To enable the jetty to be used for exporting material by barge, the following temporary works are also proposed:

i. Works to the jetty, including installation of the conveyor, barge loader equipment, and fenders;

ii. Refurbishment of the footbridge to access the jetty;

iii. Piled foundations are anticipated for the conveyor on the land side of the river wall;

iv. Removal, storage, refurbishment and replacement of the jetty cranes, in the event that BPSDC do not carry out that work.

7.42 A section of riverbed (approximately 150m x 50m x up to 1m deep) in front of the existing Battersea jetty will need to be dredged to allow sufficient space for the barges accessing the jetty. This is expected to result in approximately 4500 m^3 of dredged material. This is likely to be contaminated due to the historical use of the river at this site and I expect this to be handled in accordance with maintenance dredging practice using dedicated barges. However, as with the other contaminated material, there might be restrictions on its disposal and that might necessitate the use of lorries instead.

7.43 The worksite at Battersea as defined by the Planning Direction Drawings, and, as at other locations, takes up a minimum area necessary to permit the construction work to be undertaken.

8 BATTERSEA TO NINE ELMS

8.1 From the crossover box at Battersea, the tracks emerge with a separation of approximately 12m and head north-east to pass above the London Ring Water Main.

8.2 The next significant constraints, in terms of existing tunnels influencing the vertical alignment of the NLE running tunnels, are Thames Water's south west storm relief sewer and a UK-Power Networks' cable tunnel.

8.3 The presence of a UK Power Network access shaft beyond the Battersea site, at the end of Cringle Street, influences the horizontal alignment of the running tracks and results in their divergence to avoid this obstruction.

8.4 The engineering design has taken careful account of these utilities and structures and the need to mitigate any material impact upon them. The mitigation methods proposed are described in more detail below.

8.5 After passing UKPN's shaft and tunnel and Thames Water's relief sewer, the NLE Tunnels start to converge and make their approach to Nine Elms station, descending at a gradient of 0.55%.

8.6 The alignment passes sufficiently close to the Riverlight residential development for modifications to be incorporated into the substructure of the neighbouring portion of that development. Proximity to the Ballymore mixed-use development, further along the alignment and nearer Nine Elms station, has also resulted in the adoption of similar measures. Existing developments traversed by this alignment include Post Office facilities and commercial premises.

8.7 A cross passage is required on this portion of the alignment as part of the overall fire safety strategy. It will be 4.2m in diameter and will be formed using the SCL technique I have described above. The location of the proposed cross passage is shown on Figure 15.

8.8 The tunnels pass beneath Network Rail's viaduct carrying main lines into and from Waterloo Station.

8.9 Both tracks then enter the Nine Elms station box, between chainages 1050m to 1200m, and pass either side of the central island platform with a separation of approximately 16m.

8.10 This portion of the alignment is shown on Figure 16, 17, and 18. The remaining portions of alignment are shown on Figures 18 to 27.

9 NINE ELMS STATION

The Station Options

9.1 The engineering design options for the proposed station had to consider a number of physical constraints and opportunities, including:

i. the station platforms must follow the east-west orientation of the proposed NLE alignment;
ii. the vertical alignment of the railway dictates a platform depth of approximately -18.5m OD;
iii. the structure of the station box must include load-bearing provision for future OSD; and
iv. The need to be located in close proximity to Wandsworth Road (a Trunk Road with existing bus routes and stops) and the CGMA access roads.

9.2 A number of sites were considered in determining the final location and configuration of the station at Nine Elms as explained in Mr de Cani's evidence **[TFL1/A]**. TfL's Strategic Assessment Framework was applied to eleven locations in the Nine Elms area, resulting in four options being chosen for further investigation in a Stage 2 assessment.

9.3 All four of these options were situated on land just west of Wandsworth Road and north of Pascal Street. This area is divided into three adjoining plots of land occupied by Banham Security Ltd, CGMA and Sainsbury's. The landowners and the local authority (LBL) were involved in these discussions and the development of the options.

9.4 The process of site selection is described in detail in the Nine Elms Station report August 2013 **[NLE/C12]**.

9.5 Both Sainsbury's and Banham Security have had proposals for the redevelopment of their land. In June 2012 the London Borough of Lambeth's planning committee resolved to grant planning permission for a Sainsbury's mixed-use retail and residential redevelopment of the site and provides safeguarding for a NLE station; however, no planning permission has yet been granted for the station. Banham Security submitted a planning application for the redevelopment of its site to include new business premises and a 10 storey residential block in 2011; however, this was withdrawn by the applicant as it failed to safeguard for the NLE.

9.6 The options studies at Stage 2 all impinged upon the land owned by Sainsbury's, Banham Security, and the CGMA to varying degrees. The outcome of the Stage 2 assessment work was that Option 4 should be taken forward alongside Option 3.

9.7 Option 3 is the location proposed in the TWA Order. It lies within land owned by Banham Security, Sainsbury and the CGMA.

9.8 From an engineering perspective, station options 1 and 2 would have given rise to significant project risk due to the need to phase the works on these sites with the works proposed in the redevelopment of the Sainsbury's site and Banham Security's site. However, other factors including the poor fit with the proposed development and the likely level of compensation also led to Options 1 and 2 being discounted.

9.9 Option 4 is a station location on land owned by Sainsbury's and the CGMA. A box, forming only part of the full extent required for the station, would then lie in ground to the east of the land owned by Banham Security. The full extent of the station would be created by mining out using SCL techniques to the west and east and passing under Banham Security' land and Wandsworth Road, respectively

9.10 In the Phase 3 assessment further consideration was given to the comparative merits of Option 3 and Option 4. The options were reviewed against a number of criteria including, so far as is relevant to my evidence, the constructability and worksite requirements and the costs of construction.

9.11 Both options could be constructed however Option 4 results in the need to work around the Banham Security development. This would give rise to a more constrained worksite, and significant additional cost and durations of works compared to Option 3.

9.12 Option 4 would also be likely to give rise to additional disruption to road users as the worksite would be likely to affect Wandsworth Road

9.13 Option 4, due to the presence of the mined portions of station platforms beneath the footprint of any proposed development, would require Banham Security to provide a substructure capable of spanning over the platforms; this is likely to have to take the form of a substantial reinforced concrete slab supported by rows of large diameter piles running outside and between the platform tunnels. This transfer structure contributes significantly to the overall cost of pursuing this Option instead of providing a station through the construction of a full length box.

9.14 Option 4 would have allowed Banham Security to develop their site up until the commencement of the NLE construction. After that point Banham Security would not be able to carry out further construction work as there would, for example, be clashes in requirements for worksite areas.

9.15 In the event, having regard to a number of considerations in addition to those I have outlined, TfL determined that Option 3 should be selected. Mr de Cani **[TFL1/A]** explains this in his evidence.

The Proposed Nine Elms Station

9.16 The proposed Nine Elms station is located on the land to the north of the junction of Wandsworth Road and Pascal Street and adjacent to the southern end of Sainsbury's supermarket site. The station is rectangular in plan with the main station box almost parallel to Pascal Street; a parallel arrangement is not possible due to the impact this has on the horizontal alignment of the tunnels beyond both ends of the station. The location of the station has been developed from feasibility stage through to the current design. Figures 28 and 29 show the proposed layout of Nine Elms station

9.17 The station design has been developed on the basis that it will be constructed as a deep cut-and-cover box, formed using diaphragm walls, with a top slab just below existing ground level with a capacity to accommodate an as yet undetermined OSD to be built by others.

9.18 Nine Elms station provides an intermediate stop from Kennington to Battersea. Following consultation and discussion with the local authorities and other stakeholders the ticket hall and station entrance is at the east end (Wandsworth Road) and will open south onto Pascal Street and north to the new internal street.

9.19 The proposed Nine Elms station is not currently proposed to have a ticket hall to the western side of the station, as this is not considered as necessary. The reasons for this are set out in the evidence of Mr. de Cani **[TFL1/A]** and Mr. Bowers **[TFL7/A]**.

9.20 A ticket hall at the western end of the station could be accommodated, with lifts accessing the platforms; however, because this gives rise to additional cost and is not considered necessary it has been omitted from the current design. TfL has indicated to those who wish to see provision made to accommodate a ticket hall at the western end of the station that provision could be made but only if there is a commitment from them to provide the necessary funding. It must also be provided in time to incorporate this additional facility into the scope of work to be carried out by the Design & Build contractor.

9.21 Because of the design timetable for the NLE scheme and the need to progress it in a timely manner in order to allow for the scheme to commence as quickly as reasonably practicable, there is a significant time constraint. If the funding commitment referred to above is not given by April 2014 then provision will not be made within the design for a ticket hall at the western end of the station. This would not make provision of such a ticket hall impossible in the future but it would make it more difficult and thus more expensive to construct.

9.22 The station box extends across the full length of the site from Wandsworth Road to the CGMA area across the properties of Banham Security, CGMA and Sainsbury's. The extended station box provides space necessary at each end of the station to accommodate stairs, vent shafts and equipment for the

safe operation of the Underground, including tunnel ventilation and draught relief.

9.23 The station box includes a transfer structure at surface level capable of supporting the equivalent of an 18-storey residential development. The transfer structure provides sufficient flexibility to allow the structural grid of the OSD to work independently of the structural grid of the diaphragm-walled box.

9.24 Several of the key station elements such as the passenger lift, stair core and escalators must rise from a fixed position at platform level to ticket hall level. While the escalators and lift must rise to ground surface uninterrupted other elements such as the stairs and ventilation ducts can transfer before they reach surface level.

9.25 The ticket hall building incorporates a roof that provides enclosure to ensure the station can remain fully operational during the construction, demolition and re-development of any future OSD.

9.26 The station entrances at the eastern end of the ticket hall are located on the north and south faces of the building to address passengers approaching in both directions along Wandsworth Road. The entrance to the north faces directly onto the pedestrian route that extends east-west through the site. This provides an enlarged station forecourt and helps signify the location of the ticket hall from the New Covent Garden Market and areas to the west.

9.27 The 4m high entrance to the ticket hall is splayed in plan with the opening reducing in width from approximately 9m to 5m. This splay is partly in response to the position of the main tunnel ventilation shafts and partly in order to maximise the street frontage. The splay also improves the sight-lines between street and ticket hall and produces a more pleasant approach to the ticket hall proper. The 4m height is also partly functional as it incorporates the clearances required for plant replacement from the basement levels, which will be via the ticket hall.

9.28 Each of the two entry points lead directly to the double-height ticket hall. The ticket hall is symmetrical in plan with the escalators on axis and back-of-house facilities to the sides. It is arranged for ease of movement and way-finding. The main space provides uninterrupted passenger flows through the gate line and down the escalators to platform level.

9.29 To achieve clear unimpeded passenger flows through the ticket hall, a number of the vertical shafts and risers were transferred at basement level. Ventilation, draught relief and the escape stair core all transfer at basement level to rise on the outside of the station box. However, the passenger lift/fire fighters lift has to be vertical. It rises to the north side of the ticket hall. Under normal circumstances the lift acts as the primary passenger lift with a waiting area to one side of the gate line. During an emergency the lift can be accessed independently by fire services from the escape core.

9.30 Plant is proposed to be located within the upper basement levels. This includes upper machine chambers, fan rooms, tunnel ventilation fans, DNO sub-station, traction substation and Powerlink switch room.

9.31 If plant needs to be replaced at any point this will have to be via surface level. Accordingly, a dedicated plant replacement void with a hatch in the ticket hall floor has been incorporated into the design to achieve this. The ticket hall has also been design to accommodate this. An unobstructed route for the movement of plant leading to the plant replacement shaft is maintained at each basement level.

9.32 The outline design for the redevelopment of the Sainsbury's site includes provision for a basement level car park to be accessed via Pascal Street. The design has been developed to accommodate the access to the car park in the form of a concrete box which cuts through the station box. The profile of the station box, and transfer structure, has been adapted to accommodate this access road. The requirements at this interface are the subject of agreement between Sainsbury's and TfL and will be developed further during the detailed design stage of the NLE project.

9.33 The station is proposed to have an island platform served by three escalators descending from the ticket hall above. The platform runs the entire length of the station box. Cores at each end of the station box provide ventilation ducts/shafts and intervention and evacuation stairs. Each core contains a pair of scissor stairs, a draught relief shaft and tunnel ventilation. Fire fighter lifts are also provided at each end of the box, although the lift to the eastern end, which is a combined fire and passenger lift, is the designated fire lift.

9.34 At each end of the station a 26 person lift serves between surface level and platform. Both lifts are fully pressurised, with lobbies at each floor, and are designed to function as a fire lift. The passenger lift in the ticket hall, which is a combined passenger/firefighting lift, is the designated fire lift. The lift to the west core will be used for small plant replacement.

9.35 The space beneath the platforms is given over to service corridors and plant; including the escalator lower machine chamber, under platform exhaust (UPE) and water holding tanks. Access to these rooms is provided from the accommodation stairs within the cores.

9.36 A head house building is proposed to the west end of the station and is designed along similar lines to the ticket hall building. The ground floor level houses the stairs and secondary lift. Due to the site gradient the point of exit from the escape stairs and secondary lift in this core is at approximately +2.0m OD. A half flight of stairs has been incorporated to achieve the required +3.43m OD minimum level recommended in the flood assessment report. This means that passengers evacuating will have to ascend from the platform to +3.43m OD and descend by approximately 1.5m to exit the station.

Construction at Nine Elms

9.37 In order to construct the works at Nine Elms a worksite is required. The main worksite in this vicinity is proposed to be located on the land to the north of Pascal Street, in the London Borough of Lambeth. This area currently forms part of the customer parking and a petrol station forecourt related to the Sainsbury's retail store. Banham Security have offices and a delivery fleet maintenance site within the western end of the worksite, along with CGMA also occupying offices within the central section of the worksite. CGMA also own the boiler house and buried fuel tanks located to the north of the worksite.

9.38 Consequently, in order to use the proposed worksite existing buildings on the site will have to be demolished as follows:

i. Banham Security, including its alarm response centre and delivery fleet maintenance site;

ii. An office building belonging to CGMA;

iii. The Sainsbury's petrol station;

iv. A UK Power Network substation located on Sainsbury's land; and

v. A UK Power Network substation located on CGMA land

9.39 The worksite will be used in different ways during different phases of the construction process but the facilities that it has to accommodate include:

i. Accommodation and office space

ii. Security entrance points

iii. Two bentonite farms to supply the diaphragm wall works

iv. Materials laydown area

v. Materials storage area

vi. Crawler cranes to support the diaphragm wall works

vii. Tower cranes to support the in-situ concrete works

viii. Hoist facilities to support the station fit-out works

ix. Space for vehicle access/egress/turning as well as delivery and offloading

9.40 The worksite will be accessed via Wandsworth Road. Exit from the worksite will be via Pascal Street. Material excavated from the worksite will be removed by road.

