10 Air Quality

Environmental Statement

Volume I

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Introduction

Overview

10.1 This chapter of the Environmental Statement (ES) assesses the likely significant effects of the Northern Line Extension (NLE) on local air quality. The assessment takes full account of current policy and technical guidance for the assessment of changes to the concentration of air pollutants.

10.2 The NLE is located within the London Boroughs of Lambeth (LBL), Southwark (LBS) and Wandsworth (LBW). All three boroughs have declared all or a large proportion of their administrative areas as Air Quality Management Areas (AQMA) due to concentrations of nitrogen dioxide (NO_2) and particulate matter (PM_{10} and $PM_{2.5}$) being in exceedance of the relevant national air quality standards. Each of the worksites for the construction of the NLE are located within these AQMAs.

Scope and Objectives

10.3 The air quality assessment described in this chapter has taken into account the scoping responses provided by stakeholders including the relevant local authorities and Transport for London (TfL) / London Underground Ltd (LUL).

10.4 A review of the published ambient air quality data forms the basis for the prediction of current baseline conditions against which the magnitude of predicted impacts due to the NLE is assessed.

10.5 The air quality assessment considers emissions of dust and PM_{10} from construction activities, emissions of (NO_2) and PM_{10} from construction site plant, emissions of NO_2, PM_{10} and $PM_{2.5}$ from construction related vehicle movements, and emissions of particulate matter from the proposed ventilation shafts associated with NLE. It considers the effects associated with these emissions from two potential construction options. The first option (Construction Option A) includes for the construction of two additional temporary shafts on the Kennington Loop. The second option (Construction Option B) does not include these temporary shafts. A detailed description of these options is provided in *Chapter 4: Description of NLE*.

10.6 During the construction phase, there is the potential for earthworks and construction activities to generate fugitive emissions of particulate matter (dust and PM_{10}). There is the risk of such emissions giving rise to significant adverse effects on amenity or health at receptors located within 100m of the source of emissions (Ref. 10-1) unless appropriate mitigation measures are adopted. There are receptors located within 100m of each worksite boundary and therefore an assessment of the significance of effects from fugitive emissions of dust and PM_{10} from the site has been undertaken. The assessment includes consideration of the risk of adverse effects associated with the potential track out of material at receptors located within 50m of roads extending up to 200m from the site accesses.

10.7 There are no nationally designated ecological sites located within 40m of the site boundary or within 40m of roads extending up to 200m from any of the site accesses. It is considered highly unlikely that the proposed construction works could emit dust emissions with the potential to significantly affect the nearest ecological receptor sites and the risk to such sites is not considered further in this assessment.

10.8 The potential for changes to long term and short term mean concentrations of particulate matter (PM_{10} and $PM_{2.5}$) and NO_2 to occur as a result of the predicted increase in road traffic movements on the local road network have been considered specifically for the following scenarios (Construction Options A and B are described in more detail in Chapter 4: Description of NLE) :

- 2011 Baseline Scenario (used for air quality model verification only);
- 2012 Baseline;
- 2012 Construction Phase (Option A) Scenario (worst-case construction year with development);
- 2012 Construction Phase (Option B) Scenario (worst-case construction year with development).

10.9 The air quality assessment uses baseline 2012 traffic flows provided by TfL and construction phase vehicle schedules for the construction phase options provided by Halcrow.

10.10 The assessment considers the effects associated with emissions to air from non-road mobile vehicles and site plant during construction of the NLE and emissions from ventilation shafts during operation of the NLE. Where applicable, it describes control measures incorporated within the design of the NLE to minimise the impact associated with such effects.

10.11 The assessment does not consider the effects of changes to operational road traffic as a result of the NLE on local air quality. During its operation, it is not anticipated that the NLE would increase traffic flow and vehicle emissions on local roads. Therefore, the potential impact of operation road traffic emissions is not considered further in this assessment.

Legislation and Guidance

Air Quality Legislation

10.12 The Clean Air for Europe (CAFE) programme revisited the management of Air Quality within the EU and replaced the EU Framework Directive 96/62/EC (Ref. 10-2), its associated Daughter Directives 1999/30/EC (Ref. 10-3), 2000/69/EC (Ref. 10-4), 2002/3/EC (Ref. 10-5), and the Council Decision 97/101/EC (Ref. 10-6) with a single legal act, the Ambient Air Quality and Cleaner Air for Europe Directive 2008/50/EC (Ref. 10-7).

10.13 Directive 2008/50/EC (Ref. 10-7) is transcribed into UK legislation by the Air Quality Standards Regulations 2010 (Ref. 10-8). These limit values are binding on the UK and have been set with the aim of avoiding, preventing or reducing harmful effects on human health and on the environment as a whole.

10.14 The powers for Local Authorities and individuals to take action against emissions that have an adverse effect on amenity are set out within Part III of the Environmental Protection Act (1990) (Ref.10-9).

National Planning Policy Framework (NPPF)

10.15 The NPPF was published in March 2012 (Ref. 10-10). Paragraph 109 of the NPPF states that:

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"The planning system should contribute to and enhance the natural and local environment by:

preventing both new and existing development from contributing to or being put at unacceptable risk from, or being adversely affected by unacceptable levels of soil, air, water or noise pollution or land instability…"

10.16 Annex 2 of the NPPF defines 'Pollution' as *"Anything that affects the quality of land, air, water or soils, which might lead to an adverse impact on human health, the natural environment or general amenity. Pollution can arise from a range of emissions, including smoke, fumes, gases, dust, steam, odour, noise and light".*

10.17 There are both national and local policies for the control of air pollution and local action plans for the management of local air quality within the Lambeth, Southwark and Wandsworth areas. The effect of a proposed development on the achievement of such policies and plans are matters that may be a material consideration by planning authorities, when making decisions for individual planning applications. Paragraph 124 of the NPPF states that:

"Planning policies should sustain compliance with and contribute towards EU limit values or national objectives for pollutants, taking into account the presence of Air Quality Management Areas and the cumulative impacts on air quality from individual sites in local areas. Planning decisions should ensure that any new development in Air Quality Management Areas is consistent with the local air quality action plan."

10.18 The different roles of a planning authority and a pollution control authority are addressed by the NPPF in paragraph 122:

"... local planning authorities should focus on whether the development itself is an acceptable use of the land, and the impact of the use, rather than the control of processes or emissions themselves where these are subject to approval under pollution control regimes. Local planning authorities should assume that these regimes will operate effectively. Equally, where a planning decision has been made on a particular development, the planning issues should not be revisited through the permitting regimes operated by pollution control authorities."

10.19 The NPPF is accompanied by Technical Guidance (NPPF-TG) (Ref. 10-11). This does not include any specific guidance for the assessment of air quality impacts from residential developments, but does provide some broader guidance on assessments of dust impacts from mineral extraction sites which is relevant here and has therefore been cited in the methodology of this assessment.

National Air Quality Strategy

10.20 The UK National Air Quality Strategy (Ref. 10-12) was initially published in 2000, under the requirements of the Environment Act 1995 (Ref. 10-13). The most recent revision of the strategy (Ref. 10-14) sets objective values for key pollutants as a tool to help Local Authorities manage local air quality improvements in accordance with the EU Air Quality Framework Directive. Some of these objective values have subsequently been laid out within the Air Quality (England) Regulations 2000 (Ref. 10-15) and later amendments (Ref. 10-16).

10.21 The air quality objective values referred to below have been set down in regulation solely for the purposes of local air quality management. Under the local air quality management regime, LBL, LBS and LBW have a duty to carry out regular assessments of air quality against the objective values and if it is unlikely that the objective values will be met in the given timescale, they must designate an AQMA and prepare an Air Quality Action Plan (AQAP) with the aim of achieving the objective values. The boundary of an AQMA is set by the governing local authority to define the geographical area that is to be subject to the management measures to be set out in a subsequent action plan. Consequently it is not unusual for the boundary of an AQMA to include within it, relevant locations where air quality is not at risk of exceeding an air quality objective.

10.22 The UK's national air quality objective values for the pollutants of relevance to this assessment are displayed in Table 10-1.

Table 10-1 National Air Quality Strategy Objectives (µg/m^3)

Pollutant	Objective	Averaging period	Not to be exceeded more than
Nitrogen dioxide (NO_2)	200	1 hour	18 times per year (i.e. 99.8th percentile)
	40	Annual	Not applicable
Particulate matter (PM_{10})	40	Annual	Not applicable
	50	24 hour	35 times per year (i.e. 90.4th percentile)
Particulate matter ($PM_{2.5}$)	25	Annual	Not applicable

Regional Planning Policy

10.23 Policy 7.14 of the London Plan (2011) (Ref. 10-17) states that development proposals should:

- *"minimise increased exposure to existing poor air quality and make provision to address local problems of air quality (particularly within Air Quality Management Areas (AQMAs) and where development is likely to be used by large numbers of those particularly vulnerable to poor air quality, such as children or older people) such as by design solutions, buffer zones or steps to promote greater use of sustainable transport modes through travel plans;*
- *"be at least 'air quality neutral' and not lead to further deterioration of existing poor air quality (such as areas designated as Air Quality Management Areas (AQMAs)."*

10.24 The London Plan acts as an integrated framework for a set of strategies, including that of air quality, which sets out how administrations should go about improving air quality in London.

10.25 As well as the London Plan, the Mayor of London produced an updated Air Quality Strategy in 2010 (Ref. 10-18), setting out how the National Air Quality Strategy would be implemented in London as a whole. LBL, LBS and LBW need to have regard to this strategy when bringing forward their AQAP.

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10.26 Within the wider London area, other planning and guidance documents that relate to air quality include:

- The London Planning Statement Draft Supplementary Planning Guidance (SPG) (Ref. 10-19), which sets out some general principles of fundamental importance to the planning system in London and explains the Mayor's role in London's planning system;
- The Mayor's Transport Strategy (Ref. 10-20), which contains several transport related measures aimed at improving air quality in the London area;
- The London Councils Air Quality and Planning Guidance (Ref. 10-21), which provides an overview of the planning system, and justification as to when air quality assessments for proposed developments should be undertaken in the London area;
- The Mayor of London's The Control of Dust and Emissions from Construction and Demolition Best Practice Guide (Ref. 10-22), which contains a comprehensive list of dust control measures for construction and demolition activities, an update of which is due to be released as a SPG in Spring 2013; and
- The Vauxhall Nine Elms Battersea Opportunity Area (VNEB OA) Planning Framework SPG (Ref. 10-23), which recognises that air quality is a consideration around the VNEB OA and that air pollution is known to be highest around Vauxhall gyratory and along Nine Elms Lane and Albert Embankment. The Planning Framework states that in accordance with "*London Plan policy 7.14, development proposals should be designed to minimise exposure to existing poor air quality and provide on-site mitigation measures to ameliorate any additional negative air quality impacts arising from the development.*"

Local Planning Policy

10.27 The NLE, which consists of two stations and four construction and ventilation shafts, will span the LBL, LBS and LBW. Relevant air quality planning policy from all three of these boroughs has been considered below.

London Borough of Lambeth Policy

10.28 LBL began preparation of their Local Development Framework (LDF) in 2008. When complete, the LDF will include the Local Development Scheme, the Statement of Community Involvement, Development Plan Documents, a Proposals Map, Supplementary Planning Documents and the Annual Monitoring Report.

10.29 The LDF's Core Strategy (Ref. 10-24) was adopted in 2011. This document partially supersedes the Borough's existing Unitary Development Plan (UDP) (Ref. 10-25), but does not explicitly mention air quality. The as yet unpublished Development Management Development Plan Document (DPD) will eventually address issues in relation to the detailed application of Core Strategy policy including environmental performance, such as air quality.

10.30 LBL adopted their current UDP in 2007. The adopted UDP sets out the planning policies which govern the way a new development within the Borough is shaped to encourage sustainable communities. The implication of air quality on the planning process is highlighted in Policy 9, which states that *"Planning applications will be assessed for their traffic impact, including cumulative impacts… on the environment and the road network".* Air quality is also referenced in Policy 14, which considers parking and traffic restraint. *"Lambeth treats parking controls both as a means of managing traffic and of restraining demand, improving road safety, assisting air quality and improving the environment in general".*

10.31 LBL has a Supplementary Planning Document (SPD) for Sustainable Design and Construction (2008) (Ref. 10-26), which sets out the Council's position on the control of dust emissions during construction. Developers are encouraged to sign up to the Considerate Contractor's Scheme. The Council also encourages adherence to the Mayor and London Council's Best Practice Guidance on the Control of Dust and Emissions from Construction and Demolition (Ref. 10-22).

London Borough of Southwark Policy

10.32 The Southwark Core Strategy (Ref. 10-27) forms part of their LDF, and was adopted in April 2011. Strategic Policy 13 of the LDF is titled 'High Environmental Standards' and includes some of the saved policies within the Southwark UDP (Ref. 10-28), including Policy 3.6 – Air Quality. This policy states that "*Planning permission will not be granted for development that would lead to a reduction [deterioration] in air quality*". It also *"…identifies planning policies to be a key action in improving local air quality through influencing developments to consider air quality impacts."*

10.33 The Draft Bankside, Borough and London Bridge Opportunity Area SPD (Ref. 10-29) was published in February 2010 and is awaiting formal adoption. The SPD outlines a detailed plan to guide development within the area and ensure it is responsive to the special qualities the Opportunity Area has. This document states that there are several environmental issues that development needs to respond to, and that the levels of traffic within the Borough contribute to the poor air quality responsible for the AQMA.

10.34 The LBS has an Environmental Code of Construction Practice (CoCP) (Ref. 10-30) which outlines preventative and mitigation measures for demolition and construction sites in the borough in order to protect local residents and the environment from adverse air quality effects.

London Borough of Wandsworth Policy

10.35 The LBW Local Plan (formerly LDF) consists of a series of documents. The most important of these is the Core Strategy (Ref. 10-31), within which, Policy IS 3, states that the council will take measures to *"improve the air quality in line with the council's Air Quality Action Plan".*

10.36 LBW also has a Code of Practice for the Control of Pollution and Noise from Demolition and Construction Sites (Ref. 10-32), which sets out control measures that should be implemented by contractors working on construction sites across the borough.

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Local Air Quality Strategy and Action Plans

London Borough of Lambeth AQAP

10.37 The LBL first published its AQAP in the Annual Air Quality Report for 2004. The most recently available update on the Action Plan is that contained within the Annual Air Quality Report published in 2011 (Ref. 10-33). The Plan includes the following proposals that have already been completely or partially implemented over the years:

- London Low Emission Zone and possible extension;
- Promotion of cleaner vehicle fuel technology and alternative fuels;
- Support wider London approach to vehicle emission testing;
- Implementation of congestion charge zone;
- Management of vehicle parking and enforcement in the area;
- Work with the GLA and TfL in their programme of investment and expansion of the Underground tube network as a means of enhancing more sustainable transport in London;
- The Council will require developers to include cycle facilities within new developments and where appropriate encourage them to provide shower and changing facilities;
- Lambeth welcomes the commitment in the Mayor's Air Quality Strategy to take action to reduce particulate emissions; and
- Practices and procedures to ensure pollution emissions and dust generation is kept to a minimum during construction activities.

London Borough of Southwark Air Quality Strategy and AQAP

10.38 LBS published its joint Air Quality Improvement Strategy and Action Plan in May 2012 (Ref. 10-34). The objectives of the strategy set out how the Borough will:

- Reduce emissions from vehicular transport;
- Tackle emissions from existing fixed sources;
- Reduce emissions from new development; and
- Protect public health and monitor air quality.

10.39 The document also includes discussion on how the borough will work regionally to improve air quality across London, as well as working locally to improve air quality in Southwark.

10.40 The Action Plan states how the Council acknowledge that the vast majority of PM_{10} and nitrogen oxide (NO_X) emissions are from vehicles. The Council's Transport Plan was developed in parallel to the Air Quality Strategy and AQAP, and its objectives are to:

- Ensure that the air quality, efficiency and reliability of the transport network is maintained;
- Encourage sustainable travel choices;
- Increase sustainable transport capacity and manage demand for travel;
- Ensure the transport network is safe and secure for all and improve perceptions of safety;
- Improve travel opportunities and maximise independence for all;
- Reduce the impact of transport on the environment;
- Reduce transport's contribution to climate change;
- Reduce the impact of transport on Southwark's air quality;
- Improve the health and wellbeing of all by making the borough a better place; and
- Ensure the transport system helps people to achieve their potential.

10.41 Other measures that are described within the AQAP to reduce emissions from traffic are:

- Car clubs;
- Promoting walking and cycling;
- Travel plans;
- Reduction of idling engines;
- Road safety schemes and initiatives;
- Improving the efficiency of the Council's vehicle fleet; and
- Consideration of a local Low Emission Zone.

10.42 The AQAP states that the Council are aware that emissions from fixed source emissions points need to be reduced, as they account for almost 50% of emissions within the Borough, and that emissions from new development, including those from construction activity, should also be reduced.

10.43 The AQAP contains a section improving public health and reducing exposure to air pollutants. The document states that developers will need to submit air quality assessments for all major applications within the AQMA.

London Borough of Wandsworth Air Quality Strategy and AQAP

10.44 The LBW published its AQAP in 2004 (Ref. 10-35). The aim of the Plan is to protect the health of all those who live, work and visit the Borough. The measures that the Council have and will implement are divided into the following seven categories:

- Measures aimed at reducing the use of cars;
- Measures aimed at reducing emissions from vehicles;
- Development control;

- Enforcement of regulatory powers;
- Energy use and heating;
- Educational and promotional initiatives; and
- Encouraging businesses.

Methodology for the Assessment of Effects

Overview

10.45 There is currently no statutory guidance on the method by which an air quality impact assessment should be undertaken. Several non-statutory bodies have published their own guidance relating to air quality and development control (Ref. 10-36) or to the assessment of the significance of air quality effects (Ref. 10-37).

10.46 This section will explain the methods used to assess the significance of the impacts from:

- Fugitive emissions of particulate matter from construction phase activities;
- Site plant emissions during the construction phase;
- Road traffic emissions associated with the construction and operation of the NLE; and
- Ventilation shaft emissions during the operational phase.

10.47 Potentially affected air quality sensitive receptors have been identified for each element of the assessment and the magnitude of the change in air quality statistics at each receptor has been considered. The methods used to determine the significance of effect associated with air quality impacts are described in paragraphs 10.101 to 10.113.

Fugitive Emissions of Particulate Matter

10.48 Fugitive emissions of airborne particulate matter are readily produced through the action of abrasive forces on materials and therefore a wide range of site preparation and construction activities have the potential to generate this type of emissions, including;

- Demolition work;
- Earthworks, including the handling, working and storage of materials;
- Construction activities; and
- Trackout (the transfer of dusty materials from the site to the local road network via construction vehicles).

10.49 'Dust' is defined in BS 6069:1994 (Ref. 10-38) as particulate matter in the size range 1µm - 75µm in diameter, and is primarily composed of mineral materials and soil particles. This definition is also referred to in NPPF technical guidance (Ref. 10-11) in the context of dust impacts from mineral extraction operations and has been adopted in this assessment.

10.50 Respirable particulate matter (PM_{10}) is composed of material with an aerodynamic diameter of less than 10 micrometers (µm) in diameter, and includes the size fractions of greatest concern to impacts on human health. The majority of construction dust is larger than 10µm diameter and, therefore, increased levels of dust in the air do not necessarily equate to increased levels of PM_{10}. In general, construction dusts rarely represent an adverse risk to human health and are more typically associated with consequences of material depositing onto property.

10.51 Particulate matter may have an impact whilst airborne or as a result of its deposition onto a solid or liquid surface. Consequently, the nature of the impact requiring assessment varies between different types of receptor. In general, receptors associated with higher baseline dust deposition rates are less sensitive to impacts, such as inner city allotments, light and heavy industry or outdoor storage facilities. In comparison, some hi-technology industries or food processing plants operate under clean air conditions and increased airborne particulate matter concentrations may have an increased economic cost associated with the extraction of more material by the plants air filtration units.

10.52 Table 10-2 provides some generic examples of the type of impacts that may result from fugitive emissions of particulate matter. The sensitivity of receptor types is listed for selected impacts, with sensitivity being described as 'high' for receptors that are especially sensitive to the specified impact. For example, industrial painting operations are considered to be more sensitive to the impact of material becoming soiled by depositing material, than residential properties or schools.