9.41 The worksite is shown on Figure 30. As with other worksites, every effort has been made to keep the area of land occupied by the worksite to a minimum.

10 NINE ELMS TO KENNINGTON

10.1 From the Nine Elms station box the tracks enter separate tunnels running east approximately 800m at a decline of approximately 1%, to a cross passage at Claylands about mid-way between Nine Elms and Kennington.

10.2 Immediately beyond Nine Elms station the track curves at an alignment radius of 365m which is slightly below the desirable minimum (400m).

10.3 The constraints in this portion of the alignment include the need to connect to the Kennington Loop, at the far end, at suitable locations. The tracks on the loop are such that there is a “cant” to the trackwork; this means that the outer rail lies at a vertical elevation which is higher than the inner rail over a significant length of the loop. A step plate junction requires both rails to be at the same elevation at the point of bringing new and existing tracks together. Accordingly, the locations for the step-plate junctions for the NLE is highly constrained and can only be effectively located where they are currently proposed (and which then results in the situation I have described in paragraph 10.2, above).

10.4 A further constraint arises from the need to provide three cross passages, two of which (CP1 and CP3) are required in accordance with the fire and evacuation strategy. The third cross passage (CP2) is located at the lowest point on the vertical alignment of the tunnels and therefore houses the drainage sump and pump. The tracks need to be aligned so that they are not too far apart either vertically or horizontally at the chainages where cross passages are required.

10.5 Cross passages CP1 and CP3 have to be provided at chainage distances dictated by the Fire and Evacuation Strategy.

10.6 The location of the cross passages is shown on Figures 31 and 32. They are 4.4m in internal diameter and have SGI linings, the geometry of which dictates the diameter in contrast to that adopted for the SCL lined cross passages (at 4.2m in diameter, which is the minimum size dictated by space-proofing).

10.7 The three cross passage are to be situated close to or within water bearing ground which creates a risk of encountering sand and/or pressurised water. As a result it would be inappropriate to use the SCL tunneling technique. Instead the SGI technique I describe above will be used to construct these cross passage tunnels.

10.8 Cross passage 2 is located at the lowest point along the alignment as water will collect here and it needs to be removed using a sump and pump located within this cross passage.

10.9 The alignment of the running tunnels in this stretch has to address the constraints presented by the Victoria line in the area of Rita Road. The proposed scheme passes under the Victoria line at this point.

10.10 The Northern line (Bank branch) station platform tunnels at Oval station also present a constraint to the alignment of the proposed NLE southbound running tunnel.

10.11 In addition, there are deep shelter tunnels in the vicinity of Oval station that are a remnant of wartime bomb shelter provision. These have been back-filled. These structures also present a constraint to the alignment of the proposed NLE southbound running tunnel.

10.12 A further constraint is present in the form of the escalators. Escalators are highly sensitive to ground movements. As a result, the design has sought to avoid running directly below Oval Station escalator tunnels in order to minimise any potential effect upon them.

10.13 The Southbound tunnel then continues underneath Kennington Park before arriving at Kennington Park Shaft.

10.14 The northbound running tunnel alignment steers east then to the north-east at the Oval cricket ground, before it arrives at Kennington Green Shaft.

10.15 The TBM used to construct the southbound running tunnel will be removed via the shaft proposed at Kennington Park. The TBM used to construct the northbound running tunnel will be removed via the shaft proposed at Kennington Green.

10.16 The running tunnels from the shafts to the step plate junctions at Kennington Station will be constructed using the SCL technique I have described above. I address this in more detail in Chapter 14.

11 CLAYLAND ROADS SHAFT

11.1 In the initial scheme development, three permanent intervention and ventilation shafts were proposed in the general areas of Kennington Park, Kennington Green and Claylands Road. From a long list of possible options, a preferred option was identified which put the shaft at Claylands Road in the centre of Claylands Green with the head house located on the site of garages to the south-west of the Green in Cottingham Road connected to the shaft by an adit.

11.2 The general location of this intermediate shaft and the other two permanent shafts was indicated by the usual requirement for an intervention and access point to be provided every 1km along an underground railway.

11.3 Consultation with the public and other stakeholders identified increasing opposition to a shaft at Claylands Green. As a result, TfL commissioned further study work to examine whether an alternative ventilation and Fire and Evacuation Strategy solution could be identified which would satisfy the London Fire and Emergency Planning Authority (LFEPA)

11.4 This study undertaken is described in the Report of "TfL's review of intermediate shaft (the 'Claylands Green Shaft')" June 2013 **[NLE/C11]**.

11.5 The study resulted in the identification of an alternative approach to the Fire and Evacuation Strategy. In the event of an emergency within a running tunnel, emergency services would be afforded access to the incident via the running tunnel which is not affected. Additional safety features would be incorporated including a walkway within the running tunnels, alongside the track at track level, suitable for the use of the emergency services. The walkway has to be wide enough for emergency services personnel, with their equipment, to make their way past a train on the track. This required the walkway to be one metre wide. Noting that the evacuation of the trains by passengers was to remain from the ends of the trains, and down on to the track, there was also a requirement that traction current could be switched off over sections of the track where passengers would be escaping.

11.6 This approach also had other impacts on other elements of the project. In particular:

i. The running tunnels had to be increased in internal diameter from 4.75m to 5.2m in order to accommodate the walkways;

ii. The capacity of the ventilation systems proposed at Nine Elms station and the Kennington Green and Kennington Park shafts would have to be increased;

iii. A traction sub-station proposed at Claylands Green would have to be accommodated at Kennington Park.

11.7 The track alignment was also reviewed. However no changes to the alignment were identified as appropriate or necessary as a result of the deletion of the intermediate shaft at Claylands Green.

11.8 The alternative approach I have described above was considered acceptable to the LFEPA. Accordingly, a shaft at Claylands Green is no longer required and this does not form part of the NLE scheme before the Inquiry.

12 KENNINGTON GREEN SHAFT

General Considerations Relating to the Design of Shafts

12.1 As I have explained previously, permanent ventilation and intervention shafts are provided to ensure safety and comfort within tunnels once the underground railway is operating.

12.2 The NLE requires a shaft around the area of Kennington Green (northbound tunnel) and at Kennington Park (southbound tunnel). Separate shafts are required because the tunnels are far apart at this section of the route due to the need to connect at different points on the Kennington Loop for the northbound and southbound running tunnels.

12.3 New railways or extensions to existing railways must be designed in accordance with current safety legislation and standards. This means they must include a safe means of escape for passengers in the event of an incident and also a means of safe access for intervention by the emergency services, both of which must meet current standards.

12.4 Safe emergency escape is normally provided at stations by a combination of the normal exit/entry points and dedicated emergency escape stairs located at each end of the platform which are housed within a shaft protected by fire doors and pressurised to maintain a smoke-free environment.

12.5 Safe access for intervention by the emergency services is normally provided via these same stairs at the station and where the distance between stations is excessive via intermediate shafts, which are then identified as intervention shafts.

12.6 The stairs within intermediate shafts are usually protected at track level by fire doors and are pressurised. This allows the emergency services to get as close to the incident as possible before entering the tunnel and a potentially smoke filled environment, at which point they would have to rely on their personal breathing apparatus. A pressurised shaft thereby gives them maximum time at the incident before they have to return to replenish their oxygen supply.

12.7 Safe access within the tunnel is normally achieved by installing a tunnel ventilation system consisting of fans located at each of the stations and, where appropriate, intermediate ventilation shafts often combined with the intervention shafts described above. These fans work most efficiently in a push-pull mode with adjacent fans either extracting or in taking air. The fans are reversible so that they can be configured so that the direction of the smoke can be controlled and not drawn over a non-incident train. These fans are considered safety critical equipment so it is normal practice to provide a duty and stand-by fan such that if one is faulty or out of use for maintenance the railway can still operate.

12.8 These systems together with operational procedures will ensure that the tunnel ventilation system is configured appropriately and ensure that

passengers are evacuated away from the incident via a smoke-free environment and not into any area where traction current is still on and with trains potentially still moving.

12.9 Tunnel ventilation is also required occasionally under normal operating conditions. For most of the time the movement of the trains and the resulting “piston effect” allows temperature in the tunnels to be maintained at an acceptable temperature for passenger comfort. At times of extreme hot weather or when the train service is disrupted and trains are standing in the tunnels then the tunnel ventilation fans will run at low speed to assist tunnel cooling.

12.10 Shafts can also be used to connect the railway with a ground level traction power source for train operation if required. The location of the shaft for this purpose is dictated by the limited distance that a low voltage power supply can travel. An initial power supply simulation indicated that a sub-station is required at a point between Kennington and the proposed Nine Elms intermediate station and provision for this has been made in the design of the shaft at Kennington Park.

12.11 In broad terms, the function of a shaft determines its location. Ideally the surface features (head houses) associated with these intermediate shafts are located immediately above the shaft as this makes maintenance and plant replacement activities easier and also reduces the time for the emergency services to again access from the street to the track.

12.12 If locating the head house over the shaft is not possible then the head house can be located offset from the shaft with an underground adit, usually just below ground level, connecting the two. This configuration is proposed for the shaft at Kennington Green with the head house located on the edge of the Distillery yard.

12.13 There is no set distance between the shaft and the head house but the London Fire and Emergency Planning Authority (LFEPA) has indicated that a distance materially in excess of 50 m should be avoided.

12.14 In addition the emergency services need direct access to the head house from the public highway, ideally with a dedicated hard standing off the public highway. It must be possible to park a fire tender within 18m of the fire main inlet value and have direct line of sight between the inlet valve and the hydrant.

12.15 The location and orientation of the head house need to be such that it expels air at a height not less than 2.4m and in a direction away from sensitive receptors (such as residential properties).

12.16 In general, the ideal location for a permanent shaft would be as close to Kennington station as possible. This is because the further away from the station these shafts are located, the longer the length of new tunnel is not fully protected by the tunnel ventilation system. However, if the shaft is located beyond the connection of the NLE and Kennington Loop and/or the bifurcation

of the existing line, then control of smoke would become more difficult and less efficient because of the complex arrangement of tunnels and the potential risk of drawing smoke into the Loop or Morden branch tunnels.

12.17 With the NLE in place, and in the absence of the shafts, the existing Northern line would not have a tunnel ventilation system capable of controlling smoke in the event of an incident; neither does the existing Kennington station have a fire protected route from street to platform level. The permanent shafts provide a means to fulfil the intervention and ventilation requirements of the NLE.

12.18 As already indicated, where the head house is offset from the shaft, an adit containing an air duct connecting the shaft to the head house will need to be constructed to link the two. The air duct has to be above the level of the fans and any attenuators that are in the shaft. This constraint locates the adit at just below ground level. Therefore the adit has to be constructed using cut-and-cover methodology rather than bored (TBM) or mined (SCL) tunnelling, neither of which are suitable for use at this shallow depth. Therefore, in appraising options which include an adit, it is important to consider the effects of this construction methodology in that particular setting.

12.19 Furthermore, any option that has an adit will increase costs as a result of constructing the adit itself. If the adit passes underneath a public highway or access road it will cause disruption to the road and is likely to require utility diversions if these are provided under the road. If the adit were to run underneath a property, it would be likely to require the demolition of that property in order to be constructed.

12.20 In addition to these matters, it is also necessary to identify an appropriate worksite in order to be able to construct a shaft and head house. A worksite that is sufficiently large to provide appropriate space and access for construction vehicles is necessary. It must also be proximate to the location of the proposed shaft.

The Kennington Green Shaft Proposal

12.21 A need for a shaft to be located in the Kennington Green area was identified in order to provide appropriate ventilation and emergency access to the northbound running tunnel.

12.22 In addition the creation of a shaft at Kennington Green will allow for the removal of the northbound running tunnel TBM. It also allows for the construction of the northbound running tunnel to the step plate junction at the Kennington Loop by means of the SCL technique.

12.23 The presence of the shaft also assists in protecting the existing sections of the Northern Line and Kennington Station from the effects of smoke in the event of a fire within the NLE tunnels between Kennington and Nine Elms.

12.24 The proposal is for a shaft at Kennington Green linked by an adit to a head house in the yard of the nearby Beefeater Gin Distillery. The proposed shaft at Kennington Green would be sited some 420m from Kennington station.

12.25 The shaft would be 13.5m in diameter to accommodate fans, attenuators, firefighters' emergency stairs and maintenance access for fan and other plant replacement. The shaft is immediately above the running tunnel in order to remove the tunnel boring machine. The shaft will be lined with precast concrete segmental linings.

12.26 The head house would be approximately 100 square metres in size to accommodate sufficient free air space for ventilation and smoke extract ducts, an electrical switchroom, a fire valve cupboard and access stairs for both maintenance and emergency service. The site for the head house forms part of the Beefeater Gin Distillery's land; it is shielded from the road by a screen wall.

12.27 The overall massing of the head house has been driven largely by the technical requirements for the vents and the measure of separation required between them, depending on their function. One such requirement has been to side vent rather than top vent, particularly given the proximity of flammable substances within the distillery compound. The vents therefore exhaust or draw air from either Montford Place or Kennington Green rather than from the distillery side.

12.28 The proposed site for the head house is the yard of the Beefeater Gin Distillery. The site is owned by Chivas Brothers Ltd (CBL). This site is an HMRC bonded warehouse and, as a functioning distillery, must meet health and safety requirements regarding, for example, the unloading of ethanol. In discussions with TfL, CBL has indicated that it is in principle possible to change the details of the bonded area if required.

12.29 During early engagement between THUK and CBL, while detailed issues remained to be addressed, the concept of siting the head house within the distillery appeared to be acceptable to CBL.

12.30 During 2012 and early 2013 TfL met with the landowner to discuss this option, from perspectives including:

i. CBL's own aspirations for its site and how these might be accommodated;

ii. The design of the head house;

iii. The safety of the operation of the distillery and the head house alongside each other;

iv. Minimising disruption to distillery operations.

12.31 In order to fulfil the requirements set by its insurer, CBL intends to construct a water tank for firefighting purposes, which it would like to site on the same

location as the proposed head house. Other locations within the distillery, such as its basement, are not considered by CBL to be suitable.

12.32 To accommodate CBL's concerns, TfL has acquired nearby vacant land previously owned by Tesco. Planning permission has now been granted for the water tank and a new tanker filling station to be located on the former Tesco owned land. There is thus no impediment to the provision of the water tank, as desired by CBL, and it is anticipated that CBL will shortly be in a position to withdraw its objection to the NLE.

12.33 The potential risks of operating the Kennington Green head house alongside the distillery have been examined and information about the low level of risk and appropriate mitigation was provided to CBL on the 14 February 2013. .

12.34 The proposals at Kennington Green also include an adit which would be constructed by cut-and-cover. However, this adit runs from the shaft along the length of the Green before running westwards under Kennington Road, which is a minor road at this location here, to the distillery yard. It does not disrupt the main access route into the distillery and does not run under any property. It meets the head house just behind the distillery wall. So its impact on the distillery property is minimal.

Appraisal of Shaft Options at Kennington Green

12.35 I have described the early development of the scheme design, which identified the need for three permanent and two temporary shafts for the NLE. Work was then undertaken to identify and appraise potential sites.

12.36 Prior to TfL, becoming the sole promoter of the scheme, a workshop was held on 16 April 2010 to appraise options for each shaft site in the light of their functionality and according to agreed criteria, which were given weightings reflecting their relative importance. It was attended by representatives from London Borough of Southwark, London Borough of Lambeth, TfL and their technical and legal advisors as well as the then promoter, Treasury Holdings UK (THUK).

12.37 For the permanent shaft over the northbound running tunnel, four options were considered, as shown on Figure 33:

1 Shaft in centre of Green with head house over

2 Shaft in centre of Green with access provision over, with ventilation provision in the distillery (yard)

3 Shaft in centre of Green with head house in distillery (yard)

4 Shaft and head house in distillery yard, worksite on Green

12.38 Option 3 was identified as the preferred option. A particular advantage of this option was that it did not entail permanent loss of amenity on the Green.

12.39 The local planning authority, London Borough of Lambeth, has been involved in the selection of this shaft site from the start and has endorsed the proposed option subject to an appropriate design for the head house being in place.

12.40 In response to consultation by CBL a further review of options for a shaft was undertaken and is set out in the report entitled "TfL's review of alternative locations for the Kennington Green permanent intervention and ventilation shaft" **[CD NLE/C10]**.

12.41 This document appraised ten alternative options against a set of criteria that included engineering and design feasibility together with the availability of a suitable worksite. I speak to these matters whilst others can speak to the appraisal against the remaining criteria.

12.42 In engineering terms all of the options appraised are inferior to the proposals contained within the Order scheme with the exception of those options which involve locating the head house directly above the shaft, such as option 8 which placed the head house permanently on Kennington Green itself. But these options have to be assessed with reference to not just simple engineering considerations.

12.43 Further detailed examination of single shaft options at Kennington station and the Vauxhall Telephone Exchange has been undertaken more recently and I provide a report arising from that study at Appendix 4.3.

12.44 In respect of a single shaft at Kennington station this study draws a number of conclusions including that:

i. A number of residential properties and gardens to residential properties would have to be acquired and used to provide a shaft and a worksite;

ii. A programme delay of some 5 months would be caused;

iii. Cost increase in the order of £15m, excluding any programme elongati on and acquisition of existing properties.

iv. The shaft location would not comply with the LFEPA's spacing requirements and would result in a greater distance between intervention points that the current scheme proposes;

v. The proposal would increase settlement risks and the burden of settlement management compared to the current scheme;

vi. The likelihood is that temporary grout shafts would have to be provided to manage the potential settlement effects of the provision of adits;

vii. There would be a need to provide an adit under the existing Northern line which would give rise to additional settlement management risks;

12.45 In respect of a single shaft at the Vauxhall Telephone Exchange this work essentially drew similar conclusions to those set out in the previous paragraph with the exception that the additional costs would be £8m not £15m.

12.46 Further work has also been undertaken to examine the detail of a potential alternative of using 373 Kennington Park Road as this has been suggested by some objectors. Again, I can comment on this potential alternative from a purely engineering standpoint but there are other considerations that have to be taken into account which are addressed by Mr de Cani **[TFL1/A]**.

12.47 The most significant issues from an engineering perspective are as follows:

i. Due to the added complexity of the construction methodology (such as demolition of existing buildings and construction of the acoustic shed), the construction period at the 373 Site would be approximately 24 weeks longer than that for the proposed scheme at Kennington Green. This would extend the construction programme by two weeks.

ii. Locating the shaft at the 373 Site would result in the SCL tunnelling methodology being used for a shorter extent resulting in a reduction in costs. However, the need to demolish existing buildings and construct and dismantle an acoustic shed would negate these savings and lead to an overall increase in construction cost compared to the proposed site.

iii. Locating the shaft at the 373 Site would result in full ventilation functionality being provided for a greater length of running tunnel of approximately 100m. It could also result in the head house being located above the shaft, rather than connected by adit.

12.48 Overall, from a purely engineering perspective, locating a shaft at 373 Kennington Park Road has no significant advantages over and above the proposed scheme.

Worksite

12.61 The Kennington Green Shaft's worksite will impact on the Green and its surroundings. However, the operation of the worksite will be subject to the NLE's Code of Construction Practice and the area of the worksite will be reinstated upon completion of the works. The use of land purchased from Tesco and adjoining the neighbouring Gin Distillery would permit a small reduction in the impact of the worksite in the immediate vicinity of the Green.

12.62 The configuration of the Shaft is shown on Figure 34. The area occupied at the Green will be approximately 2,150m^2. Overall requirements for the worksite, which is shown on Figure 35, include:

2.4m high hoarding

60T/100T crane

Muck bin (12m x 9m)

Diesel tank (with bund) (5 x 4m)

Double stack welfare and office accommodation (9 x 3.5m)

Two stores (9 x 3.5m)

Two security cabins (2 x 3m)

Batching plant and segmental lining store (12 x 9m)

Stand-by crane (5 x 3m)

Shaft skip (4 x 3m)

Main riding cage (2 x 2m)

Compressor (2.5 x 1.5m)

Generator (3.5 x 1.5m)

Occasional temporary closure of roads would be required during works for the siting of large mobile cranes for periods of approximately 48 hours for activities such as the removal of the TBM.

12.63 The excavated material from the worksite will be removed by road. The likely traffic generated by this worksite is outlined in the appendices to the Proof of Evidence of Mr Bowers **[TFL7/B]**.

13 KENNINGTON PARK SHAFT

13.1 I have already described above some of the general considerations relating to the need for, and design of, intermediate ventilation and intervention shafts. These matters are all obviously relevant to the proposed shaft at Kennington Park.

13.2 A need for a shaft to be located in the Kennington Park area was identified in order to provide appropriate ventilation and emergency access to the northbound running tunnel.

13.3 In addition the creation of a shaft at Kennington Park will allow for the removal of the southbound running tunnel TBM. It also allows for the construction of the southbound running tunnel to the step plate junction at the Kennington Loop by means of the SCL technique.

13.4 The presence of the shaft also assists in protecting the existing sections of the Northern line and Kennington station from the effects of smoke in the event of a fire within the NLE tunnels between Kennington and Nine Elms.

13.5 The proposal is for a head house to be constructed in the north-eastern corner of Kennington Park, which is occupied by a lodge and some recently constructed timber structures. The shaft is proposed to be located in the Park and will be connected to the head house via an underground adit. The proposed shaft location in Kennington Park is 320m from Kennington station. The configuration of the shaft is shown on Figure 36.

13.6 The shaft would be 13.5m in diameter to accommodate fans, attenuators, firefighters' emergency stairs and maintenance access for fan and other plant replacement. The shaft is immediately above the running tunnel in order to remove the tunnel boring machine. The shaft will be lined with precast concrete segmental linings.

13.7 The head house would be approximately 100m^2 to accommodate sufficient free air space for ventilation and smoke extract ducts, an electrical switchroom, a fire valve cupboard and access stairs for both maintenance and emergency service.

13.8 The overall massing of the head house has been driven largely by the technical requirements for the vents and the measure of separation required between them, depending on their function.

13.9 At Kennington Park a substation is also to be constructed which is linked to the shaft. The substation is constructed below ground using cut-and-cover construction methods over two basement levels. The first basement level incorporates the ventilation adit linking the shaft to the head house and the second the traction power substation. This structure is constructed using secant piled walls and is internally constructed using reinforced concrete.

13.10 The adit runs from the shaft through the park to the parcel of land on which the lodge currently stands. As it is entirely in the Park it does not run under any property, however the junction of Kennington Park Road and Kennington Park Place will experience some congestion.

13.11 Early development of the scheme design identified the need for three permanent and two temporary shafts, although now the only shafts proposed are the two permanent shafts at Kennington Green (described above) and Kennington Park.

13.12 A workshop on 16 April 2010, prior to TfL taking on sole promotion of the scheme appraised options for each shaft site in the light of their functionality and according to agreed criteria, which were given weightings reflecting their relative importance. It was attended by representatives from the London Boroughs of Southwark and Lambeth, TfL and their technical and legal advisors as well as the then promoter, Treasury Holdings UK (THUK).

13.13 For the permanent shaft over the southbound running tunnel, three options were considered:

Option 1 Shaft in park with head house over
Option 2 Shaft in park and access provision over, with ventilation provision in lodge
Option 3 Shaft in park with entire head house in lodge

13.14 Option 1 was identified as the preferred option, largely due to its lesser impact on property, ecology and its marginally better ventilation efficiency.

13.15 The local planning authority, London Borough of Lambeth, has been involved in the selection of this shaft site from the start and has endorsed the proposed option subject to an appropriate design being in place.

13.16 In response to subsequent public consultation a further review of options for a shaft was undertaken and is set out in the report entitled “TfL’s review of alternative locations for the Kennington Park permanent intervention and ventilation shaft” **[NLE/C10]**.

13.17 This document appraised six alternative options against a set of criteria that included engineering and design feasibility together with the availability of a suitable worksite. I speak to these matters whilst others can speak to the appraisal against the remaining criteria.

13.18 The six alternative options appraised were:

Option 1: shaft, head house and worksite within the Veolia compound

Option2: shaft in Park, head house on Veolia compound and worksite in Park and Veolia Compound

Option 3: shaft, head house and worksite at Kennington station

Option 4: shaft, head house and worksite at Oval Green (which is a traffic island close to Oval station and between Kennington Park Road, Camberwell New Road and Brixton Road)

Option 5: shaft, head house and worksite in Park

Option 6: shaft, head house and worksite at Vauxhall Telephone Exchange

13.19 Again, all of the options are, necessarily, situated within a densely populated and highly developed urban area. This has been a major constraint in identifying potential sites: there simply is very little suitable land which is not already in residential, commercial or social amenity use.

13.20 Option 1 would require a change in the running tunnel alignment. It is also less efficient in terms of the provision of ventilation and smoke extraction than the proposed shaft. While this option removes the need for the acquisition of land in the Park, it would require the relocation of the waste operations undertaken here. There is no obvious alternative location available for these services and the local authority does not support this option.

13.21 Option 2 also results in a shaft that is further from Kennington station than the proposed scheme. Again it is less efficient in terms of the provision of ventilation and smoke extraction than the proposed shaft. This option still requires the use of the Park and would also impinge upon Veolia's waste operations.

13.22 Option 3 is the same option as that considered as Option 9 in relation to Kennington Green above. It involves the construction of a shaft at the rear of Kennington station. The shaft and head house would need to be linked to the running tunnel by a long adit which could only be constructed by cut-and-cover techniques due to its shallow depth if passing over the existing tunnels. The route would traverse residential properties. Thus this option would be likely to require demolition of some residential properties. Further the TBM could not be removed via the shaft. Instead dismantling chambers would have to be constructed using SCL at Kennington station to receive the TBM. The TBM would then be dismantled and removed via Nine Elms or Battersea. The construction of the shaft, adit and dismantling chamber is likely to cause significant and prolonged disruption to services at Kennington station. The proposed temporary grout shafts at Radcot Street and Harmsworth Street in connection with the formation of the step plate junction would once again be required as the construction of gallery tunnels via the Kennington Green shaft would no longer be possible.

13.23 Option 4 would locate all the necessary facilities at Oval Green. It would result in a shaft that is further from Kennington station than the proposed shaft resulting in less effective ventilation and smoke control. Further the geological ground conditions for tunneling are more difficult in this area that in the

proposed location, giving rise to greater settlement risks and a greater burden of settlement monitoring and mitigation. There is also uncertainty regarding the presence of former war time bomb shelters in this area. This option also gives rise to potential highway safety implications as there is potential for the head house to block visibility sightline for highway users.

13.24 Option 5: This option would locate all the necessary facilities within the park. It is a better engineering solution that the option pursued as part of the scheme because the shaft is above the alignment, the head house is above the shaft and it provides direct access to the head house from the street. However it results in permanent loss of part of Kennington Park and was a much less popular option during public consultation than the shaft which is now proposed as part of the NLE scheme.

13.25 Option 6: This option locates all the necessary facilities within the Vauxhall Telephone Exchange site. This option is the same as Option 10 studies in relation to the Kennington Green Appraisal and referred to above. It would not be located in a position that would comply with distance requirements between intervention points. Again, the shaft and head house would need to be linked to the running tunnel by a long adit which could only be constructed by cut-and-cover techniques if passing over the existing tunnels due to its shallow depth. The route would traverse residential properties. Thus this option might require demolition of some residential properties. Again, the TBM could not be removed via the shaft. Instead dismantling chambers would have to be constructed using the SCL technique at a point near the step plate junction at Kennington station to receive the TBM. The TBM would then be dismantled and removed via Nine Elms or Battersea. The construction of the shaft, adit and dismantling chamber is likely to cause significant and prolonged disruption to services and Kennington station. The proposed temporary grout shafts at Radcot Street and Harmsworth Street would be likely to be required as the construction of gallery tunnels via the Kennington Green shaft would no longer be possible.

13.26 It follows that in engineering terms all of the options appraised are inferior to the proposals contained within the Order scheme with the exception of option 5. Option 5, of course, involves locating the shaft and head house permanently on Kennington Park itself. The merits of this appraisal have to be appraised in terms other than simply engineering considerations. I understand that it is generally regarded to be unacceptable due to the permanent loss of open space within the park.

13.27 Kennington Park worksite will be located at the north-eastern corner of Kennington Park. In order to commence the traction substation works reconfiguration of the worksite will be required. The worksite will be reinstated upon the completion of the works. The proposed worksite is shown on Figure 37.

13.28 The site compound will be approximately 3,000m² and include:

2.4m high hoarding

60T/100T crane

Muck bin (10 x 10m)

Diesel tank (with bund) (5 x 4m)

Double stack welfare and office accommodation (9 x 3.5m)

Two stores (9 x 3.5m)

Two security cabins (2 x 3m)

Batching plant and segmental lining store (10 x 10m)

Stand-by crane (5 x 3m)

Shaft skip (4 x 3m)

Main riding cage (2 x 2m)

Compressor (2.5 x 1.5m)

Generator (3.5 x 1.5m)

13.29 Access to the site would be via Kennington Park Place, requiring the relocation of the existing car parking. Occasional temporary closure of this road would be require during works for the siting of large mobile cranes for periods of approximately 48 hours for activities such as the removal of the TBM.

13.30 The excavated material from the worksite will be removed by road The likely traffic generated by this workside is outlined in the appendices to the Proof of Evidence of Mr Bowers **[TFL7/B]**.