Table 10-2 Types of Impacts from Emissions of Particulate Matter

Pollutant	Objective	Averaging period
Change in 24 hour PM_{10} concentrations	Residential properties, schools, hospitals and clinics	Receptor sensitivity was considered when Air Quality Objective Value was set
Change in rate at which air filtration units require maintenance	Hospitals and clinics	High
	High-tech industries	High
	Food processing industries	High
Change in the rate at which material accumulates on glossy surfaces, such as glass or paint work	Painting and furnishing operations	High
	Residential properties	Medium
	Schools	Medium
	Food retailers	Medium
	Offices	Medium
	Museums and Galleries	Medium
	Glasshouses	Medium

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Pollutant	Objective	Averaging period
Change in the rate at which property or products becomes soiled by deposited material	Food processing industries	High
	Painting and furnishing operations	High
	Museums and Galleries	High
	Residential properties	Medium
	Food retailers	Medium
	Offices	Medium
	Horticultural Land	Medium
Change in the rate at which mineral material is deposited onto vegetation	Ecological sites	Medium-Low
Change in chemical composition of mineral material deposited	Ecological sites	Medium-Low
	Outdoor Storage	Medium-Low
	Horticultural Land	Low
	Allotments	Low

10.53 This assessment is consistent with the overarching approach to the assessment of the impacts of construction and the determination of their significance set out in current guidance from the Institute of Air Quality Management (IAQM) (Ref. 10-1). The assessment considers the significance of potential effects with the mitigation in place, as described within the CoCP (see *Appendix N of ES Volume II*), and recommends mitigation measures appropriate to the identified risks to receptors. The CoCP reflects measures described within the Mayor of London's current Best Practice Guidance in the Control of Dust and Emissions from Construction and Demolition (Ref. 10-22) and the soon to be published SPG.

10.54 These documents include dust and emission controls that are considered standard practice at construction sites across the London area, and include a tier system based on the risk of dust and emissions occurring from construction sites. The greater the risk of dust and emissions occurring, the higher the tier and associated mitigation measures and monitoring required at that site. The tier that a particular construction site is assigned is based on the size of the development area (in m^2), the number of properties proposed, whether or not the site is classed as 'major development' by the Mayor of London, the London Development Agency and/or the London Borough within which it is located, and/or the frequency and likelihood of emissions and dust from the site to have an impact on nearby sensitive receptors.

10.55 Following the methodology described in Section 4 of the Mayor of London's BSP (ref. 10-22), the worksites that form the construction phase of the NLE are likely to be classed as Tier 2 or medium risk sites, where the proximity and nature of works being undertaken means that there is 'potential for emissions and dust to have an intermittent or likely impact on sensitive receptors'. This is because of the proximity of sensitive receptors to the worksites, the extent of excavation required, the number of construction phase vehicle movements and the occurrence and scale of dust generating activities.

Road Traffic Emissions

10.56 The incomplete combustion of fuel in vehicle engines results in the presence of hydrocarbons (HC) such as benzene and 1,3-butadiene, and sulphur dioxide (SO_2), carbon monoxide (CO), PM_{10} and $PM_{2.5}$ in exhaust emissions. In addition, at the high temperatures and pressures found within vehicle engines, some of the nitrogen in the air and the fuel is oxidised to form NO_X, mainly in the form of nitric oxide (NO), which is then converted to NO_2 in the atmosphere. NO_2 is associated with adverse effects on human health. Better emission control technology and fuel specifications are expected to reduce emissions per vehicle in the long term.

10.57 Exhaust emissions from road vehicles affect the concentrations of principal pollutants of concern, NO_2 PM_{10} and $PM_{2.5}$, at sensitive receptors in the vicinity of a development. Therefore, these pollutants will be the focus of the assessment of the significance of road traffic impacts.

10.58 Although SO_2, CO, benzene and 1,3-butadiene are also present in motor vehicle exhaust emissions, detailed consideration of the associated impacts on local air quality is not considered relevant here. Road traffic emissions of these substances have been reviewed by the local authorities and nowhere within the LBL, LBS and LBW is there a risk of exceeding these objectives. The NLE would not be capable of compromising the achievement of the relevant air quality objectives for the protection of human health. Emissions of SO_2, CO, benzene and 1, 3-butadiene from road traffic are therefore not considered further within this assessment.

10.59 The magnitude of road traffic emissions for the baseline and construction phase scenarios are calculated from traffic flow data. The assessment considers the operational phase impact of road traffic emissions at receptors adjacent to roads in the vicinity of the NLE.

10.60 This assessment follows current guidance for the determination of baseline pollutant concentrations, and uses emissions factors for road traffic from the Highways Agency's current emissions factors toolkit (EFT) 5.2.

Site Plant Emissions

10.61 During the proposed construction works, there is the potential for emissions associated with on-site non-road mobile machinery (NRMM) or construction plant to affect local air quality. It is anticipated that peak site preparation/construction work will comprise a number of different types of plant, as detailed within *Chapter 4: Description of the NLE* of this ES.

10.62 The emissions of concern associated with NRMM or construction plant are those of NO_X, SO_2 and particulate matter (both PM_{10} and $PM_{2.5}$).

Ventilation Shaft Emissions

10.63 During the operational phase of the NLE, there is the potential for emissions associated with the two ventilation shafts to affect local air quality.

10.64 The emissions of concern associated with these operational shafts are those of particulate matter (PM_{10} and $PM_{2.5}$).

Use of Measurement Data

10.65 The air quality assessment makes use of monitoring data to establish baseline conditions within the air quality study area, as a source of background pollutant concentration data and as a source of data for model verification.

10.66 The LBL, LBS and LBW carry out some monitoring and measurement of NO_2 and particulate matter data within the air quality study area. Where suitable, this data has been used in the air quality assessment. This includes data gathered at the continuous monitoring station at Bondway in Lambeth, and the continuous monitoring stations off Battersea Park Road and at Wandsworth Town Hall in Wandsworth.

Air Quality Sensitive Receptors

Receptors Potentially Affected by Construction Phase Dust Emissions

10.67 When assessing the impact of dust emissions generated during demolition and construction works, receptors are defined as the nearest potentially sensitive receptor to the boundary of the site in each direction. These receptors have the potential to experience impacts of greater magnitude due to emissions of particulate matter generated by the works, when compared with other more distant receptors, or less sensitive receptors.

10.68 The worksites associated with the construction of the NLE are described in detail in *Chapter 4: Description of the NLE.* There are a number of receptors that are sensitive to dust in the immediate vicinity of the NLE construction work sites. The location of these receptors is shown in Figure 10-1. A summary is provided below:

- Battersea station worksite:
  - residential properties on Battersea Park Road to the south.
- Nine Elms station worksite:
  - residential properties on Apple Blossom Court to the south;
  - residential properties on Bramley Crescent to the south; and
  - residential properties off Wandsworth Road to the east.
- Kennington Green ventilation shaft worksite:
  - residential properties on Kennington Road to the north, south and west.
- Kennington Park ventilation shaft worksite:
  - residential properties on Kennington Park Place to the north;
  - nursery on Kennington Park Place to the north; and
  - residential properties on St Agnes Place to the east.
- Harmsworth Street temporary works shaft worksite:
  - residential properties on De Laune Street to the west;
  - residential properties on Sharsted Street to the north; and
  - residential properties on Harmsworth Street to the east.
- Radcot Street temporary works shaft worksite:
  - residential properties on Radcot Street to the north;
  - residential properties on Ravensdon Street to the east and west; and
  - residential properties on Stannary Street to the south.

Receptors Potentially Affected by Road Traffic Emissions

10.69 The concentration of road traffic emitted pollutants at the roadside or at sensitive receptors is influenced by a number of factors. These include background pollution levels and the amount of traffic emissions, which is dictated by traffic flow rates, composition and speed.

10.70 The air quality objective values for pollutants associated with road traffic have been set by the Expert Panel of Air Quality Standards (EPAQS) (who has now been merged into the Department of Health's Committee on the Medical Effects of Air Pollutants (COMEAP)) at a level below the lowest concentration at which the more sensitive members of society have been observed to be adversely affected by exposure to each pollutant. Therefore all receptors that represent exposure of the public are of equal sensitivity as any member of the public could be present at those locations.

10.71 Impacts from road traffic emissions are quantified at eight existing receptors in the vicinity of the NLE and local highway network, where there is the potential for a significant change in road traffic flows. Each of the receptors chosen represents the maximum level of exposure that would be experienced at other receptors in their vicinity. The receptors are listed in Table 10-3 and their location displayed in Figure 10-1.

Receptors Potentially Affected by Site Plant Emissions

10.72 The receptors potentially affected by site plant emissions are those located in close proximity to the worksites where plant is in operation. This would include those receptors described above and shown in Figure 10-1.

Receptors Potentially Affected by Ventilation Shaft Emissions

10.73 The receptors potentially affected by ventilation shaft emissions are those located in close proximity to the ventilation shaft sites when in operation. This would include the residential properties near to Battersea station, on Battersea Park Road, properties near to Nine Elms station, to the south off Pascal Street, properties off Kennington Road, adjacent to the Kennington Green ventilation shaft work site, and residential properties and the nursery on Kennington Park Place, near to the Kennington Park ventilation shaft.

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Table 10-3 Air Quality Sensitive Receptors

Receptor	Description	Grid Reference (x,y)
R1	Eustace Building, Queenstown Road, Wandsworth (ground floor flat)	528627,177488
R2	Bank Court, Battersea Park Road, Wandsworth (ground floor flat)	528577,176804
R3	258 Queenstown Road, Wandsworth	528770,176824
R4	75 Battersea Park Road, Wandsworth (ground floor flat)	529187,177272
R5	Alverston House, Kennington Park Road, Lambeth (ground floor flat)	531242,177744
R6	Hornby House, Kennington Road, Lambeth (ground floor flat)	531267,177922
R7	184 Kennington Park Road, Lambeth	531395,177993
R8	151 Kennington Park Road, Lambeth	531502,178098
R9	Conrad House, Wandsworth Road, Lambeth	530103,177377
R10	Temple Court, Wandsworth Road, Lambeth	530032,177163

Prediction of Construction Phase Dust Impacts

10.74 At present, there are no statutory UK or EU standards relating to the assessment or control of nuisance dust. The emphasis of the regulation and control of demolition and construction dust should therefore be the adoption of good working practices on site. Good design practice, as informed by impact assessments, is able to avoid the potential for significant adverse environmental effects at the design stage. This approach assumes that mitigation measures, beyond those inherent in the proposed design, that are identified as being necessary in the impact assessment, will be applied during works (possibly secured by planning conditions, legal requirements or required by regulations) to ensure potential significant adverse effects do not occur.