14 CONNECTION TO KENNINGTON LOOP

14.1 The two proposed shafts will be used for construction of the SCL running tunnels between the shafts and the step plate junctions to connect the NLE track to the Kennington Loop. I have already explained above that the location at which this connection can be made is constrained by the need to connect at a point where the existing track within the Kennington Loop is level (i.e. without a difference in elevation between the two rails).

14.2 In order to construct the running tunnels between the permanent shafts and the step-plate junctions two construction methods were considered. These were named Method A and Method B.

14.3 For Construction Method A the entire route except at the stations, overrun tunnels, platform tunnels and step plate junctions would be constructed below ground level in bored tunnels driven by TBMs. The tunnels would be driven from Battersea as I have described but would pass through the permanent ventilation/intervention shafts at Kennington Green and Kennington Park before joining the existing underground tunnels of the Northern line at the Kennington Loop by using step-plate junction techniques just south of Kennington station. Under Method A, the TBM would stop at a dismantling chamber adjacent the step-plate junctions and the cutter head would be removed before the TBMs are taken back and dismantled and removed at the permanent Kennington Green and Kennington Park shafts. Temporary shafts would be constructed at Radcot Street and Harmsworth Street to build the dismantling chamber and also undertake possible ground treatment and groundwater control required for the step plate junction construction.

14.4 For Construction Method B, the TBMs would be driven in a similar manner to Construction Method A but would stop and be removed at the permanent shafts at Kennington Park and Kennington Green. The running tunnels between the permanent shafts and step-plate junctions would then be constructed by SCL techniques. Possible ground treatment and groundwater control required for the step-plate junctions and the SCL running tunnels would be undertaken by gallery tunnels themselves constructed using the SCLE technique, which would run parallel to the step-plate junctions. No temporary shafts would be required for Construction Method B.

14.5 Both methods were assessed in the Environmental Statement **[TFL/A19/1]**, with further information provided in the ES Addendum **[TFL/A19/8]**.

14.6 The preferred construction option could only be prudently selected once the procurement process had progressed further that it had at the time when the TWAO Application was made. Since then the procurement process has advanced to a sufficient stage to enable TfL to confirm that Option B is considered to be an appropriate technical option. When taking into account proposed mitigation, both options were considered to be acceptable in environmental terms, but Option B would not require the temporary shafts, eradicating construction work in Radcot Street and Harmsworth Street. It is also considered that Method B may result in a shorter overall construction

programme. Construction Method A is now not pursued as part of the NLE project.

14.7 I therefore describe Construction Method B is more detail and this is illustrated by Figures 38 and 39.

14.8 Once the Kennington Green and Kennington Park shafts have been constructed, two gallery tunnels of approximately 3.5m internal diameter would be constructed from the shafts parallel to and at a higher level than the proposed SCL running tunnels using the SCL technique. To avoid interference with the Kennington Loop, the galleries are located to the north of the proposed northern running SCL tunnel alignment and to the south of the proposed southern running SCL tunnel alignment.

14.9 The gallery tunnels are required in order to be able to provide ground treatment such as compensation grouting and for groundwater control purposes.

14.10 Compensation grouting is a technique that enables ground settlement to be carefully controlled. It is a well-established technique employed on tunnelling projects around the world to minimise settlement. Indeed, it was used to protect what is now named Elizabeth Tower at the Houses of Parliament (but which is better known as Big Ben) during the construction of the very deep excavation to provide the Jubilee Line station at Westminster.

14.11 It works by injecting a cement-based paste-like substance, called grout, into the ground to firm up the area where settlement is expected to occur. The grout is injected via small-diameter underground pipes (called “tube-à-manchettes” [TAMs]) placed within the ground and radiating from the shaft like spokes of a wheel. This method can be employed very precisely and is an effective way of minimising settlement damage to buildings.

14.12 After completion of the gallery tunnels the 5.2m diameter running tunnels will be constructed using SCL techniques.

14.13 In order to connect the new running tunnels to the existing Northern line Kennington loop a step plate construction methodology is proposed. This method involves staged excavation and staged support installation around the existing running tunnel. It will be constructed using SGI lining techniques (as I have described previously). The step plate junction will be constructed in a stepped, cone shape of decreasing diameter SGI tunnel linings until it is just larger than the existing tunnel on the Kennington loop. The final connection is made during railway possessions when the existing track bed is removed, and the new track alignment installed.

14.14 In this way the junctions can be provided so as to avoid compromising the operation of the existing NLE during the majority of the construction works.

14.15 After completion of the SCL running tunnels and the step plate junction works the gallery chambers will be backfilled with concrete.

14.16 The worksites use to support the construction of the features described in this section are those at Kennington Green and Kennington Park. All material excavated will be removed by road from those worksites as described above.

15 KENNINGTON STATION

15.1 Kennington station is an existing Underground station serving as an interchange between the Charing Cross and Bank branches of the existing Northern line.

15.2 The station has four parallel platforms, with the two northbound tunnels in the London Borough of Lambeth and the two south bound tunnels in the London Borough of Southwark. The two centremost tunnels were built as part of the original station; the remaining two were added in 1926 when the Charing Cross, Euston and Hampstead line was connected to the station (now the Charing Cross Branch of the Northern line). The station consequently provides a northbound and southbound connection to both branches of the Northern line.

15.3 It has two southbound and two northbound platforms, with three and four cross passages respectively. The majority of southbound Charing Cross branch trains terminate at Kennington; they then go around the Kennington Loop to the northbound Charing Cross branch platform, while southbound Bank branch trains continue to Morden. Due to the NLE, Charing Cross branch trains will continue to Battersea. There will be an increase in passenger interchange at Kennington station as a consequence of the NLE as passengers transfer between the two branches. To mitigate the effect of the increased number of interchanging passengers and to improve safety, four new cross passages will be constructed at Kennington station as part of the NLE project, two each between the northbound and the southbound platforms. More detail is provided in the Proof of Evidence of Mr Bowers **[TFL7/A]**.

15.4 The NLE proposed works are limited to platform level only. The layout of the existing station at platform level and the layout of the proposed arrangement with the addition of the cross passages are shown on Figure 40.

15.5 The cross passages will have an internal diameter of 4.4m and will be constructed using the SGI technique I have described previously.

15.6 Except for areas directly occupying station platforms, there will be no worksite at Kennington station and access to the station platforms will be by works trains operating during engineering hours.

16 GROUND MOVEMENT

16.1 London pioneered the construction of underground railways in the mid nineteenth century, and it now has one of the most extensive underground systems in the world. The NLE project is very far from being the first project of its kind, but instead can be described as the latest in a long succession of railway infrastructure projects in London. There is much to be learnt from previous projects, especially those in recent decades, and the assessment methodology and mitigation techniques described in this section of my evidence draws upon the lessons derived from them.

16.2 The potential impacts on buildings from the construction of the NLE considered here are from the effects of ground movement on buildings as a result of tunnelling and other deep excavations. Most people are unfamiliar with what these are likely to be and the methods used to predict their scale and extent. So it is useful to say something about their impacts on buildings, and to set those impacts in the context of the types of movement which most buildings experience during their existence.

16.3 Prior to the requirement for piled foundations to support increasingly high and heavily-loaded structures, London buildings were mostly founded on strip footings in the stiff clays and gravels of the region. Many buildings will have settled after construction, generally within ten years of their completion, and sometimes their owners have repaired any damage that occurred (primarily repairs to cracks in the fabric of the buildings).

16.4 Settlement under load in clays and alluvial soils is generally complete in the first decades of a building's life, but buildings also experience seasonal movement throughout their life, especially in dry years. Many buildings founded on strip footings have settled unevenly by more than 25mm since they were first completed, and have responded to this movement without structural failure.

16.5 Thus settlement movements resulting from tunnelling have to be understood in the context of the other forms of movement which most buildings experience.

16.6 Tunnelling and excavation produce settlement movements of the ground above and nearby. The movements are usually downwards but horizontal movements can occur as well. These movements have effects (impacts) on buildings above or near to the new tunnels or excavations only where the ground movements at one part of the building are different from those at another part.

16.7 If the whole of the building settles a uniform amount, say 25mm, it usually experiences no detrimental effects. Indeed the whole of Central London has sunk some 200mm since 1800 as a result of water abstraction from the underlying Chalk, but this has not had any adverse effect on the buildings involved.

16.8 Tunnelling or excavation can produce different movements at various parts of a building. These are called differential movements and a building can respond in a number of ways, depending on its construction and the nature of its finishes.

16.9 The approach to the prediction of settlement has been developed through work on the Jubilee Line Extension (JLE), Channel Tunnel Rail Link (CTRL) and Crossrail. The process allows the nature of the likely building response to be assessed and allows measures to protect the building to be identified where necessary.

16.10 The NLE project has adopted the same approach as used and approved by both Houses of Parliament during the passage of the Crossrail Bill.

16.11 The assessment is undertaken in three phases as summarised by Table 3.

Phase 1

16.12 In the first phase, Phase 1, simple criteria are used, based on predicted settlement at the ground surface, to eliminate buildings which are subjected to minimal effects from the need for further study. Other than Listed Buildings, any buildings forecast to be subjected to settlement of less than ten millimetres are judged to be only experiencing minimal effect.

16.13 Ten millimetres is a very small amount of movement. To put this into context, buildings can naturally encounter settlement of this magnitude due to seasonal factors. Depending on where the building is in the country and what kind of soil it is on, very hot summers can result in ground movement. That is because clay soils, in particular, are sensitive to seasonal changes in moisture content. If there is a reduction in moisture content in the soil due to drying conditions there is an accompanying reduction in volume and this results in shrinkage which can manifest itself as settlement. In reverse, as a consequence of wetting, those same soils can increase in volume and that results in heaving. It is well-known from many measurements that have been taken that buildings can quite easily experience movements of the order of 10 millimetres just seasonally from effects such as hot summers followed by wet winters.

16.14 To apply the 10mm Phase 1 threshold, surface settlement contours resulting from tunnelling (and other excavation work) are produced based on methods of analysis that predict the settlement from theoretical and empirical ("observed") relationships. Structures within the 10mm settlement contour are subject to further assessment. The 10mm contour is selected as the cut-off on the basis of empirical evidence from other tunnelling projects. Buildings subjected to less than 10mm of settlement have consistently been shown to suffer damage categorised as negligible.

16.15 A key input into the modeling exercise is the assumption made regarding volume loss in connection with tunnelling. The term "volume loss" requires some explanation.

16.16 As the formation of the tunnel (for example, using a TBM) advances through the ground, at the ground surface an area of settlement develops both ahead of and to the sides of the tunnel face. After the tunnel has passed through, at right-angles to the direction of tunnelling there is a residual saucer-like depression at the ground surface, centred on the longitudinal axis of the tunnel, which is called the settlement "trough".

16.17 For the same diameter of tunnel, a deeper tunnel generates a smaller magnitude of settlement at the ground surface, although the settlement trough would be wider. For two tunnels at the same depth, but of different diameters, the larger the diameter the greater the magnitude of settlement although the relationship between tunnel diameter and magnitude of settlement is not linear.

16.18 A calculation of the volume loss caused by a tunnel can be made. That is the entire volume of ground associated with the settlement trough divided by the total volume of the tunnel being constructed. Volume loss is expressed as a percentage. This is a very important parameter.

16.19 For typical modern tunnelling the volume loss will be in the range of 0.5 to 1 per cent. The Channel Tunnel Rail Link used EPBMs. The volume losses experienced were typically in the range of 0.5 to 1 per cent. For the Jubilee Line Extension the same figures applied and also for the Docklands Light Railway Woolwich extension. Those figures are applicable for earth pressure balance machine tunnelling which will be used for the running tunnels on the NLE.

16.20 For spray-concrete linings, the Jubilee Line Extension experience was that the volume losses were a little higher, typically between 1 to 1.5 per cent.

16.21 The Assessment undertaken within the NLE Environmental Statement assumed the following volume losses:

i. 1.5% volume loss associated with tunnel boring by EPBM;

ii. 2% volume loss associated with the use of SCL.

16.22 It can be seen that the volume loss assumptions assumed are in the region of 50% greater than that experienced in relation to the projects I have referred to above. In other words the model used over-predicts the amount of settlement that a property is likely to encounter and deliberately so.

16.23 For this reason and because the 10mm threshold is a small amount of movement, the assessment approach used in Phase 1 is highly robust.

16.24 I have shown on Figures 41 to 46, inclusive, the contours that were produced in relation to the NLE project [NLE/A19/4]. The areas of greatest ground movement identified in the Phase 1 assessment were at the western end of the Battersea Station box, the eastern end of the Nine Elms station and in the location of the two proposed step plate junctions at Kennington.

Phase 2

16.25 In Phase 2 an assessment report is prepared for each individual building forecast at the Phase 1 stage to be subject to settlement of 10 millimetres or greater.

16.26 Phase 2 is a conservative assessment of the potential damage to buildings based on the distortions the buildings might experience based on "green field" displacements. By “green field” displacement, I mean that the presence of the building itself, and its potential stiffening effect on soil structure interaction, is ignored. The settlement predictions are simply made on the basis that the ground surface is a green field; with no buildings or other man-made objects present. It is assumed, pessimistically, that the building that is present has no influence on ground settlement. However, once the green field settlement is identified the extent and degree to which a building on the land might distort can be analysed.

16.27 The results of the Phase 2 assessment enable the degree of “damage”, to which a building might be subject, to be classified on a scale as follows (and as described more fully by Table 2) :

i. Category 0: Negligible

ii. Category 1: Very slight

iii. Category 2: Slight

iv. Category 3: Moderate

v. Categories 4 and 5: Severe

16.28 Buildings identified in Phase 2 as falling within Categories 3 and above are then subjected to further analysis in Phase 3.

16.29 All of the experience on the projects I have referred to above has confirmed that the results of the Phase 2 exercise are conservative, and that is deliberately so.

The assessment that has been undertaken for the NLE has been addressed in the Settlement Report forming Appendix I2 of Volume IIc of the Environmental Statement **[NLE/A19/4]**. The assessment only identifies the Kent Building at BDCH as falling within Category 3 (Moderate). All other buildings examined fall within Categories 0 to 2. Applying the assessment methodology strictly as I have described would result in only the Kent Building coming forward for a Phase 3 assessment.

16.30 However, the consultants who undertook the assessment have advised that the properties listed in Table 5-1 on their report include structures of a sensitive nature and that all the buildings listed in that Table should come forward into Phase 3 for assessment as the NLE project progresses.

16.31 All listed buildings, with predicted settlement of 10mm or more automatically qualify for a detailed assessment at Phase 3.

Phase 3

16.32 Phase 3 involves a detailed assessment of the likely effects upon a building. This is undertaken on an iterative basis as more precise construction details, equipment and methods to be used become available to those predicting the settlement behaviour. It is expected that the settlements predicted at this stage will be reduced, because the construction details, equipment and methods will be selected with the objective of achieving a reduction in actual settlement compare to predicted settlement.

16.33 The potential settlement impact on each building will thus be reviewed and, where appropriate, revised. Where still shown to be needed, any necessary protective works already defined will be undertaken. This will complete a full Phase 3 assessment of each building.

16.34 Monitoring of a building considered in Phase 3 building will be undertaken before, during and after the construction works to ensure that the predicted movements of the building and/or damage levels are not exceeded.

16.35 Obviously at the present design stage of the project the Phase 3 assessment has not been undertaken. This is in keeping with the projects I have referred to above.

Mitigation

16.36 The primary form of mitigating the risk of settlement is through the use of best practice in the tunnelling operations, including continuous working, erecting linings immediately after excavation and providing tight control of the tunnelling process to reduce the magnitude of settlement.

16.37 Where the Phase 3 assessment process identifies it as appropriate additional mitigation can be provided. There are essentially really three categories of protective measures:

i. At-source measures i.e. actions can be taken from within the tunnel or from within the excavation process to minimise settlement.
ii. Ground treatment measures i.e. which involve improving or changing the engineering response of the ground, usually by grouting. This is proposed in the gallery tunnels at Kennington, for example.
iii. Structural measures i.e. works to the building itself to increase its capacity to resist, modify or to accommodate movements. A typical example of that would be the use of tie-rods for masonry buildings.

16.38 An assessment of the potential impact of ground movement associated with the NLE project upon utilities has been undertaken and this has identified that strengthening or pipe replacement works may be required on a number of utilities **[NLE/A19/4]**.

Surveys

16.39 Defect surveys will be undertaken on all properties predicted to experience 10mm or more settlement as a result of the assessment process I have described above. This is a written and photographic record of the existing cracking and deterioration of finishes and structures and will be carried out by an appropriately qualified engineer or surveyor working jointly for the promoter of the works and the owner of the building. Owners of properties where defect surveys are required will be contacted in advance to arrange access but the survey will not be undertaken until shortly before the start of construction activities that could affect the building.

Monitoring

16.40 Generally, all buildings in risk category 3 or above will be monitored during tunnel construction. Monitoring for category 2 and below will be covered by the general background surface monitoring undertaken to confirm ground movements are within the magnitude of those predicted.

16.41 If unexpected movements occur they will be fully investigated and, if necessary, appropriate protective measures taken.

16.42 In addition to this, general settlement monitoring will be carried out over the whole area potentially affected by settlement. TfL is prepared, at a landowner's request, to enter into TfL's standard form of settlement deed with any landowner who is concerned about settlement at their property and who has a property within the limits of deviation of the NLE scheme.

16.43 This will provide a personal legal undertaking from TfL concerning settlement and a formal legal agreement between owners of a potentially affected property and TfL.

16.44 The settlement deed contains standard undertakings offered by LU to all owners of qualifying buildings. Each party is responsible for its own costs of entering into a deed.

16.45 Property owners do not have to enter into the deed unless they choose to. It is not necessary to enter into the deed to benefit from TfL's policy to receive compensation in the event of damage to a property as a result of tunnelling or construction work carried out by TfL.

Predicted Responses to Ground Movement

16.47 Contours of predicted settlements arising from the construction of the NLE have been provided in the Settlement Report forming Appendix I2 of Volume IIc of the Environmental Statement **[NLE/A19/4]**. I have reproduced the appropriate drawings as Figures 41 to 47. The Settlement Report provides a detailed description of the analytical work carried out and has assessed a wide range of types of buildings, utilities and other assets, at the ground surface and buried, in terms of their responses to ground movement. The

findings of these assessments are included in the Settlement Report and form a guide to the mitigation measures such as ground treatment, underpinning and additional monitoring that are likely to be required. A further phase of analysis will, however, be carried out by the Design & Build contractor during the process of detailed design to determine what mitigation measures will be required.

17 CONSTRUCTION MANAGEMENT (CODE OF CONSTRUCTION PRACTICE)

17.1 The management of the construction process is a crucially important component of any large construction project such as the NLE. It is vitally important that best practice is implemented from a safety and an environmental perspective. In this section of my evidence I outline the construction management proposals. However, it needs to be remembered that at this stage of the project no contract has been awarded and no contractor chosen to implement the works. The precise details of the construction management process will thus be defined at a point in time in the future. What can be offered now is a commitment to a framework that the contractor awarded the Design & Build Contract will be required to follow.

17.2 That framework is the Code of Construction Practice (CoCP). A draft CoCP was set out in the Environmental Statement and updated in the Addendum to the ES **[NLE/A19/9]]**.

17.3 It is envisaged that the Code and compliance with it will be the subject of a condition to be attached to the NLE deemed planning permission. The Code will remain subject to review in order to reflect changes in construction industry practice, and the like; however, any changes made will be agreed between TfL and the relevant local planning authorities. TfL has been in discussions with relevant stakeholders including the relevant local planning authorities for some time regarding the content of the CoCP. These discussions are continuing and are intended to continue up to the commencement of the project. Indeed, the mechanism proposed will allow for amendment of the CoCP during the construction of the project if appropriate.

17.4 The provisions of the Code are based on current good practice for major rail projects involving tunnelling in and around London. Indeed, it is based in detail upon the Code of Construction Practice developed for the Crossrail project which was approved during the passage of the Crossrail Bill by both Houses of Parliament.

17.5 This CoCP sets out standards and procedures for managing the environmental impact of constructing the NLE. It covers environmental, public health and safety aspects of the project that may affect the interests of local residents, businesses, the general public and the surroundings in the vicinity of the proposed construction sites.

17.6 It is split into two parts. Part A sets out:

i. the context and underlying principles of the NLE CoCP;.

ii. the principal obligations of Contractors and developers when undertaking work;

iii. the general measures to be used during construction;

iv. how those general measures will be applied by the contract and enforced by TfL, and the relevant local authority;

v. the details of the measures to be taken in relation to each relevant environmental topic.

17.7 Part B of the CoCP will be developed by TfL and its main Contractor when appointed to supplement Part A. Part B shall be subject to the approval of the relevant local planning authority in accordance with the planning conditions to which the NLE works are subject. It will identify detailed site-specific measures and take into account the environmental issues in the NLE area and each of the NLE constituent work sites (such as site set ups and servicing arrangements). Part B may include, but is not limited to:

i. conditions imposed on planning permissions;

ii. assurances given in relation to planning and other consents;

iii. Site Environment Management Plans and other Environment Management Plans to be produced /coordinated by the main Contractor;

iv. consents obtained /coordinated by the main Contractor under Section 61 of the Control of Pollution Act 1974 (herein referred to as “Section 61”); and

v. Traffic Management Plans

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17.8 The purpose of the CoCP is to ensure that best practice is adopted in relation to the construction process so that adverse effects of construction on the environment are kept to a reasonable minimum. Overall, it aims to mitigate nuisance to the public and to safeguard the environment.

17.9 The TfL NLE Project Manager (PM) will be responsible for compliance with the Code. TfL will apply its Environmental Management System approach. The PM will ensure that:

i. the Contractor(s) submit reports regarding performance and other relevant matters sufficient to inform the PM regarding compliance with the CoCP;

ii. arrangements for auditing are in place and are implemented; and

iii. there is a clear definition of accountability and responsibility throughout the Client and Contractor organisations.

17.10 Following the imposition of the proposed planning condition, it is intended that the CoCP will be enforced by the local planning authority for the relevant worksite in consultation with their Environmental Health departments.

Environmental Principles

17.11 TfL is committed to ensuring that NLE is built, where reasonably practicable, in accordance with all relevant and current environmental legislation and best practice for minimising the environmental effects of construction.

17.12 TfL's arrangements for managing Contractors will include the selection of competent Contractors who must plan and implement appropriate Health, Safety, Quality and Environmental systems. This will require tenderers for the main construction contracts to have as a minimum an Environmental Management System (EMS) which is consistent with current legislation and best practice and which will deliver the works in accordance with the provisions of this Code.

Health and Safety Principles

17.13 TfL is committed to ensuring the health, safety and welfare of its employees and people who may be affected by the conduct of its undertakings. TfL will apply appropriate industry standards for health and safety and will seek continuous improvement in safety performance.

17.14 TfL and those acting on its behalf will ensure that adequate arrangements are in place for the discharge of all duties as named parties under the current Construction (Design & Management) Regulations (CDM). TfL will assess the competence and resources for health and safety of organisations appointed as other duty-holders under CDM, and will monitor compliance with discharge of its own and others' CDM duties throughout the project.

17.15 TfL will ensure the development of a health and safety management system. This system will include documentation defining TfL's internal arrangements for managing health and safety on the project and the specific requirements for health and safety applying to all designers and Contractors appointed to work on the project.

17.16 TfL will ensure that all Contractors appointed to carry out work on the TfL project produce a Health and Safety Plan defining how their work and associated risks to health and safety will be managed.

7.17 TfL's arrangements for health and safety will include a system for management of risks. At the time of contract appointment the Contractor will be presented with a Project Risk Register as part of the Client's Health & Safety File submission. Subsequently, the Contractor's responsibilities will include that all hazards are identified, on an ongoing basis throughout the life of the project, suitable and sufficient assessments are made of the associated risk, followed by adoption and execution of appropriate measures to eliminate the risk or to control the risk, so far as is reasonably practicable.

17.18 Where risks to the public are involved, these will be reduced to as low as reasonably practicable, and will be managed in accordance with current guidance.

17.19 Tunnelling works will be required to comply with the requirements of the Association of British Insurers Construction Code for risk management in tunnelling works.

17.20 TfL will continuously monitor the work of Contractors and will conduct a programme of audits and inspections to ensure compliance with the requirements of this Code and other project health and safety requirements.

Site Management

17.21 Contractual arrangements will require all NLE Contractors to provide suitably qualified staff to manage and execute works for which they are responsible. TfL will require that all Contractors demonstrate an appropriate awareness of local sensitivities, expected codes of conduct, working knowledge of the legislation, codes of practice, and guidance relevant to the various construction activities in which they are engaged. Staff will be required to be suitably trained and qualified.

17.22 The CoCP requires the production of a number of Environmental Management Plans (EMPs) throughout the lifetime of this project. The EMPs will include but are not limited to:

i. Site environmental management plan(s);

ii. Noise and vibration management plan;

iii. Traffic management plan(s);

iv. Site waste management plans;

v. Air quality and dust management plan

vi. Water conservation plan;

vii. Green travel plan;

viii. Energy management plan;

ix. Ecology management plan;

x. Ecology reinstatement plan; and

xi. Lighting management plan(s) for any construction sites where potentially significant impacts are identified;

17.23 These plans will set out the environmental objectives/targets of the project, how the project will deliver the environmental requirements, and how environmental issues that arise are to be handled to ensure compliance with relevant legislation, regulations, best practice and the CoCP. The requirement

for EMPs will be subject to ongoing review with the relevant local planning authority and other relevant stakeholders. The plans will define the approach to address all relevant environmental issues and will set out how TfL intends to operate the construction and work sites and will set out the specific control measures necessary to deliver the requirements of the CoCP. The Contractor may not commence work until TfL is satisfied that all appropriate procedures and processes are in place.

Community Consultation & Liaison

17.24 TfL and/or Contractors will be committed to providing community relations personnel who will be focussed on engaging with the community to provide appropriate information and to be the first line of response to resolve issues of concern. TfL will take all reasonable steps to engage with residents.

17.25 TfL will ensure that occupiers of nearby properties will be informed in advance of works taking place, including the duration. In the case of work required in response to an emergency, the local authority and local residents shall be advised as soon as reasonably practicable that emergency work is taking place.

17.26 TfL and its Contractors will implement a community liaison plan following further consultation with the Boroughs and representatives of local residents and local businesses. TfL is seeking to address the concerns of residents and local business and especially to effective monitoring and mitigation of predicted and actual effects of the construction programme.

17.27 TfL will, in consultation with the Boroughs, establish and maintain a Community Liaison Group (or Groups) and this (or these) will meet regularly before and during the construction period.

17.28 TfL will maintain a telephone helpline service which includes a complaints option staffed 24 hours per day during the construction period to handle enquiries and complaints from the general public. It will also act as a first point of contact and information in case of an emergency. All calls will be logged, together with a record of the responses and action taken. Appropriate contacts and response times will be the subject of a detailed procedure to be agreed prior to the commencement of construction. Potentially affected occupiers will be notified of the helpline number and it will be widely advertised and displayed on site signboards.

1.29 A Complaints Register recording the nature of the complaint and action taken will be maintained. This register will record all complaints received (for example, written, via the telephone helpline, or direct to site personnel) and an updated copy will be provided to the relevant local authority each month (or such other interval as agreed with the relevant local authority). A summary of the Complaints Register (with all personal details removed) will be provided to others on request.

1.30 A Commitment Register, which includes relevant documents, will be provided as a component of, or accompaniment to, the CoCP Part B which is to be agreed with the relevant local planning authorities.

Working Hours

17.31 Tunnelling work due to its nature has to be undertaken 24 hours a day 7 days a week. This is because it is not possible to stop these operations without significant safety and settlement risks arising.

17.32 Details of working hours will, with the exception of tunnelling works, be the subject of submissions for prior consents under Section 61 CoPA 1974 which shall be made to the relevant local authority. Unless otherwise agreed with the relevant local authority, no construction works will be undertaken outside normal working hours unless formal consent under Section 61 has been obtained.

17.33 Only general principles relating to the types of activity for which it is likely to be necessary to seek Section 61 consent for working outside normal working hours are set out here.

17.34 Normal working hours are planned to be from 0800 to 1800 on weekdays (Mon-Fri excluding Bank Holidays) and 0800 to 1300 on Saturdays. Where feasible, operations likely to cause disturbance and/or disruption will be limited to these hours.

17.35 In addition start up and shut down activities will take place for up to one hour before and after these times. Start up and shut down activities can include but are not limited to maintenance, site briefings, meetings and training.

17.36 I need to make it clear that start up and shut down activities will not include operation of plant or machinery that would give rise to noise likely to exceed threshold levels for normal working hours. The start-up and shut down periods shall not be regarded as extensions to normal working hours and particular care will be taken to limit and control disturbance to local residents during such periods.

17.37 Non-disruptive preparatory work, repairs and maintenance may be carried out on Saturday afternoons or Sundays between 1000 and 1600.

17.38 TfL will adhere to normal working hours as far as reasonably practicable but in some circumstances it may be that some works would cause less disturbance and/or disruption if carried out wholly or partly outside normal working hours. Therefore, it may be proposed that some works be rescheduled outside normal working hours in which case express permission will be sought from the relevant local planning authority. However, any such rescheduling of works will not be proposed (or indeed permitted by the relevant local planning authority) if it is considered that it would have a material adverse effect on local residents or other local occupiers.