10.75 Examples of accepted good site practice include guidelines published by the Building Research Establishment (Ref. 10-39), the GLA (Ref.10-22) and considerate contractor schemes.

10.76 A qualitative assessment has therefore been undertaken to assess the significance of any effects on sensitive receptors. The steps in the assessment process are to consider potential sources of emissions on the basis of the four main activity groupings of demolition, earthworks, construction and trackout. For each activity group, the same steps are applied with respect to the potential impacts at identified receptors, before coming to an overall conclusion about the significance of the effects predicted.

10.77 The steps are:

- Identify the nature, duration and the location of activities being carried out;
- Establish the risk of significant effects occurring as a result of these activities;
- Review the proposed or embedded mitigation against good site practice;
- Identify additional mitigation measures, if necessary, to reduce the risk of a significant adverse effect occurring at receptors; and
- Summarise the overall effect of the works with respect to fugitive emissions of particulate matter and then report the significance of the effects.

Prediction of Road Traffic Emission Impacts

10.78 This assessment has used the latest version of dispersion model software 'ADMS-Roads' to quantify pollution levels at selected receptors. ADMS-Roads is a modern dispersion model that has an extensive published track record of use in the UK for the assessment of local air quality impacts, including model validation and verification studies (Ref. 10-40). The general model conditions used in this assessment are listed in Table 10-4.

Table 10-4 General ADMS-Roads Model Conditions

Variables	Model Input
Surface roughness at source	1.5 m
Minimum Monin-Obukhov length for stable conditions	100 m
Terrain types	Flat
Receptor location	x,y coordinates determined by GIS (z = 1.5 m)
Road traffic emissions	NO_X, PM_{10} and $PM_{2.5}$
Emission factors	EFT Version 5.2 (Defra, 2013)
Emission profiles	None used, conservative approach
Meteorological data	1 year (2011) hourly sequential meteorological data from London Heathrow Airport
Receptors	Selected receptors only
Model output	Long-term NO_X concentrations Long-term PM_{10} concentrations Long-term $PM_{2.5}$ concentrations

10 Air Quality

Traffic Data

10.79 The baseline traffic data used within this assessment has been sourced from the London Atmospheric Emissions Inventory, which was provided by TfL / LUL. The construction phase vehicle movements associated with each worksite for both construction options (Option A) and Option B) has been provided by Halcrow. The data was converted into emission rates for 2012 using Defra's current Emission Factor Toolkit (V5.2) (Ref. 10-41). A summary of the traffic data used within this assessment is provided in *ES Volume II: Appendix F*.

10.80 TfL has confirmed that traffic in London is decreasing. As such, the construction phase assessment scenarios are based on existing (2012) traffic flows. The worst year of construction traffic for each worksite has been added to the 2012 baseline traffic data to obtain with construction phase scenarios for both construction options.

10.81 The NLE is anticipated to open in 2020 and be fully operational by 2031 following the full development of the VNEB OA. The operation of the NLE is likely to indirectly result in an increase in road traffic within the air quality study area, as the overall development of the VNEB OA will to lead an significant extra provision of housing and employment.. However, it is the intention of the NLE to provide a sustainable travel alternative, and TfL also promote the use of public transport and reduce the use of cars through other measures.

10.82 Details of the traffic counts and survey data can be found in the Transport Assessment (TA) submitted in support of this application *(*see *Chapter 6: Traffic and Transport* and *ES Volume II: Appendix C*).

Meteorological Data

10.83 One year (2011) of hourly sequential observation data from London Heathrow Airport meteorological station has been used in this assessment. The station is located approximately 21km west of the site and experiences meteorological conditions that are representative of the conditions experienced in the area for the years of assessment. The surface roughness of land surrounding the meteorological station is 0.2m and at the location of the modelled sources a surface roughness value of 1.5m has been used to represent the built-up environment.

Background Data

10.84 Background pollutant concentration data has been sourced from Local Authority measurement and monitoring data where possible. Where this has not been possible, background pollutant concentration data has been sourced from Defra's background pollution maps (Ref. 10-42) which cover 1km by 1km grids and are based on data gathered in 2010.

10.85 A summary of the background pollutant concentration data used in this assessment is provided in Table 10-5.

Table 10-5 Summary of Background Pollutant Concentration Data (2012) used in Air Quality Assessment

Receptor	Grid Square (x,y)	NO_X	NO_2	PM_{10}	$PM_{2.5}$
R1	528500,177500	61.0	35.0	22.0	15.3
R2	528500,176500	63.3	36.0	21.3	14.9
R3	528500,176500	63.3	36.0	21.3	14.9
R4	529500,177500	68.0	37.9	22.0	15.4
R5	531500,177500	66.5	37.5	22.2	15.5
R6	531500,177500	66.5	37.5	22.2	15.5
R7	531500,177500	66.5	37.5	22.2	15.5
R8	531500,178500	73.9	40.5	22.7	15.8
R9	530500,177500	68.8	38.3	22.5	15.7
R10	530500,177500	68.8	38.3	22.5	15.7

10.86 Due to the uncertainty in the assumption that year on year background NO_2 concentrations will decrease, 2012 background data has been used for both the baseline and future year assessment, therefore providing a conservative approach.

Bias Adjustment of Road Contribution Pollutant Concentrations

10.87 As discussed above, model verification has been informed by existing air quality monitoring data gathered by the London Boroughs within which the air quality study area is located, in 2011, the most recent year with fully ratified data available. The model associated with the verification exercise described below has used the 2011 hourly sequential meteorological data and the 2012 baseline traffic data described above, but with emission rates obtained for 2011 using Defra's current Emission Factor Toolkit (Ref. 10-41). It has also used 2011 background data sourced from Defra's background pollutant concentration maps (Ref. 10-42).

10.88 Two continuous monitoring stations are currently located within the air quality study area, one in the LBW and the other in the LBL.

10.89 The proposed Battersea station (located in the LBW) is currently situated adjacent to Battersea Park Road, near to the Battersea station work site. This station only began monitoring pollutant concentrations in July 2012, and was not present in 2011. The period mean data gathered in 2012 was annualised to a projected annual mean for 2011, following the methodology described in Local Air Quality Management Technical Guidance (LAQM TG(09)) (Ref. 10-43). The 2011 concentration was lower than the annual mean concentrations monitored by urban background sites in the area, and considerably lower than other roadside annual mean concentrations in the area. Therefore, data from the station has been excluded from the verification exercise.

10 Air Quality

10.90 The proposed Nine Elms station (located in the LBL) is currently situated adjacent to the Bondway Interchange in the north of the Borough. It was fully operational in 2011, and maintained by King's College London as part of the London Air Quality Network. In June 2011, this continuous monitoring station was reclassified from a 'roadside' site to 'industrial' site, in line with Defra's classification of continuous monitoring stations reported in LAQM TG(09) (Ref. 10-43). This is to reflect the fact that there is a strong local source of PM_{10} arising from a LUL ventilation shaft immediately to the south west of the monitoring inlet. There is no evidence to suggest that the presence of the ventilation shaft has influenced monitored concentrations of NO_2. As such, this site remains suitable for the adjustment of that primary pollutant.

10.91 The verification process has been undertaken following the methodology described in LAQM TG(09) (Ref. 10-43). Modelled predictions were made for annual mean concentrations of NO_2 at the location of the Bondway Interchange continuous monitoring station, as shown in Figure 10-1. A comparison of the unadjusted NO_2 concentration predicted and the monitored NO_2 concentration indicated that the model under predicted annual mean concentrations by about 10%. To account for this model bias, predicted and monitored road NO_X contributions were compared and the resultant factor applied to the road NO_X contribution of predictions made at the sensitive receptor included in this assessment. A summary of the verification exercise is provided in Table 10-6.

Table 10-6 Summary of Model Verification Exercise

Continuous Monitoring Station	Measured Annual Mean NO_2 ($\mu g/m^3$)	Measured Road Contribution NO_X ($\mu g/m^3$)	Modelled Annual Mean NO_2 ($\mu g/m^3$)	Modelled Road Contribution NO_X ($\mu g/m^3$)	Road Contribution NO_X Factor
Bondway Interchange	72.1*	79.6	65.4	56.6	1.4

**Annualised to annual mean concentration for 2011 using nearby urban background Continuous Monitoring Stations*

10.92 Due to the proximity of the LUL ventilation shaft, the PM_{10} concentrations monitored at this site could not be used for the verification of concentrations of particulate matter (PM_{10} and $PM_{2.5}$). In the absence of any other representative sources of particulate matter monitoring data in the air quality study area, an assumption has been made that the model would perform similarly for each primary pollutant considered. As such, the same adjustment has been applied to the modelled road PM_{10}, $PM_{2.5}$ and NO_X contributions, as recommended in LAQM TG (09) (Ref. 10-43).

NO_X to NO_2 Conversion

10.93 To accompany the publication of the guidance document LAQM TG(09) (Ref. 10-43), a NO_X to NO_2 converter was made available as a tool to calculate the road NO_2 contribution from modelled road NO_X contributions. The tool comes in the form of an MS Excel spreadsheet and uses Borough specific data to calculate annual mean concentrations of NO_2 from dispersion model output values of annual mean concentrations of NO_X. This tool was used to calculate the total NO_2 concentrations at receptors from the modelled road NO_X contribution and associated background concentration. Due to the location of the NLE, the non-urban setting has been selected.

Predicting the Number of Hours in which the Hourly NO_2 Objective is Exceeded

10.94 Research projects completed on behalf of Defra and the Devolved Administrations (Ref. 10-42) and (Ref. 10-46) have concluded that the hourly mean NO_2 objective is unlikely to be exceeded if annual mean concentrations are predicted to be less than $60\mu g/m^3$.

10.95 In 2003, Laxen and Marner concluded:

> *"…local authorities could reliably base decisions on likely exceedences of the 1-hour objective for nitrogen dioxide alongside busy streets using an annual mean of 60 µg/m3 and above."*

10.96 The findings presented by Laxen and Marner (Ref. 10-44) are further supported by AEA Technology AEAT (Ref. 10-45) who revisited the investigation to complete an updated analysis including new monitoring results and additional monitoring sites. The recommendations of this report are:

> *"Local authorities should continue to use the threshold of 60 $\mu g/m^3$ NO_2 as the trigger for considering a likely exceedence of the hourly mean nitrogen dioxide objective."*

10.97 Therefore this assessment will evaluate the likelihood of exceeding the hourly mean NO_2 objective by comparing predicted annual mean NO_2 concentrations at all receptors to an annual mean equivalent threshold of $60\mu g/m^3$ NO_2. Where predicted concentrations are below this value, it can be concluded with confidence that the hourly mean NO_2 objective ($200\mu g/m^3$ NO_2 not more than 18 times per year) will be achieved.