17.39 Proposals for working outside normal working hours will be discussed with the relevant local authority in the context of the full information available in Section 61 applications.

17.40 There are some types of work that necessarily have to take place outside normal working hours or, being non-disruptive, can reasonably be done. These include:

i. The conveyor at Battersea will normally be operational on a 24 hours per day, 7 days per week basis as the TBMs will be producing material for disposal on a 24/7 basis and it will be necessary to load material including tunnel arisings on to barges every high tide (with some 'downtime' between each high tide);

ii. Internal fit out works within the tunnels, stations and shafts including electrical, communications, ventilation and signalling works. This work involves complex and time consuming activity but is non-disruptive. Also, because the works involve linking with the existing Northern Line, some of it will have to take place at night (or at weekends) when the Underground is closed or during possessions (which are most likely to occur at night, at weekends and/or on Bank Holidays) or at other such times as are necessary for safety critical works.

iii. In order to safeguard the works it may be necessary for certain items of construction plant and equipment particularly associated with the tunnelling operations to be kept running 24 hours per day, 7 days per week. This shall include pumps, ventilation fans, cranes, compressors, batching plants and possibly generators. Any such equipment will be shielded in order to provide appropriate noise attenuation

iv. Works which require temporary possession of roads and railways, or which need to take place during non rail-traffic hours or when volumes of road traffic are low, for reasons of safety, engineering practicability or operational requirements. Limiting disruption to the travelling public may also be a factor with regard to such works.

v. Works in connection with utilities which have to be undertaken when demand is low.

vi. Operations which for reasons of engineering practicability must be completed once commenced and which cannot be completed within a working day (for example, a major concrete pour and certain piling operations).

17.41 Times at which such works could need to take place may include Saturday afternoons, night-times, Sundays and/or Bank Holidays from time to time.

17.42 In the case of work required in response to an emergency or which, if not completed, would be unsafe or harmful to the permanent works, the local authority will be informed as soon as reasonably practicable of the reasons

for, and likely duration of, the works. The local authority will provide a telephone number and nominate an officer to receive such notification; this will be reviewed regularly. Examples of the type of work envisaged might include where pouring concrete takes longer than planned due to equipment failure.

17.43 Where work has to be rescheduled for reasons not envisaged and is expected to extend beyond the agreed or normal working hours or exceed the agreed limits and dispensation to the Section 61 consent, the Contractor will apply for a variation to the section 61 consent to the relevant local authority at least 14 days in advance of the start of those works. Where rescheduling relates to work of a critical nature (such as key activities likely to delay other key activities) applications will be made where practicable 48 hours in advance and no fewer than 7 days in advance if the work is expected to last for a period of 5 days or more.

17.44 Where such working outside normal hours has been discussed and accepted, nearby occupiers who are likely to be affected by the works will be informed by letter to their postal address as soon as reasonably practicable by TfL about the nature and likely duration of the works.

17.45 Deliveries will be arranged to minimise impacts on the road system as far as reasonably practicable, although loading and unloading will normally take place during normal working hours. However, there are good reasons why it may sometimes be necessary for this activity to take place at other times (e.g. large loads or to minimise disruption).

17.46 Each case will be considered on its merits and will be the subject of prior agreement with the relevant local authority. A procedure for obtaining prior agreement will be established.

Site Layout and Facilities

17.47 Site layouts and appearance will be designed using the following principles

i. the sites will be screened and fully secured;

ii. storage sites, fixed plant, machinery, equipment and temporary offices will be located to limit environmental effects, as far as reasonably practicable, and having due regard to neighbouring accommodation, as far as allowed by the constraints of the site(s);

iii. site lighting will be located and directed so as not to intrude into occupied residential properties or disturb wildlife on sensitive areas or constitute a road hazard; and

iv. fixed site plant and facilities will be powered from mains electrical sources.

17.48 TfL will ensure, as far as reasonably practicable, that the visual intrusion of construction sites on nearby residents and users of local facilities and amenities is contained and limited. TfL will display the helpline number and a contact name and address at appropriate locations on the boundaries of the sites.

17.49 The type of hoarding or fencing used and vehicle access and egress points will be agreed with the relevant local authority.

17.50 TfL will promote and enforce a "good housekeeping" policy on the construction sites to ensure that they are clean, tidy and safe.

17.51 TfL will ensure that appropriate welfare facilities are provided for construction personnel including toilets, showers, locker rooms and first aid posts. The facilities will be connected to mains services and drainage, where reasonably practicable.

Site Security

17.52 TfL will ensure that the construction site(s) are secure and staffed for security on a 24 hour basis. Access to the sites will be limited to specified entry points only and all personnel entries/exits will be recorded and monitored for both security and health and safety purposes.

17.53 The site boundaries will be secured and constructed such that they minimise opportunities for unauthorised entry. The boundary will be monitored both directly and remotely (by CCTV) by the Contractor/Contractor's security team.

Site Lighting

17.54 Site lighting and signage will be provided to ensure the safety and security of the construction sites and will be at the minimum luminosity necessary. Where appropriate, lighting to site boundaries will be provided and illumination will be sufficient to provide a safe route for the passing public and the lux levels on footways shall be at least equal to those provided by the existing street lighting. In particular, precautions will be taken to avoid shadows cast by the site hoarding on surrounding footpaths, roads and amenity areas.

17.55 Industry standard procedures will be implemented at all construction sites for site lighting. Lighting will also be designed, positioned and directed so as not to unnecessarily intrude on adjacent buildings, wildlife sites and land uses and so as to prevent unnecessary interference with local residents, railway operations, passing motorists, or the navigation lights for air or water traffic and wildlife breeding seasons.

Emergency Planning and Response

17.56 TfL will ensure that emergency procedures for each work site are developed. The procedures will be standardised as far as possible across the work sites and will be appropriate to the anticipated hazards and the specific layout. The

emergency plan will include Emergency Services, Police, etc., and will include notification procedures so that the Services can act accordingly in the event of an incident. The emergency plan will include emergency pollution control measures that will take into account EA guidelines. The emergency plan will contain emergency phone numbers and the method of notifying local authorities and statutory authorities. Contact numbers for the key TfL and Contractor's staff will also be included.

17.57 TfL will ensure that the requirements of the London Fire and Emergency Planning Authority (LFEPA) will be followed for the provision of site access points. Where appropriate, the accesses will be designed to the requirements of current LFEPA guidance. In accordance with procedures and processes agreed prior to start of construction, the emergency services will be notified of any variations of the accesses. In all cases the arrangements put in place will also be suitable for and agreed with the London Ambulance Service (LAS).

17.58 All construction sites and associated accommodation and welfare facilities will have in place appropriate plans and management controls to prevent fires. The site fire plans will be prepared, regularly reviewed, and updated as necessary, and will have due regard to relevant current guidance.

17.59 During detailed construction planning and design development stages, TfL will look to reduce fire risk and potential fire load applicable to the works and the operating station. The specification of non-combustible materials, products and packaging will be pursued wherever reasonably practicable. The project will also have to comply with any third party requirements as may be appropriate at specific sites.

Cranes

17.60 Crane arcs will be confined within the site boundary unless agreed otherwise with the local authority and property owners/occupiers whose air space is affected. TfL will obtain the relevant permissions from the highway authority (TfL or the relevant local authority as appropriate) for cranes located adjacent to roads. Cranes will be operated in accordance with the requirements of the current Code of Practice for Safe Use of Cranes.

Highways and Access

17.61 TfL will ensure that legal requirements for works affecting highways are implemented and shall undertake the works in such a way as to maintain, as far as reasonably practicable, existing public access routes and rights of way during construction. TfL will limit undue inconvenience to the public as far as reasonably practicable whilst carrying out the works. Detailed proposals will be set out in a Traffic Management Plan (TMP). The NLE TWAO includes any necessary provisions for stopping up and diversion of highways, together with protective provisions for highway authorities.

17.62 A Traffic Management Plan (TMP) or plans will be produced, coordinated and then implemented by the main Contractor. The plan(s) will address pedestrian

issues and diversion routes as appropriate and will be prepared in consultation with highway and traffic authorities and the emergency services. The TMP(s) will include:

v. site boundaries and the main access/egress points for the worksites;

vi. temporary and (if any) permanent closures and diversions of highways;

vii. the strategy for traffic management including parking; and

viii. local routes to be used by lorries generated by construction activity, including: lorry holding areas, lorry route signing strategy, means of monitoring lorry use and any routes prohibited from use by Contractors' vehicles.

17.63 TfL and its Contractor will comply with any relevant requirements that may be detailed in the NLE TWAO before commencing works that will involve interference with the highway. All temporary closures of highways and public rights of way will be for as short a time as reasonably practicable. Pedestrian access to premises will be maintained. As far as reasonably practicable, diversion routes will be provided prior to the commencement of the relevant parts of the works and will be maintained to a comparable standard of those that they replace. Suitable signage and barriers will be provided. Local residents and businesses will be informed in advance of the dates and durations of closures and, with the exception of emergency works as referred to above, will be provided with details of diversion routes a minimum of two weeks in advance (or when final details are available).

17.64 Where temporary alterations to the highway are required, the highway will be restored to the reasonable satisfaction of the relevant highway authority. Surveys will be used to establish the condition of the highway prior to the commencement and after the completion of the NLE works. The locations where surveys will be undertaken will be identified in the TMP.

17.65 All reasonably practicable measures will be put in place to avoid/limit and mitigate the deposition of mud and other debris on the highway. These measures will have regard to the nature and the use of the site and could include:

i. hard standings at the access and egress points which will be cleaned at appropriate intervals;

ii. vehicle wash down points to clean vehicle wheels at each exit point on to the highway;

iii. the correct loading of vehicles and sheeting of loads where necessary to avoid spillage during their journeys; and

iv. the use of mechanical road sweepers combined with water sprays for the suppression of dust to clean site hard standings and roads and footpaths in the vicinity of the site.

17.66 After completion of any works affecting a highway, all surplus materials arising from the works will be cleared from the highway, leaving it in a clean and tidy condition in accordance with the reasonable requirements of the highway authority.

17.67 Details of local routes to be used by construction lorries will be set out in the TMP. As far as reasonably practicable, there will be no parking of lorries on the highway in the vicinity of any worksite except in specified holding areas for delivery or removal of materials from the site. An appropriate control system will be implemented for the dispatch of all vehicles containing excavated material, demolition materials or other waste material. Waste will be controlled and deposited in accordance with relevant legislation. Signs identifying the NLE project and Contractor contact numbers will be displayed in a prominent position on vehicles carrying project waste on public roads.

17.68 TfL will, where reasonably practicable, ensure that persons with restricted mobility (PRM) and those with other forms of disability, as specified in the Disability Discrimination Act 2005, continue to have access to services and buildings where existing access and services are temporarily disrupted during the NLE construction works. Where the normal means of access has to be diverted or blocked off, alternative safe routes for persons with restricted mobility will be identified, taking into account existing hazards and obstructions such as pavement kerbs and street lighting standards (poles). Where particular difficulties are identified, arrangements will be made on a site by site basis.

Noise and Vibration

17.69 TfL will, as far as reasonably practicable, seek to control and limit noise and vibration levels so that affected properties and other sensitive receptors are protected from excessive or prolonged noise and vibration associated with construction activities. TfL will apply Best Practicable Means (BPM), as defined under Section 72 of the Control of Pollution Act 1974 to all activities including those undertaken below ground.

17.70 TfL will obtain consents from the relevant local authority under Section 61 (which will include noise and vibration limits where relevant) for the proposed

surface construction works. Site specific management and mitigation requirements for noise and vibration, both on and off-site, will be further defined in the Section 61 consents. By exception, TfL may agree with the local authority that, for certain activities not anticipated to be noise sensitive, such as normal site investigation and site set up (subject to these being in accordance with this Code), that a Section 61 consent will not be necessary.

17.71 TfL will undertake appropriate noise and vibration monitoring as agreed in advance with the relevant local authority, including agreeing appropriate threshold levels before works start, having regard to the TfL NLE Construction Noise and Vibration Mitigation Scheme.

17.72 The results of any noise and vibration monitoring will be made available, as required, to the relevant local authority. Access to the sites will be facilitated at all reasonable times for inspection and/or noise measurements by the local authority environmental health personnel.

17.73 Each item of plant used on the project will comply with the noise limits set out in relevant EU Directives and in domestic Regulations. TfL will adopt the recommendations for the control of noise, as set out in BS 5228-1:2009 section 8, and for the control of vibration, as set out in BS 5228-2:2009 section 8.

17.74 Plant and equipment likely to create noise and/or vibration whilst in operation will, as far as reasonably practicable, be located away from sensitive receptors. The use of barriers to absorb and/or deflect noise away from noise sensitive areas will be employed where required and reasonably practicable.

17.75 All plant, equipment, and noise control measures applied, will be maintained in good and efficient working order and operated such that noise emissions are minimised as far as reasonably practicable. Any plant, equipment, or items fitted with noise control equipment found to be defective will not be operated until repaired.

17.76 Where reasonably practicable, fixed items of construction plant will be electrically powered in preference to being diesel or petrol driven.

17.77 Vehicles and mechanical plant utilised on site for any activity associated with the construction works will be fitted with effective exhaust silencers and shall be maintained in good working order and operated in a manner such that noise emissions are controlled and limited as far as reasonably practicable.

17.78 Machines in intermittent use will be shut down or throttled down to a minimum during periods when not in use. Static noise-emitting equipment operating continuously will be housed within suitable acoustic enclosure, where appropriate.

17.79 For underground activities, and also for conveyors above surface level, the following measures will be adopted, where reasonably practicable and appropriate:

Conveyors

i. The mounting for any conveyors used to remove excavated material from the works (underground, sub-surface or surface) will be designed and installed so as to mitigate the transmission of noise and vibration;

ii. A maintenance programme will be implemented to ensure that the noise generation of any conveyor does not deteriorate over time.

iii. The surface conveyor systems will be of similar standard to underground conveyors and will be acoustically enclosed where they run through, or are adjacent to, noise sensitive areas. They too will be the subject of a maintenance programme. The conveyer will be covered throughout its length to prevent material spillage.

Temporary Construction Railway

iv. The alignment, jointing and mounting of the temporary construction railway will be installed, maintained and operated in a manner so as to minimise the transmission of vibration and ground borne noise from the passage of rail vehicles.

v. Any diesel locomotives used will be fitted with efficient exhaust silencers.

Temporary Tunnel Ventilation

vi. All tunnel ventilation plant with connections to the atmosphere in any noise-sensitive location will be subject to mitigation measures appropriate to its local environment.

17.80 Occupiers of nearby properties shall be informed in advance of the works taking place, including the duration and likely noise and vibration effects. In the case of work required in response to an emergency, the relevant local authority and local residents shall be advised as soon as reasonably practicable that emergency work is taking place. Potentially affected residents will also be notified of the helpline number.