Predicting the Number of Days in which the Daily PM_{10} Objective is Exceeded

10.98 The guidance document LAQM TG(03) (Ref. 10-46) set out the method by which the number of days in which the PM_{10} 24-hr objective is exceeded can be obtained based on a relationship with the predicted PM_{10} annual mean concentration. The most recent guidance (Ref. 10-43) suggests no change to this method. As such, the formula used within this assessment is:

$$No.\ of\ Exceedances = 0.0014 \times C^3 + 206/C - 18.5$$

Where C is the annual mean concentration of PM_{10}.

Prediction of Construction Site Plant Impacts

10.99 The assessment of the effects of emissions from NRMM or construction plant has been considered qualitatively. The assessment is based the location of the NRMM or construction plant, the proximity of sensitive receptors and the suitability of control measures incorporated into the design of the NLE. The control measures to be implemented are described within the CoCP provided in *ES Volume II: Appendix N*.

Prediction of Operation Ventilation Shaft Impacts

10.100 The assessment of the effects of emissions from the operational ventilation shafts located at Kennington Green and Kennington Park has been considered

qualitatively. The assessment is based upon the location of the ventilation shafts, the proximity of sensitive receptors and the suitability of control measures incorporated into the design of the NLE.

Method for Assessment of Significance

Construction Phase Dust Emissions Assessment of Significance

10.101 For amenity effects (including that of dust), the aim is to bring forward a scheme, including mitigation measures if necessary, that does not introduce the potential for additional complaints to be generated.

10.102 The scale of the risk of adverse effects occurring due to each group of activities, with mitigation in place is described using the terms high, medium and low risk. The basis for the choice of descriptor is set out for each section. Experience in the UK (Ref. 10-1) is that good site practice is capable of mitigating the impact of fugitive emissions of particulate matter effectively. So that in all but the most exceptional circumstances, effects at receptors (Table 10-7) can be controlled to ensure they are of negligible or slight adverse significance at worst.

Table 10-7 Descriptors Applied to the Predicted Adverse Effects of Fugitive Emissions of Particulate Matter

Significance of Effect at Single Receptor[a]	Description
Major	A significant effect that is likely to be a material consideration in its own right
Moderate	A significant effect that may be a material consideration in combination with other significant effects, but is unlikely to be a material consideration in its own right
Minor	An effect that is not a significant change but that may be of local concern
Negligible	An effect that is not a significant change

a Where the description of the significance of effect differs from that defined by the IAQM, the following applies: Minor = Slight, Major = Substantial

Construction Phase Road Traffic Emissions Assessment of Significance

10.103 With regard to road traffic emissions, the change in pollutant concentrations with respect to baseline concentrations has been quantified at receptors that are representative of exposure to impacts on local air quality within the study area. The absolute magnitude of pollutant concentrations in the baseline and with-development scenarios is also quantified and this is used to consider the risk of the air quality limit values being exceeded in each scenario.

10.104 For a change of a given magnitude, the IAQM have published recommendations for describing the magnitude of impacts at individual receptors (Table 10-8) and describing the significance (Table 10-9) of such impacts.

Table 10-8 Magnitude of Changes in Ambient Pollutant Concentrations of NO_2, PM_{10} and $PM_{2.5}$

Magnitude of Change	Annual Mean Concentrations of NO_2 (µg/m^3)	Annual Mean Concentrations of PM_{10} (µg/m^3)	Annual Mean Concentrations of $PM_{2.5}$ (µg/m^3)	Exceedances of the 24-hr Mean Objective for PM_{10} (days)
Large	Increase / Decrease >4	Increase / Decrease >4	Increase / Decrease >2.5	Increase / Decrease >4
Medium	Increase / Decrease 2 – 4	Increase / Decrease 2 – 4	Increase / Decrease 1.25 – 2	Increase / Decrease 2 – 4
Small	Increase / Decrease 0.4 – 2	Increase / Decrease 0.4 – 2	Increase / Decrease 0.25 – 1.25	Increase / Decrease 1 – 2
Imperceptible	Increase / Decrease <0.4	Increase/Decrease <0.4	Increase / Decrease <0.25	Increase / Decrease <1

10.105 A change in predicted annual mean concentrations of NO_2 or PM_{10} of less than 0.4 µg/m^3 is considered to be so small as to be imperceptible (Ref. 10-37). A change (impact) that is imperceptible, given normal bounds of variation, would not be capable of having a direct effect on local air quality that could be considered to be significant.

10.106 The magnitude of the change in the predicted number of exceedences of the 24-hour objective is directly derived from the predicted annual mean value using the relationship defined in the Design Manual for Roads and Bridges Screening Tool. The magnitude descriptors in the table above are as proposed by Environmental Protection UK (Ref. 10-36).

10.107 The criteria in Table 10-9 relate to air quality statistics that are elevated about the objective values in many urban locations, this is not the case with $PM_{2.5}$. A change in the annual mean concentration of $PM_{2.5}$ equivalent to 1% of the objective value is 0.25µg/m^3. It is unusual for schemes of this type to give rise to a change of more than 0.1µg/m^3.

10.108 All relevant receptors that have been selected to represent locations where people are likely to be present are based on impacts on human health. The air quality objective values have been set at concentrations that provide protection to all members of society, including more vulnerable groups such as the very young, elderly or unwell. As such the sensitivity of receptors was considered in the definition of the air quality objective values and therefore no additional subdivision of human health receptors on the basis of building or location type is necessary.

Table 10-9 Air Quality Impact Descriptors for Changes in Ambient Pollutant Concentrations of NO_2 and PM_{10}

Absolute Concentration in Relation to Objective/Limit Value	Change in Concentration[a]		
	Small	**Medium**	**Large**
Increase with Scheme			
Above Objective/Limit Value With Scheme (>40µg/m^3)	Minor Adverse	Moderate Adverse	Major Adverse
Just Below Objective/Limit Value With Scheme (36-40µg/m^3)	Minor Adverse	Moderate Adverse	Moderate Adverse
Below Objective/Limit Value With Scheme (30-36µg/m^3)	Negligible	Minor Adverse	Minor Adverse
Well Below Objective/Limit Value With Scheme (<30µg/m^3)	Negligible	Negligible	Minor Adverse
Decrease with Scheme			
Above Objective/Limit Value Without Scheme (>40µg/m^3)	Minor Beneficial	Moderate Beneficial	Major Beneficial
Just Below Objective/Limit Value Without Scheme (36-40µg/m^3)	Minor Beneficial	Moderate Beneficial	Moderate Beneficial
Below Objective/Limit Value Without Scheme (30-36µg/m^3)	Negligible	Minor Beneficial	Minor Beneficial
Well Below Objective/Limit Value Without Scheme (<30µg/m^3)	Negligible	Negligible	Minor Beneficial

a Where the description of the significance of effect differs from that defined by the IAQM, the following applies: Minor = Slight, Major = Substantial

10.109 For receptors that are predicted to experience a perceptible change, the effect of the change on local air quality and the risk of exceeding the air quality objective value is summarised in Table 10-8. A small increase in annual mean concentrations, at receptors exposed to baseline concentrations that are just below the objective value (36µg/m^3 to 40µg/m^3) is considered to have a slight adverse effect as the slight increase in the risk of exceeding the objective value is significant. However, a small increase in annual mean concentration at receptors exposed to baseline concentrations that are below or well below (< 36µg/m^3) is not likely to affect the achievement of the objective value and is therefore not a significant effect (negligible).

Construction Site Plant and Operational Ventilation Shaft Emissions Assessment of Significance

10.110 For the effects associated with emissions from site plant during the construction phase and emissions from the ventilation shafts during the operational phase, the aim would be for the incorporation of control measures into the design of the NLE construction and operational phases to reduce any potential effects.

10.111 The use of such mitigation has been proven at construction sites across the country and ventilation shaft sites at other locations in London to reduce emissions so that they would have negligible effect on local air quality.

Assessment of Significance

10.112 The significance of all of the reported effects is then considered for the NLE in overall terms. The potential for the NLE to contribute to or interfere with the successful implementation of policies and strategies for the management of local air quality are considered if relevant, but the principal focus is any change to the likelihood of future achievement of the air quality objective values set out in Table 10-1 for the following pollutants:

- Annual mean nitrogen dioxide (NO_2) concentration of 40µg/m^3;
- Annual mean particulate matter (PM_{10}) concentration of 40µg/m^3;
- Annual mean fine particulate matter ($PM_{2.5}$) concentrations of 25µg/m^3;
- 24-hour mean PM_{10} concentration of 50 µg/m^3 not to be exceeded on more than 35 days per year; and
- Hourly mean nitrogen dioxide (NO_2) concentrations of 200µg/m^3 not to be exceeded more than 18 times per year.

10.113 The achievement of Local Authority goals for local air quality management are directly linked to the achievement of the air quality objective values described above and as such this assessment focuses on the likelihood of future achievement of the air quality objective values.

Baseline Conditions

Local Authority Review and Assessment of Local Air Quality

10.114 Under the requirement of Part IV of the Environment Act (Ref. 10-13), the LBL, LBS and LBW have undertaken a phased review and assessment of air quality within their geographical boundaries.

London Borough of Lambeth

10.115 The first round of the review and assessment process identified that areas across Lambeth were found to exceed the objectives for annual average concentrations of NO_2 and daily mean concentrations of PM_{10}, mainly from the contribution of road traffic emissions. As a result, an AQMA was designated for northern parts of the borough, which was then extended to encompass the whole borough in 2003.

10.116 In 2007, the monitoring of pollutants within the borough over the previous couple of years led Lambeth Council to amend the 2003 AQMA order. This was to include the hourly mean objective for NO_2 and the annual and 24-hour mean objectives for PM_{10}, which were also at risk of being exceeded in busy areas.

10.117 The LBL's most recent published air quality report states that the pollutants included within the updated AQMA declaration of 2007 continue to exceed their relevant air quality objectives.

London Borough of Southwark

10.118 The initial review and assessment of local air quality undertaken by LBS identified that not all of the national air quality standards would be met. As such, the area of the borough north of the A205 was declared as an AQMA in 2003. The council's last review and assessment publication was the Updating and Screening Assessment undertaken in 2006. This report stated that concentrations of NO_2 and PM_{10} continued to exceed the relevant air quality objectives. The Council continue to measure and monitor concentrations of these pollutants within their geographical area.