17.81 Noise insulation (or a grant therefore) or further mitigation may be offered where the predicted or actual noise levels exceed the prescribed levels defined in the TfL NLE Construction Noise and Vibration Mitigation Scheme, as described in the evidence of Mr Thornely-Taylor **[TFL3/A]**.

17.82 TfL will, as far as reasonably practicable, ensure that the noise from reversing alarms is controlled and limited. This will be managed through the following hierarchy of techniques:

i. the site layout will be designed to limit, and where reasonably practicable, avoid the need for the reversing of vehicles. TfL will seek to ensure that drivers are familiar with the worksite layout;

ii. banksmen will be utilised to avoid, as far as reasonably practicable, the use of reversing alarms;

iii. reversing alarms incorporating one or more of the features listed below or any other comparable system will be used where reasonably practicable;
   a) highly directional sounders;
   b) use of broadband signals;
   c) self-adjusting output sounders; and
   d) flashing warning lights.

iv. reversing alarms will be set to the minimum output noise level required for health and safety compliance.

Air Quality

17.83 TfL will, as far as reasonably practicable, seek to control and limit emissions to the atmosphere in terms of gaseous and particulate pollutants from vehicles and plant used on the site, and dust from construction, demolition, vehicles and plant activities. TfL will identify potential sources and apply appropriate control techniques, and these will be documented in an Air Quality and Dust Management Plan.

17.84 TfL will ensure that the adverse effects of vehicle and plant emissions are controlled. Measures to be considered for limiting emissions and avoiding nuisance will include the following as appropriate and as far as reasonably practicable:

i. ensuring that the engines of all vehicles and plant on site are not left running unnecessarily;

ii. using low emission vehicles and plant fitted with catalysts, diesel particulate filters or similar devices;

iii. using ultra low sulphur fuels in plant and vehicles;

iv. requiring that plant will be well maintained, with routine servicing of plant and vehicles to be completed in accordance with the manufacturers recommendations and records maintained for the work undertaken;

v. requiring that all project vehicles, including off-road vehicles, will hold current MOT certificates, where required due to the age of the vehicle, (or to be tested to an equivalent standard) and that they will comply with exhaust emission regulations for their class;

vi. siting plant away from potential sensitive receptors;

vii. avoiding the use of diesel or petrol powered generators and using mains electricity or battery powered equipment (NB an emergency diesel generator may be required during tunneling works);

viii. maximising energy efficiency (this may include maximising vehicle utilisation by ensuring full loading and efficient routing);

ix. Complying with the requirements of the London Low Emissions Zone, all vehicles;

x. In line with Mayoral environmental strategies and commitments to reduce carbon dioxide emissions, Contractors are also encouraged to include zero or ultra-low carbon vehicles in their fleet such as electric, plug-in hybrid or biomethane vehicles where possible; and

xi. All members of the Contractor's staff who drive vehicles under this Contract shall undertake a fuel-efficient driver training course within three months of the commencement of the contract.

Dust Control

17.85 TfL will ensure that all Contractors comply with the provisions of all legislation relevant to the control of dust and emissions. TfL will require that measures to reduce the impact of dust are designed and implemented in an appropriate and timely manner. The Supplementary Planning Guidance 'The Control of Dust and Emissions from Construction and Demolition' will form the basis of the site specific plans for the control of dust.

17.86 TfL will ensure that an Air Quality and Dust Management Plan is prepared and implemented for the worksite(s), which details controls to limit dust emissions,

including the consideration of using green walls, screen and other green infrastructure to minimise the impact of dust and pollution and also to improve the local ambience during construction.

17.87 The same approach as has been approved by Parliament in relation to the control of dust for the Crossrail project will be adopted by TfL. Three levels of control for dust impacts are planned, with the standard level, Tier 1, as the minimum that will be implemented on any site. A risk-based approach will be used to identify construction sites with potential to generate significant quantities of dust near sensitive receptors and which require additional levels of control (Tiers 2 and 3).

17.88 Thus where the standard Tier 1 approach is identified as sufficient to mitigate potential impacts that will be adopted. If it is insufficient, then the Tier 2 level of control will be considered. If that is sufficient to mitigate potential impacts then the Tier 2 approach will be adopted. If that is insufficient then the measures in Tier 3 will be adopted. These matters will be addressed in the Air Quality and Dust Management Plan.

17.89 There are a very large number of dust controls included within the Tier 1 approach. These can be seen at 6.3.7 of the draft CoCP contained in Appendix N1 of the ES Addendum **[NLE/A19/9]**.

17.90 Tier 2 incorporates the Tier 1 measures and adds further control measures. These can be seen in paragraph 6.3.9 on the draft CoCP contained in Appendix N1 of the ES Addendum.

17.91 Tier 3 requires the highest standard of dust control reasonably achievable to be adopted, which will incorporate all relevant Tier 1 and Tier 2 techniques as set out above, as well as additional site specific measures. Techniques such as total enclosure of certain operations to protect vulnerable receptors would be implemented where appropriate.

17.92 In the event of a pollution incident arising from dust, the Contractor will be required to agree remedial mitigation measures for implementation with the relevant local authority.

17.93 TfL will ensure that, unless agreed with the relevant local authority as inappropriate, dust monitoring is carried out during construction at all Tier 2 and Tier 3 activities. A risk-based approach will be used to identify the type of dust monitoring to be used at each worksite by looking at the details of the specific packages of work within the site boundaries, the dust raising potential of those construction activities, proximity to potential receptors and the duration of construction activities at each location.

17.94 Where sites have a risk score that assigns them to the low risk category, no dust monitoring will be carried out. Where sites have a risk score that is in the medium risk category, passive deposition monitoring techniques (glass slides/Frisbee gauges/sticky pads) will be adopted at appropriate locations

(site boundaries/local receptors) according to specific site conditions as outlined further below.

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17.95 Where sites have a risk score that is in the high risk category, additional monitoring techniques will be adopted according to specific site conditions as required. The detail of dust monitoring on Tier 3 sites is described in the draft CoCP at paragraph 6.3.12.

17.96 In the event that all monitoring indicates that the above measures have not prevented a material increase in dust leaving the site, and this gives rise to a problem that is reported via the Helpline or the Community Liaison Group, TfL will take reasonable steps to ensure the parties affected are compensated.

Water Resources

17.97 TfL will undertake the works and implement working methods which will be developed to protect surface and groundwater from pollution and other adverse impacts including change to flow volume, water levels and quality. This will be completed in accordance with relevant legislative requirements and appropriate industry guidance.

17.98 TfL will ensure that the design of the site layout and facilities and management of construction operations will take account of the guidance contained within the relevant EA Pollution Prevention Guides and Construction Industry Research and Information Association (CIRIA) documents and will be based on accepted industry practice.

17.99 Contingency plans to deal with major pollution incidents at the work sites will be included within the overall emergency planning. EA guidance on pollution incident response planning will be reflected in the emergency plans.

17.100 TfL will implement working methods that reduces water consumption and continually improves water-use efficiency on site. TfL will ensure a water conservation plan based on the water hierarchy, is prepared and implemented for the worksite(s). The plan will include but not limited to:

i. Water audits that identify all water-using processes, activities and equipment on site (aligned with significant changes in site(s) activities through the project life cycle);

ii. Action plan, including staff engagement and training, to reduce water consumption by all water-using processes, activities and equipment on site;

iii. Monitoring regime that assess the effectiveness of water conservation measures in the plan; and

iv. Reporting the effectiveness of plan on an annual basis**.**

17.101 The water hierarchy that will be followed is set out in the draft CoCP at Paragraph 7.2.2 **[NLE/A19/5]**.

17.102 Site drainage, including surface runoff and dewatering effluents, will be discharged to sewers where appropriate and relevant permissions will be obtained from the sewerage undertaker. Surface water run-off will be controlled to achieve run off rates of 50% of those of the site as previously developed.

17.103 TfL will ensure that the site drainage meets the effluent standards required by the sewerage undertaker, or EA, as appropriate, and will provide holding or settling tanks, separators, and other measures as may be required. TfL will ensure that access is provided to the undertaker so that samples of discharge can be obtained and analysed and the flows verified as required. The relevant sections of BS 6031:2009 Code of Practice for Earthworks for the general control of site drainage will be followed.

17.104 TfL will seek to control flood risk to appropriate levels set by the Environment Agency, using mitigation, compensation and/or monitoring where required. Approval will be obtained in advance for all crossings of, diversions to, and work affecting watercourses from the EA as set out in the protective provisions contained in the TWAO. Watercourses, including land and/or road drainage, within the construction sites will be maintained to provide effective working conditions at all times.

17.105 All reasonably practicable measures will be taken to prevent the deposition of silt or other material in, and the pollution by sediment of any existing watercourse, borehole, aquifer or catchment area, arising from work operations. The measures will accord with the principles set out in industry guidelines, including the EA's note 'PPG05: Works in near or liable to affect water courses' and CIRIA's report 'C532: Control of water pollution from construction sites'. Measures may include use and maintenance of temporary lagoons, tanks, bunds and silt fences or silt screens as well as consideration of the type of plant used and the time of the year for working in watercourses.

17.106 TfL will ensure that protection measures to control the risk of pollution to surface water will be adopted. These are set out in paragraph 7.5.1 of the draft CoCP.

17.107 TfL will ensure that protection measures to control the risk of pollution to groundwater will be included within the overall strategy and in compliance with relevant legislation. Where reasonably practicable, TfL will avoid using materials in the permanent or temporary works that could pollute groundwater. This will include special consideration for the use of substances listed in relevant legislation.

17.108 TfL will follow Port of London Authority guidance for dredging in the tidal Thames and its tributaries. As far as is practicable, during the critical period of June to August planned, non-emergency dredging will be avoided (and it is to be noted that this is a locally significant spawning area for Smelt, between

April and May). This will be achieved through programming capital dredging outside this period, and implementing a monitoring program to identify future maintenance dredging. Where practicable, TfL will undertake a single maintenance dredge prior to the critical period.

17.109 TfL however needs to preserve the ability to undertake emergency dredging within the critical period of June to August should there be a requirement to do so. Dredging in response to an unforeseen event or occurrence outside of the control of TfL or its contractors and which could not be reasonably expected or planned and which jeopardises the operation of the barge loading facilities constitutes an emergency and would be addressed through consultation with relevant stakeholders including the relevant local planning authorities and the Port of London Authority.

17.110 So far as is practicable, to assist with minimising water quality and aquatic ecology impacts, TfL will undertake capital and maintenance dredging using techniques that limit the dispersal of inter-tidal sediments.

Contaminated Land

17.111 TfL will apply all relevant statutory and industry best practice guidance in relation to contaminated land and will develop remediation measures in accordance with relevant legislation and guidance. If contaminated land is identified, the statutory guidance and industry best practice will be applied to ensure that where it is reasonable to do so, remediation is carried out so that the land no longer presents a significant risk of harm being caused.

17.112 TfL will carry out site assessments, investigations and/or risk assessments wherever construction work is planned in order to assess the potential for contamination in both the land and groundwater. The necessary measures will be agreed with the Environment Agency and the Local Authority as part of the construction planning process, in accordance with industry best practice.

17.113 A set of criteria for site investigation will be developed prior to the commencement of any intrusive works. Where site investigation reveals the presence of contaminated land, and groundwater, an appropriate remedial strategy will be developed to identify the most appropriate option for dealing with the presence of the contamination. This strategy would include a number of detailed matters that are set out in paragraph 8.2.2 of the draft CoCP but which include liaison with the relevant planning authority and other stakeholders, the agreement of appropriate protection measures and appropriate monitoring.

Materials and Waste Management

17.114 TfL will implement a material resource management plan and minimise waste creation. Where the method of procurement may involve design, the role of design in ensuring reduction in material and waste will be demonstrated. This will also be reflected in the construction strategy.

17.115 TfL will manage demolition / construction / fit out and excavation wastes generated at worksites in accordance with the waste hierarchy. This is set out in the draft CoCP at paragraph 9.1.4. This will be delivered through the Site Waste Management Plan(s) (SWMP).

17.116 TfL will follow, if reasonably practicable to do so:

i. CL:AIRE The Definition of Waste: Development Industry Code of Practice for all excavated materials produced onsite during the works.

ii. WRAP and/or Environment Agency Quality Protocols for materials, e.g. the WRAP Quality Protocol for the Production of Aggregates from Inert Waste.

iii. Institution of Civil Engineers (ICE) Demolition Protocol for all demolition works required during the works.

17.117 TfL will ensure that the requirements of the waste hierarchy are enforced and the duty of care placed on all parties to take responsibility for protecting the interests and safety of others from the potential effects of handling, storing, transporting and depositing of excavated materials and wastes. TfL will ensure that waste is managed in accordance with Policy 5.3 Sustainable Design and Construction of the London Plan 2011, the Mayor's Business Waste Strategy as well as all relevant legislation and best practice guidance.

17.118 TfL will be responsible for the development and maintenance of a Site Waste Management Plan (SWMP). The plan will be developed following best practice and, as a minimum, meet all the requirements of the legislation and Waste Resource Action Programme (WRAP) SWMP template. The Principal Contractor is responsible for ensuring compliance with the SWMP. The SWMP will include an audit programme to be undertaken to demonstrate compliance with statutory requirements

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17.119 Waste treatment sites will be identified in consultation where appropriate with the relevant LPAs, Defra and the EA. With the dynamic nature of disposal sites it is imperative to maintain a regular dialogue with the waste management treatment/disposal operators, or other relevant party, to explore options for beneficial re-use of the excavated materials: and uphold validity of the robust case for disposal of the excavated material.

17.120 TfL will comply with the 'duty of care' to protect the interests and safety of others from the potential effects of handling, storing, transporting and depositing of excavated materials and demolition/construction waste arising from the project. Such compliance will include the implementation and monitoring of accepted industry practices for the control of dust, mud and other debris on site.

17.121 TfL will also comply with its waste 'duty of care' responsibilities to ensure that waste is produced, stored, transported and treated or disposed of in a responsible manner and in compliance with all relevant legislation. Where it

passes responsibility for waste management onto Contractors, the duty of care will be transferred as appropriate.

17.122 The SWMP will include detailed procedures for compliance with the requirements for waste transfer and consignment notes, in accordance with relevant legislation, and arrangements for auditing the actions of other parties in the waste handling chain. A sample waste transfer and consignment note documents, together with details of the administrative arrangements for record keeping, will be included in the SWMP.