London Borough of Wandsworth

10.119 The LBW declared the whole borough as an AQMA in 2001, due to exceedances of the annual mean air quality objective for NO_2 and PM_{10}, and the 24 hour mean objective for PM_{10}. The most recent local air quality management report available from the LBW is the 2011 Progress Report (Ref. 10-47), the main findings of which were that there have been very few changes in Wandsworth's area since the last round of review and assessments. Concentrations of the PM_{10} and NO_2 objectives are unlikely to be met in some parts of the borough. There is also concern over exceedances of the hourly mean objective for NO_2 in some parts of the borough.

Local Authority Monitoring and Measurement Data

10.120 The LBL, LBS and LBW undertake the monitoring and measurement of pollutant concentrations within their administrative areas, as part of the review and assessment of local air quality management duties.

10.121 Pollutant concentrations monitored within the three boroughs and the surrounding area has been sourced from published documentation. This data is summarised in Table 10-10.

Table 10-10 Local Air Quality Data (% Data Capture in Parenthesis)

Station Name	Type and Description of Sampler	Year[a]	2011 Annual Average Pollutant Concentrations ($\mu g/m^3$)		
			NO_2	NO_x	PM_{10}
Lambeth 5 – Bondway Interchange	Automatic - Industrial (assumed Roadside for NO_2)	2012	-	-	-
		2011	77 (81)	171 (81)	43 (79)
		2010	77 (99)	172 (99)	43 (78)
		2009	77 (89)	171 (87)	42 (86)
Wandsworth – Battersea	Automatic - Roadside	2012	39 (47) 38[b]	92 (47) 92[b]	23 (46) 25[b]
		2011	41[b]	89[b]	24[b]
		2010	-	-	-
		2009	-	-	-
Southwark – Old Kent Road	Automatic - Roadside	2012	52 (83)	125 (83)	25 (83)
		2011	46 (74)	106 (74)	27 (81)
		2009	-	-	-
		2008	-	-	-
Wandsworth – Town Hall	Automatic – Urban Background	2012	48 (96)	95 (96)	-
		2011	47 (70)	85 (70)	-
		2010	53 (98)	102 (98)	-
		2009	48 (97)	93 (97)	-
Westminster – Horseferry Road	Automatic – Urban Background	2012	40 (94)	-	19 (88)
		2011	41 (99)	64 (99)	19 (76)
		2010	49 (95	74 (95)	21 (57)
		2009	44 (99)	72 (99)	15 (2)

a Not all data monitored in 2012 is currently ratified

b Annualisation of provisional 2012 data to provide estimation of annual mean concentrations in 2011 and 2012 using Continuous Monitoring Station data from nearby urban background sites

10.122 The table of data above shows that at busy roadside locations in the vicinity of the site, annual mean concentrations of NO_2 are in exceedance or at risk of exceeding the air quality objective for that pollutant. Annual mean concentrations of PM_{10} are in exceedance at locations adjacent to particularly busy roads.

10.123 At urban background locations, set back from busy roads and other pollutant sources, annual mean concentrations of NO_2 are still exceeding or are at risk of exceeding the air quality objective for that pollutant.

10.124 Table 10-10 shows the percentage of data capture for each site and year displayed when monitoring was undertaken. Defras' guidance (LAQM TG(09)) (Ref. 10-43) advises that data capture rates of 90% or more are desirable. Data capture rates of 75% or less should be treated with extreme caution, as pollution episodes may have been missed.

Baseline Dust Climate

10.125 A background level of dust exists in all urban and rural locations in the UK. Dust can be generated on a local scale from vehicle movements and from the action of wind on exposed soils and surfaces. Dust levels can be affected by long range transport of dust from distant sources into the local vicinity.

10.126 Residents currently experience dust deposition at a rate that is determined by the contributions of local and distant sources. This baseline rate of soiling is considered normal and varies dependent on prevailing climatic conditions. The tolerance of individuals to deposited dust is therefore shaped by their experience of baseline conditions.

10.127 Existing local sources of particulate matter includes wind-blown dust from industrial activities in the area, exhaust emissions from energy plant and road vehicles, break and tyre wear from road vehicles and the long range transport of material from outside the study area.

Predicted Baseline Pollutant Concentrations

10.128 Predicted annual mean concentrations of NO_2, PM_{10} and $PM_{2.5}$, and the number of exceedances of the 24 hour PM_{10} air quality objective, at the selected receptors during the baseline scenario, are listed in Table 10-11.

10.129 Baseline annual mean concentrations of NO_2 are in exceedance of the national air quality objective for that pollutant at all of the air quality sensitive receptors considered. This is typical of roadside locations across much of London, particularly those adjacent to busy roads.

10.130 The predicted annual mean NO_2 concentrations in the baseline scenario are close to or in excess of the annual mean equivalent value (60 µg/m^3) for the hourly mean NO_2 objective, as identified by research described above. Therefore, there is a risk that the hourly mean national air quality objective for NO_2 is exceeded across the study area.

10.131 Baseline annual mean concentrations of PM_{10}, $PM_{2.5}$ and the number of exceedances of the 24 hour PM_{10} objective are well below their respective national air quality objectives for the respective pollutants at all receptor locations considered.

Table 10-11 Air Quality Statistics Predicted for the Baseline Scenario (2012)

Receptor	Annual Mean Concentration (µg/m^3)			No. Days PM_{10} >50 µg/m^3
	NO_2	PM_{10}	$PM_{2.5}$	
R1	**55.6**	23.9	16.6	10
R2	**55.5**	23.1	16.1	9
R3	**53.3**	22.9	16.0	9
R4	**56.4**	24.0	16.7	11
R5	**59.4**	24.4	16.9	12
R6	**58.8**	24.4	16.9	11
R7	**57.2**	24.2	16.8	11
R8	**60.1**	24.7	17.2	12
R9	**56.2**	24.1	16.4	11
R10	**55.3**	24.0	16.4	11
Objective Value	40	40	25	35

Impact Assessment

Construction Phase Effects

Construction Phase Dust Impacts

10.132 As with the majority of construction projects of this type, the works would be undertaken in a phased manner. Early phases of the works at each worksite are likely to involve excavations and earthworks, followed by construction and trackout of material. These activities are likely to be the principal sources of dust during the construction phase. The principal sources of dust are likely to be from the cutting and grinding of materials and the movement of construction related road vehicles. The latter phase of construction, when the majority of the earthworks and construction are complete, will involve the landscaping and finishing works. During these phases, the principal sources of dust will include the storage, handling and movement of materials generated during the associated earthworks.

10.133 The worst-case receptors located close enough to each worksite to be adversely affected by the works during demolition, earthworks, construction and trackout, include the residential properties located off Battersea Park Road in Wandsworth, Pascal Street, Wandsworth Road, Kennington Road, Radcot Street, Ravensdon Street and Stannary Street in Lambeth, and Kennington Park Place, St Agnes Place, De Laune Street and Harmsworth Street in Southwark.

10.134 The potential impacts considered at the nearest sensitive receptors to each worksite are:

- Effects on amenity and property including changes to the rate of deposition of particulate matter onto glossy surface and other property; and
- Changes in 24 hr mean concentrations that might increase the risk of exposure to PM10 at levels that could exceed the 24 hr air quality objective.

TfL Code of Construction Practice

10.135 The assessment of construction phase dust impacts assumes that a high level of mitigation is already incorporated into the design of the construction phase works, as set out within the CoCP provided in *ES Volume II: Appendix N*. The CoCP states that:

> *"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… 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). This will be addressed in the Air Quality and Dust Management Plan.*
>
> *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."*

10.136 The dust control measures described within the CoCP for sites with a low risk of dust arisings occurring (Tier 1) include, but are not limited to the following:

- Ensure water suppression is used during demolition activities;
- Maintain all dust control equipment in good condition and record all maintenance activities;
- Ensure regular cleaning of hardstanding areas;
- Provide and ensure the use of wheel cleaning facilities near the site exit wherever there is the potential for carrying dust or mud off the site;
- Clean the public highway using wet sweeping methods when necessary;
- Ensure all vehicles carrying loose or potentially dusty material to or from the site are fully sheeted;
- Ensure bulk cement and other fine powder materials are delivered in enclosed tankers and stored in silos with suitable emission control systems to prevent escape of material and overfilling during delivery;
- Store materials with the potential to produce dust away from site boundaries where reasonably practicable;
- Ensure sand and other aggregates are stored in bunded areas and are not allowed to dry out;
- Minimise the amount of excavated material held on site;
- Avoid double handling of material wherever reasonably practicable;
- Sheet or otherwise enclose loaded bins and skips;
- Minimise drop heights from conveyors, loading shovels, hoppers and other loading or handling equipment and use fine water sprays on such equipment wherever appropriate;
- Carry out site inspections regularly to monitor compliance with dust control procedures set out above and record the results of the inspections, including nil returns, in a site log book;
- Record any exceptional incidents causing dust episodes on or off the site and the action taken to resolve the situation in the site log book.

10.137 At sites where there is a medium risk of dust arisings occurring (Tier 2), a higher level of dust control measures will be required, on top of those listed above for low risk sites (Tier 1). The additional dust control measures for medium risk sites include, but are not limited to the following:

- Strip insides of buildings, as far as reasonably practicable, before demolition;
- Screen buildings, where dust producing activities are taking place, with debris screens or sheeting;
- Avoid carrying out earthworks during dry weather if reasonably practicable having regard to programme and contracting arrangements for the relevant works or provide and ensure appropriate use of water sprays to control dust;
- Ensure slopes on stockpiles are no steeper than the natural angle of repose of the material and maintain smooth profile;
- Ensure mixing of cement, bentonite, grout and other similar materials takes place in enclosed areas remote from site boundaries and potential receptors;
- Where appropriate use increased hoarding height to protect receptors; and
- Consider full enclosure of sites or specific operations where there is a high potential for dust production and the site is active for an extensive period.

10.138 In addition to the control measures described above, a comprehensive site survey will be undertaken at the sites that are deemed to be medium risk (Tier 2) to determine the prevailing wind direction (using available meteorological data) and a minimum of two permanent PM_{10} monitoring stations will be installed along the transect of the average wind direction and to make data readily available to the local authority.