17.123 Littering on site by any individual under the control of TfL will be dealt with under a disciplinary procedure to be set out in the SWMP. TfL and its Contractor will:

i. Develop storage, segregation, transportation and other management procedures for contaminated or hazardous materials;

ii. Obtain any necessary permits and/or exemptions for the storage treatment and disposal of waste (including dewatering discharge);

iii. Use registered waste carriers/brokers or seek registration as a waste carrier for the handling of all waste, including contaminated materials; and

iv. Ensure that removal and disposal of hazardous waste complies with duty of care procedures and that delivery is to appropriately permitted facilities.

17.124 Provision will be made for a suitable environmental specialist to identify any Hazardous Waste, so that it can be suitably managed and disposed of during the works. Measures to control the handling of and working with any asbestos that may be encountered during the works are set out in the CoCP at paragraphs 9.3.2 and 9.3.3.

Energy Management

17.125 TfL will implement working methods that reduces energy consumption and continually improves energy efficiency on site. This will include but not be limited to:

i. Avoiding unnecessary day and night time site, accommodation and office lighting;

ii. Installing energy efficient security and task lighting, e.g. LED;

iii. Providing well insulated site accommodation; and

iv. Metering, data collection, communication and reporting**.**

17.126 TfL will ensure that energy management considerations are integral to the design of the works and to the construction strategy and consequent energy impacts.

17.127 TfL will develop an energy management plan to demonstrate how energy consumption during construction will be minimised. This plan will complement the Green Travel Plan and will include but not limited to:

i. Energy audits that identify all energy-using processes, activities and equipment on site (aligned with significant changes in site(s) activities through the project life cycle);

ii. Action plan, including staff engagement and training, to reduce energy consumption by all energy consuming processes, activities and equipment on site and in the site offices;

iii. Monitoring regime that assess the effectiveness of energy efficiency measures in the plan; and

iv. Reporting effectiveness of the plan annually excavation work.

Ecology and Nature Conservation

17.128 TfL will ensure that procedures are implemented to control and limit disturbance to areas of nature conservation interest and protected species and habitats in accordance with relevant legislative requirements and accepted industry practice, including allowing sufficient time to obtain the required licenses or consents.

17.129 TfL will produce site specific ecological management plan as required, for consultation with relevant local authorities, Natural England, and the Environment Agency, as appropriate. The plans will include a programme for any outstanding ecology surveys, methods for watching briefs, measures to be adopted in the event of the discovery of protected species and measures for the relocation of certain species. TfL will produce site specific ecology

reinstatement plan, as required, for consultation with relevant local authorities, the Environment Agency wildlife bodies, as appropriate. The plans will implement the TfL Biodiversity Action Plan, as well as relevant borough Biodiversity Action Plans.

17.130 Mitigation measures to protect species and habitats will be considered on a site by site basis and will include the general principles set out in the draft CoCP at paragraph 11.2.1.

17.131 TfL will use reasonably practicable measures to minimise the loss of trees. Any essential remedial or protective work to trees adjacent to construction activity will be carried out by suitably trained or qualified personnel using recognised methods in accordance with BS 5837 "Guide for trees in relation to construction".

17.132 The site specific Ecology Reinstatement Plans will include suitable mitigation measures for specific worksites where mature tree loss is possible. The plan will be discussed with the local planning authority and in preparing the plans the TfL will take into account their observations. The plan will cover such issues as tree protection measures, monitoring during construction, replanting and post-construction monitoring.

Archaeology and Built Heritage

17.133 An initial study indicates that there is limited potential for finds of archaeological interest as a result of TfL works. At Battersea Power Station (BPS) some temporary works will take place within an Archaeological Priority Area (APA) and some permanent and temporary works will be undertaken at Nine Elms and Kennington close to but outside of APAs. TfL will carry out the works in such a way as to ensure that disturbance to potential archaeological sites and deposits and listed buildings will be managed in accordance with accepted industry practice and, where disturbance is unavoidable, is controlled and limited as far as reasonably practicable.

17.134 The works will require activity within the curtilage of BPS, a building of historical and architectural interest (a Grade II* “listed building”). Also works will be undertaken at platform level at Kennington station (Grade II listed). No other listed buildings are predicted to be materially affected although there are a number of listed buildings close to some of the Kennington worksites. The NLE construction sites at Kennington Green and Kennington Park are both in Conservation Areas. At both it will be necessary to demolish an existing building or structure and to remove or lop trees. Kennington Park is a designated Grade II Registered Park whilst Kennington Green is designated under the London Squares Preservation Act 1931. TfL will have regard to the special qualities of the Conservation Areas.

17.135 A watching brief will be undertaken and appropriate steps will be taken if anything of archaeological interest is found. Specific provisions will be addressed in the scope for the watching brief. The provisions will include a number of matters that are listed at paragraph 12.3.1 of the draft CoCP.

17.136 As can be seen the draft CoCP addresses a wide scope of matters but taken together I believe that it will ensure that the NLE is constructed in accordance with Industry best practice.

18 USE OF THE RIVER THAMES

18.1 Consistent with the policy position described by others, TfL is proposing to use the River Thames to transport much of the material excavated in the course of the construction of the NLE project.

18.2 As I have described above this involves using a conveyor to bring material from the Battersea station worksite to the riverside at the existing Battersea Power Station jetty.

18.3 A number of parties have objected to the extent of the powers sought in the Order in relation to the potential for the conveyor to over sail the River and use plot 10006. I am instructed that TfL no longer seeks rights over Plot 10006 in terms of the ability to place a structure in/over the River and TfL will ask the Secretary of State to modify the TWA Order appropriately. The conveyor will thus not over sail the River although vessel movements in that plot may well still be required

18.4 Further concerns have been raised relating to the potential for the route and height of the conveyor to adversely affect operations at Cringle Dock – a dock in close proximity to the BPS Jetty. There is no need for the conveyor to adopt a route or height that would adversely affect the operations at Cringle Dock and the requirement for an approval from the PLA under the TWAO's protective provisions provides sufficient safeguard to ensure that this does not happen.

18.5 A preliminary Navigation Risk Assessment (NRA) **[NLE/A19/9]** has been developed to support the proposals and demonstrate that the use of the River Thames to transport excavated material is appropriate and viable. The preliminary navigation risk assessment has assessed whether the additional river traffic generated by the export of excavated material can be accommodated safely by the River and can be accommodated alongside other known/committed river traffic and fixed installations. This preliminary navigation risk assessment covers the section of river between Victoria Railway Bridge and Vauxhall Bridge, known as Nine Elms Reach. It has been prepared by Marine and Risk Consultants Ltd (Marico).

18.6 The assessment is preliminary because the contractor’s methods of working will not be known and the disposal site not selected until after the contractor has been appointed. Details of the disposal site will be determined once the Design & Build contractor has been appointed but it is intended that the excavated material will be put to beneficial use at a site or sites approved by the Environment Agency in a similar manner to that used by Crossrail at Wallasea Island.

18.7 A Navigation Risk Assessment is not usually undertaken at this stage in the design process; however it has been decided to carry out a preliminary assessment at this time to provide more confidence that the use of barges to remove excavated material is feasible and would be permitted.

18.8 The preliminary NRA is based on the following assumptions:

i. Based on available information from Thames Tideway Tunnel (TTT), the NLE removal of excavated material operation from BPSJ will be completed before the start of the TTT export of excavated material from their proposed Kirtling Street jetty;

ii. The NLE removal of excavated material operation from BPSJ includes material excavated from the BPSD site;

iii. The contractor will use barges of a capacity of approximately 1,000 tonnes capacity (although the contractor will be free to determine his own mode of marine transport);

iv. Up to two barges could be loaded over a tidal cycle;

v. Sufficient capacity will be provided to allow two barges to be loaded per tide;

vi. Barges may be berthed two deep but will not incur into Port of London Authority (PLA) Authorised Channel; and

vii. At peak periods it is expected that up to 20,000 tonnes of excavated material will be produced per week and loaded into barges from the two berths on BPSJ.

18.9 The methodology used is based on the Formal Safety Assessment approach to risk management as adopted by the International Maritime Organisation and follows the requirements of the Port Marine Safety Code. The assessment used the proprietary Marico Marine “Hazman II” programme to undertake the risk assessment process. This software is owned by Marico who undertook the assessment but also is currently used by the PLA to manage their navigation risk assessment requirements as mandated by the Port Marine Safety Code.

18.10 The assessment examined the risks presented by all users of the River. It was undertake in consultation with many stakeholders.

18.11 To understand the assessment it is necessary to understand what risk is. A hazard can be defined as “something with the potential to cause harm, loss or injury”, the realisation of which results in an accident. The potential for a hazard to be realised can be combined with an estimate or known consequence of outcome. This combination is termed “risk”. Risk is therefore a measure of the frequency and consequence of a particular hazard and in order to compare risk levels a matrix is used.

18.12 At the low end of the scale, frequency is extremely remote, consequence insignificant and risk can be said to be negligible. At the high end, where hazards are defined as frequent and the consequence catastrophic, then risk

is termed intolerable. Between the two is an area defined “As Low As Reasonably Practicable” (ALARP). The IMO guidelines allow the selection of definitions of frequency and consequence to be made by the organisation carrying out the NRA. This is important, as it allows risk to be applied in a qualitative and comparative way. To identify high risk levels using a quantitative mathematical approach would require a large volume of casualty data, which is not generally available.

18.13 ALARP can be defined as “Tolerable”, if the reduction of the risk is impracticable, or if the cost of such reduction would obviously be highly disproportionate to the improvement. It can also be defined as “Tolerable”, if the cost of reducing the risk is greater than any improvement gained.

18.14 Thus the assessment identified all potential hazards involved in using the river for the transportation of material and considered the likely frequency of that hazard arising and the scale of the likely consequences. For each hazard it was thus possible to identify the potential risk.

18.15 The PLA already has comprehensive and robust risk control systems in place to mitigate risk from freight traffic navigating through a serious of regulations and protocols identified in the Preliminary NRA.

18.16 The assessment identified that with these existing controls in place the risks associated with hazards identified in the proposed NLE removal of excavated material operation are currently within or below the ALARP band.

18.17 The assessment went on to identify however that with further mitigation in place NLE’s excavated material removal operation could be mitigated to below ALARP into the “Low Risk” category.

18.18 As a result there is no reason in principle why the proposed strategy for removing excavated material should not be capable of implementation.

18.19 The treatment of fenders has given rise to objections; these will now be removed, following completion of the works, as one of the measures taken in connection with the disposal of excavated material by River.

19 OBJECTIONS

I set out in Appendix 3 my responses to the objections that have been received and that raise issues that are relevant to my evidence.

20 RESPONSE TO STATEMENT OF MATTERS

20.1 The Secretary of State has issued a list of matters to be considered at the Public Inquiry. This evidence addresses the following Statement of Matters (*in italics*) at the Chapters stated.

20.2 *The main alternative options considered by TfL and the reasons for choosing the proposals comprised in this scheme.*

All the proposals for the key features of the NLE have already been subject to a rigorous process of optioneering, consistent with TfL's procedures and with procedures with which I have been involved for other projects in the UK and overseas. Each of the previous chapters in my evidence which address a feature of the NLE such as the alignment, the stations, and the shafts, includes reference to the options that have been studied. Chapters 3 and 4 are expressed in more general terms, but there is increased detail regarding options in Chapter 7 to 15, inclusive, which relate to the NLE scheme in its entirety from Battersea to Kennington station. The evidence of Mr de Cani **[TFL1/A]** is also pertinent to the process of optioneering.

20.3 *The likely impact on local residents, others visiting or passing through the area, businesses and the environment of the scheme during construction and operation, including*:

Impacts on properties from ground movements;

Ground movements are addressed in Chapter 16 and have been the subject of a detailed settlement report which is contained in the Environmental Statement as Appendix I2 in Volume IIc **[NLE/A19/4]**. The design process adopted is entirely in keeping with other underground railway projects in London, where a wealth of experience of building and infrastructure response to tunnelling and other works such as underground stations already exists. Settlement predictions along the entire alignment of the NLE have been presented in the Settlement Report and I have reproduced the relevant drawings as my Figures 41 to 46.

Impacts on users of the River Thames

I have addressed the use of the River Thames in Chapter 18, which solely concerns this matter. However, I first make reference to this matter in Chapter 7, where I give attention to features of the NLE at Battersea. The use of the River will be beneficial to the project and recent studies have found that the disposal of excavated material using river transport is viable.

Impacts on water resources, including flood risk and the potential contamination

These matters receive attention separately in my evidence. I have introduced the matter of flood risk in Chapter 4 and in Appendix 4.2 I have provided a

detailed description of the assessment that has been carried out for the NLE. The flood risk is being adequately managed and is reflected in the design of the stations, in particular. As also addressed by the Environmental Statement **[NLE/A19/1]**, the impact on water resources, in terms of interference with the natural groundwater regime for example, will be minimal and contamination will be contained by the provisions made in the Code of Construction Practice (CoCP), as I have described in Chapter 17.

20.4 *The effects of the construction of a permanent shaft and head house in Kennington Park and Kennington Green*.

The effects of the construction of the shafts and their related features have received very careful attention. Strenuous efforts have been made to contain worksites within the minimum area viable for works of the kind proposed. The Code of Construction Practice will be critical in connection with this matter .

20.5 *The effects of the scheme on statutory undertakers and other utility providers, and their ability to carry out undertakings effectively, safely and in compliance with any statutory or contractual obligations.*

My response to the matter at paragraph 20.4 also applies here.

20.6 *The measures proposed by TfL for mitigating any adverse impacts of the scheme, including:*

the proposed Code of Construction Practice

I have stressed the importance of the Code of Construction Practice, the scope of which includes procedures pertinent to the matter of mitigating adverse impacts.

any measures to avoid, reduce or remedy any major or significant adverse environmental impacts of the scheme.

In my Chapter 17, I have addressed each of the areas of environmental concern relevant to the NLE and I have identified the adequacy of the CoCP with regard to impacts of the scheme.

21 CONCLUSION AND WITNESS DECLARATION

21.1 The engineering of the NLE is appropriate and can be fully justified having regard to all relevant constraints. The worksites are required in order to construct the NLE. It has been established that there is no in-principle reason why the strategy to use the River Thames for the removal of excavated material should not be capable of implementation. The permanent shafts at Kennington Green and Kennington Park are required to provide necessary ventilation and for safety-related reasons. The procedures to identify, mitigate, monitor and respond to ground movement represent best practice; they are appropriate to ensure that any potential impacts will be adequately controlled and mitigated.

21.2 There is a comprehensive framework for the management of construction in the form of the draft Code of Construction Practice which, once agreed with the relevant local planning authorities and then applied, will ensure that best practice is adopted in the construction of the NLE project.

21.3 I conclude that the engineering of the proposed NLE is both appropriate and fully justified.

21.4 I hereby declare that this Proof of Evidence includes all the facts which I believe to be relevant to the Inquiry. I believe the facts that I have stated in this Proof of Evidence are true. I understand my duty to the Inquiry to help it with matters within my expertise and I have complied with that duty.