10.139 At sites where there is a high risk of dust arisings occurring (Tier 3), an even higher level of dust control measures will be required, on top of those listed above for low risk (Tier 1) and medium risk (Tier 2) sites. The additional dust control measures for high risk sites would be site specific and include actions such as:

- Having personnel on site to monitor and manage dust emissions from potentially high risk activities; and
- Total enclosure of high risk dust generating activities.

10.140 High risk sites (Tier 3) would also require more stringent monitoring, to include establishing baseline dust levels prior to the commencement of potentially dust generating activities. Where practicable, such baselines will make reference to data sourced from local background PM_{10} concentrations (such as measured by the Automatic Urban and Rural Network (AURN) monitoring sites and appropriate local authority automatic monitoring sites and those established by dust monitoring in the neighbourhood) and will ideally refer to data from the preceding 12 month period.

10.141 During the high risk construction events themselves, particulate monitoring will be undertaken using appropriate survey instruments such as Osiris, Topaz, DustScan or similar devices sited at appropriate locations such as site boundaries, potential receptors or in a transect orientated to the prevailing wind, as required by specific site characteristics.

10.142 The survey instruments used will operate an alarm (PC based or mobile phone) should a predetermined site action level be reached. This level will be established in consultation with the relevant local authority and by reference to both local authority and AURN PM_{10} monitoring data. Subject to such consultation, a preliminary site action level of 250µg/m^3 (15 minute average) is proposed for both Total Suspended Particulates (TSP) and PM_{10}.

10.143 There is the potential for dust and short-term PM_{10} effects to occur at sensitive receptor locations, as a result of the construction of the NLE, throughout the duration of the works. The potential effects are summarised below for demolition, earthworks, construction and trackout, as defined in the IAQM Guidance (Ref. 10-1).

Demolition

10.144 The worksites have been selected so that there is only a small requirement for demolition of buildings and structures as part of the works. The buildings to be demolished include a collection of commercial buildings to the north of Pascal Street at the Nine Elms station worksite, Kennington Park Lodge at the Kennington Park worksite, off Kennington Park Place, and a stretch of wall and railings at the Beefeater Gin Distillery at the Kennington Green worksite.

10.145 The nearest sensitive receptors to the demolition works and material storage areas at the Nine Elms station worksite are the residential properties located to the south of Pascal Street, on Apple Blossom Court and Bramley Crescent, the nearest of which is approximately nine meters away. At the Kennington Park vent shaft worksite the nearest sensitive receptors are residential properties located approximately 26m away on Kennington Park Place to the north and St Agnes Place to the east. The nearest sensitive receptors to the Kennington Green shaft worksite demolition works are the residential properties on Kennington Road, 11m to the south and 16m to the north.

10.146 With the implementation of the CoCP, the demolition works at each worksite will be undertaken in accordance with the control measures described therein. Such measures include, but are not limited to, the appropriate hoarding of each worksite, the use of water suppression, the use of rubble shoots, the consideration of material storage locations and the stripping of buildings from the inside out. Due to the proximity of residential properties on Bramley Crescent to the Nine Elms station demolition works, additional mitigation, such as the sheeting off of the southern façade of the demolished buildings, may be required.

10.147 The scale of the demolition works at these locations is such that, despite the close proximity of sensitive receptors, the implementation of measures listed in the CoCP would be sufficient to reduce potential impacts so that the significance of any effect associated with the demolition works would be negligible.

Earthworks

10.148 Site clearance works, excavations, tunnelling, foundation works, the laying of utilities and the temporary stockpiling of material represent the principal activities that may generate emissions of particulate material during the earthworks associated with the construction of the NLE. The potential for stockpiles of materials to generate dust depends on the nature of the material. Earth is soft and friable compared to hardcore. However, hardcore generally has a lower moisture content than soil, and consequently they can both be a potential source of dust.

10.149 The tunnels between Battersea and the Kennington Loop will mostly be constructed by tunnel boring machines (TBMs). The TBMs will be launched through the Battersea station Box, driving east towards the Kennington permanent vent shafts, where they would be removed and de-commissioned. The material from tunnel excavation would mostly be exported by barge from the Battersea station worksite.

10.150 In addition to the tunnelling activity from the Battersea worksite, the construction works associated with the proposed Battersea station are anticipated to take up to 48 months to complete, with earthworks accounting for the first 16 of those months. The earthworks undertaken here would involve installation of main deep foundations to the station box and the excavation for the diaphragm wall works, the main station box, the basement slab to the station and the crossover box. The nearest sensitive receptors to these works are the residential properties located on Battersea Park Road, approximately 46m to the southeast, and Bradmead, 90m to the south.

10.151 The earthworks associated with the proposed Nine Elms station would take approximately 10 months to compete and would involve the excavations and foundation works associated with the construction of a deep cut and cover box, retained by diaphragm walls. It also includes for a shaft that will be sunk on the east side of the proposed station box at Nine Elms, in advance of the diaphragm walled box, for the Nine Elms Crossover. The nearest sensitive receptors to these works are the residential properties on Apple Blossom Court and Bramley Crescent 15m to the south.

10.152 The earthworks associated with the Kennington Green and Kennington Park ventilation shafts will be undertaken in unison and will take approximately 15 months to complete. The nearest sensitive receptors to the Kennington Green ventilation shaft earthworks are the residential properties on Kennington Road, 12m to the southwest. The nearest sensitive receptors to the Kennington Park ventilation shaft earthworks are the residential properties on Kennington Park Place and Bishop's House Day Nursery, 30m to the north.

10.153 The earthworks associated with the temporary shafts on Radcot Street and Harmsworth Street would involve the excavation of a shaft, to enable access to

each tunnel portal below. Upon completion, both shafts will be backfilled and returned to the same state as before the works. The nearest sensitive receptors to the Radcot Street temporary shaft earthworks are the residential properties on Ravensdon Street, 5m to the east and west. The nearest sensitive receptors to the Harmsworth Street temporary shaft earthworks are the residential properties on De Laune Street, 5m and 6m to the north and south respectively.

10.154 With the implementation of the CoCP, the earthworks at each worksite will be undertaken in accordance with the control measures described therein. Such measures include, but are not limited to, the appropriate hoarding of each worksite, the use of water suppression, the consideration of material storage and stockpile locations away from the nearest sensitive receptors, the removal of excavated material on an as soon as possible basis and the enclosure of construction vehicles. Due to the proximity of residential properties at some worksites, additional mitigation, such as the timing of works to coincide with more favourable meteorological conditions, may also be required.

10.155 The risk of amenity effects and the amount of mitigation effort required is strongly influenced by the weather conditions at the time of the works. With good site practice as established through the CoCP (see *ES Volume II: Appendix N*), the earthworks would have a minor adverse effect at worse on amenity and a negligible effect on short term PM_{10} concentrations at all receptors adjacent to each worksite.

Construction

10.156 Dust emissions during construction can give rise to elevated dust deposition and PM_{10} concentrations. These are generally short-lived changes over a few hours or days, which occur over a limited time period of several weeks or months.

10.157 The construction works associated with the tunnels would take place in an enclosed environment using wet tunnelling methods. Any effects on the rate of dust deposition and short-term concentrations of PM_{10} associated with this element of the works would be negligible.

10.158 At the Battersea station site, construction works involve the laying of two diaphragm walls, the erection of the station itself, the crossover box and overrun tunnels. The construction works associated with the diaphragm walls would include the use of ready-mixed concrete delivered to site and the operation of two bentonite farms. The farms would be operational for a limited period of the construction works, until walls are completed and a box lid is constructed on top. Once this lid is laid, the works will then begin on the station and crossover boxes. The nearest sensitive receptors to these construction works are the residential properties located on Battersea Park Road, approximately 46m to the southeast, and Bradmead, 90m to the south.

10.159 At the Nine Elms worksite, the station will be constructed inside a deep cut and cover box, retained by diaphragm walls, with a top slab just below existing ground level. The nearest sensitive receptors to these construction works are the residential properties on Apple Blossom Court and Bramley Crescent 15m to the south.

10.160 Construction works relating to the ventilation shafts and temporary construction shafts are limited to the installation of plant and infrastructure within the shafts themselves, with the exception of two head houses being erected off Kennington Road and Kennington Park Place. Each shaft will be lined by pre-cast concrete segments and a reinforced concrete base slab. The concrete used will be ready-mixed and delivered to site as required.

10.161 With the implementation of the CoCP, the construction works at each worksite will be undertaken in accordance with the control measures described therein. Such measures include, but are not limited to, the appropriate hoarding of each worksite, the use of water suppression, the consideration of material storage and stockpile locations away from the nearest sensitive receptors and the use of design/prefabricated materials to reduce the need for grinding, sawing and cutting. Due to the proximity of residential properties at some worksites, additional mitigation, such as the erection of higher hoarding to shield the nearest sensitive receptors from higher risk works, may also be required.

10.162 Placing activities which are a potential source of PM_{10} such as cutting and grinding of materials and bentonite storage away from boundaries would minimise the possibility of exposure to PM_{10} at receptors within 30 m of the site boundary.

10.163 If these and other measures described within the CoCP are implemented, then impacts on amenity and PM_{10} concentrations at local receptors are capable of being reduced to a minor adverse level at worst.

Trackout

10.164 Trackout occurs when dust and mud from the construction worksites is transferred onto the public highway by construction vehicles egressing the worksite. Once dried, the mud deposited on the highway can become a potential source of dust and PM_{10} that is re-suspended from traffic on the road.

10.165 Locations where trackout effects may potentially affect sensitive receptors are:

- Adjacent to Battersea Park Road, as construction traffic egresses the Battersea station worksite;
- Adjacent to Pascal Street and Wandsworth Road, as construction traffic egresses the Nine Elms station worksite;
- Adjacent to Kennington Road and Kennington Park Road, as construction traffic egresses the Kennington Green worksite;
- Adjacent to Kennington Park Place and Kennington Park Road, as construction traffic egresses the Kennington Park worksite;
- Adjacent to De Laune Street, Kennington Park Place and Kennington Park Road, as construction traffic egresses the Harmsworth Street worksite; and
- Adjacent to Stannary Street, Ravensdon Street and Kennington Park Road, as construction traffic egresses the Radcot Street worksite.

10.166 With the implementation of the CoCP, the effects of trackout at each worksite will be minimised in accordance with the control measures described therein. Such measures include, but are not limited to, the use of wheel cleaning facilities where required, the regular cleaning of the public highway using wet cleaning methods where required and the sheeting of all vehicles transporting loose materials to and from the site.

10.167 The implementation of control measures as described in the CoCP should be sufficient in reducing any impacts on amenity associated with trackout to an effect

of minor adverse significance at worse, and impacts on short term concentrations of PM_{10} to an effect of negligible significance.

Summary

10.168 The residual effects (following mitigation) of the construction dust assessment are summarised in Table 10-12. Overall, the effect of the demolition and construction phase activities are considered to be minor adverse at the nearest sensitive receptors to each worksite, and is not considered to represent a significant effect.

Table 10-12 Summary of Construction Phase Emissions Effects Significance

Source	Effects on Amenity and Property	Ecological Effects	Exposure to PM_{10} at levels that could exceed the 24-hour air quality objective
Demolition	Negligible	N/A	Negligible
Earthworks	Minor Adverse	N/A	Negligible
Construction	Minor Adverse	N/A	Minor Adverse
Trackout	Minor Adverse	N/A	Negligible
Overall Significance			Minor Adverse

Site Plant Emissions

10.169 The assessment of construction phase site plant emissions impacts assumes that mitigation will be incorporated during construction. TfL will ensure that the adverse effects of vehicle and plant emissions are controlled following the adoption of measures described within the CoCP (*ES Volume II: Appendix N*), at each of the worksites. In addition to suitable Tier 1, 2 and 3 measures listed previously, mitigation to be considered for limiting emissions will include, but not limited to, the following as appropriate and as far as reasonably practicable:

- Ensuring that the engines of all vehicles and plant on site are not left running unnecessarily;
- Using low emission vehicles and plant fitted with catalysts, diesel particulate filters or similar devices;
- Using ultra low sulphur fuels in plant and vehicles;
- 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;
- 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 (a procedure for checking this to be set out in the Air Quality and Dust Management Plan);
- Siting plant away from potential sensitive receptors;
- Avoiding the use of diesel or petrol powered generators and using mains electricity or battery powered equipment (NB an emergency diesel generator will be required during tunnelling works);
- In compliance with the London Low Emission Zone, all vehicles, cars and vans shall meet or exceed the following CO2 limits and European emission standards (Euro standards):
  - Cars - maximum certified CO_2 emissions of 95g/km and a minimum of Euro 5 emission standards
  - Vans equal to or less than 1,205kg kerb weight – maximum certified CO_2 emissions of 105g/km CO_2 and a minimum of Euro V emission standards
  - Vans between 1,205 and 1,660kg kerb weight – maximum certified CO_2 emissions of 145kg/km CO_2 and a minimum of Euro V emission standards
  - Vans greater than 1,660kg kerb weight – maximum certified CO_2 emissions of 205g/km CO_2 and a minimum of Euro V emission standards
- In compliance with the London Low Emission Zone, all heavy duty road vehicles and non-road diesel engines shall meet or exceed the following emission standards:
  - Heavy duty road vehicles >3500kg kerb weight – Euro VI European emission standards
  - Non road diesel engines between 19 and 36kW – Stage 3A European emission standards
  - Non road diesel engines between 37 and 55kW – Stage 3B European emission standards
  - Non road diesel engines between 56 and 560kW – Stage 3B European emission standards

10.170 The implementation of control measures as described in the CoCP (*ES Volume II: Appendix N*) should be sufficient in reducing emissions associated with site plant to a negligible level.

Road Traffic Emissions

10.171 The assessment of construction phase road traffic emissions impacts assumes that a mitigation measures will be implemented during construction of the NLE, as set out within the CoCP provided in *ES Volume II Appendix N*. This includes the preparation of a Travel Management Plan (TMP) which will provide a strategy for traffic management and local routes to be use by lorries generated by construction activities.

10.172 Predicted annual mean concentrations of NO_2, PM_{10}, $PM_{2.5}$ and the number of exceedances of the 24 hr 50µg/m^3 air quality objective value, at the selected air quality sensitive receptors in the year of construction phase scenario, are listed in Table 10-13. This is taken to be 2012, which will represent a worse situation than that during the actual peak construction years.

10.173 During the construction phase of the NLE (under Construction Option A and B), annual mean concentrations of NO_2 would continue to exceed the national air quality objective for that pollutant. Annual mean concentrations are predicted to

range from 56µg/m^3 (R1) to around 60µg/m^3 (R8) at the sensitive receptors considered in this assessment.

10.174 The predicted annual mean NO_2 concentrations during the construction of the NLE (under Construction Option A and B) are close to or in excess of the annual mean equivalent value (60µg/m^3) for the hourly mean NO_2 objective, as identified by research described above. Therefore, there is a risk that the hourly mean national air quality objective for NO_2 may be exceeded across the study area.

10.175 Construction phase (Construction Option A and B) annual mean concentrations of PM_{10}, $PM_{2.5}$ and the number of exceedances of the 24 hour PM_{10} objective are well below their respective national air quality objectives for the respective pollutants at all receptor locations considered.

Table 10-13 Air Quality Statistics Predicted for the Construction Phase

Receptor	Construction Option[a]	Annual Mean Concentration (µg/m^3)			No. Days PM_{10} >50 µg/m^3
		NO_2	PM_{10}	$PM_{2.5}$	
R1	Option A	**55.7**	23.9	16.6	10
	Option B	**55.7**	23.9	16.6	10
R2	Option A	**55.8**	23.1	16.1	9
	Option B	**55.8**	23.1	16.1	9
R3	Option A	**53.4**	23.0	16.0	9
	Option B	**53.4**	23.0	16.0	9
R4	Option A	**56.6**	24.1	16.7	11
	Option B	**56.6**	24.1	16.7	11
R5	Option A	**59.5**	24.5	16.9	12
	Option B	**59.4**	24.5	16.9	12
R6	Option A	**58.8**	24.4	16.9	11
	Option B	**58.8**	24.4	16.9	11
R7	Option A	**57.2**	24.2	16.8	11
	Option B	**57.2**	24.2	16.8	11
R8	Option A	**60.2**	24.7	17.2	12
	Option B	**60.2**	24.7	17.2	12
R9	Option A	**56.4**	24.1	16.8	11
	Option B	**56.4**	24.1	16.8	11
R10	Option A	**55.7**	24.0	16.7	11
	Option B	**55.7**	24.0	16.7	11
Objective Value		40	40	25	35

a Option A: includes temporary shaft construction on Kennington Loop for removal of TBMs. Option B: does not include temporary shaft construction on Kennington Loop for removal of TBMs.

10.176 The changes that are predicted to occur as a result of the NLE, in relation to the baseline conditions for each of the sensitive receptors, are listed in Table 10-14.

Table 10-14 Predicted Magnitude of Change in Air Quality Statistics

Receptor	Construction Option	Annual Mean Concentration (µg/m^3)			No. Days PM_{10} >50 µg/m^3
		NO_2	PM_{10}	$PM_{2.5}$	
R1	Option A	+ 0.1 (i)	<+0.1 (i)	<+0.1 (i)	<+1 (i)
	Option B	+ 0.1 (i)	<+0.1 (i)	<+0.1 (i)	<+1 (i)
R2	Option A	+0.3 (i)	<+0.1 (i)	<+0.1 (i)	<+1 (i)
	Option B	+0.3 (i)	<+0.1 (i)	<+0.1 (i)	<+1 (i)
R3	Option A	+0.1 (i)	<+0.1 (i)	<+0.1 (i)	<+1 (i)
	Option B	+0.1 (i)	<+0.1 (i)	<+0.1 (i)	<+1 (i)
R4	Option A	+0.2 (i)	<+0.1 (i)	<+0.1 (i)	<+1 (i)
	Option B	+0.2 (i)	<+0.1 (i)	<+0.1 (i)	<+1 (i)
R5	Option A	+0.1 (i)	<+0.1 (i)	<+0.1 (i)	<+1 (i)
	Option B	<+0.1 (i)	<+0.1 (i)	<+0.1 (i)	<+1 (i)
R6	Option A	<+0.1 (i)	<+0.1 (i)	<+0.1 (i)	<+1 (i)
	Option B	<+0.1 (i)	<+0.1 (i)	<+0.1 (i)	<+1 (i)
R7	Option A	+0.1 (i)	<+0.1 (i)	<+0.1 (i)	<+1 (i)
	Option B	+0.1 (i)	<+0.1 (i)	<+0.1 (i)	<+1 (i)

R8	Option A	<+0.1 (i)	<+0.1 (i)	<+0.1 (i)	<+0.1 (i)
	Option B	<+0.1 (i)	<+0.1 (i)	<+0.1 (i)	<+0.1 (i)
R9	Option A	0.2 (i)	<+0.1 (i)	<+0.1 (i)	<+0.1 (i)
	Option B	0.4 (s)	<+0.1 (i)	<+0.1 (i)	<+0.1 (i)
R10	Option A	0.2 (i)	<+0.1 (i)	<+0.1 (i)	<+0.1 (i)
	Option B	0.4 (s)	<+0.1 (i)	<+0.1 (i)	<+0.1 (i)

Magnitude of change descriptor: (i) = imperceptible (s) = Small

10.177 During the construction phase (Construction Option A and B), the additional vehicle movements associated with the construction worksites would lead to an imperceptible to small change to annual mean concentrations of NO_2, PM_{10} and $PM_{2.5}$, and the number of exceedances of the 24 hour PM_{10} objective, at all of the sensitive receptors considered. The greatest effect would occur at receptors located adjacent to Wandsworth Road (R9 and R10), where construction vehicles pass to and from the Nine Elms station worksite. The effect of road traffic emissions at these locations would be minor adverse and negligible elsewhere. Overall, road traffic emissions associated with the construction of the NLE would have an effect of minor adverse significance.

Operational Phase Effects

Road Traffic Emissions

10.178 During operation, it is not anticipated that there will be a direct increase in road traffic as a result of the NLE itself, as the intention of developing the NLE is to promote the use of public transport and reduce the use of cars. However, as a result of developing the NLE and, as such, the VNEB OA as a whole, there is likely to be an indirect increase in road traffic as a result of additional provision in housing and employment.

10.179 Whilst there is likely to be an increase in road traffic during the operation of the NLE, as this will be an indirect effect of the NLE, it is not assessed within this chapter. However, through developing the NLE, TfL and its partners (including the London boroughs) will endeavour to deliver the Mayor's vision for transport, as set out within the Mayor's Transport Strategy.

10.180 The NLE will improve transport opportunities for all Londoners and will reduce transport's contribution to climate change. As such, it is considered that the NLE, during operation, will provide betterment in comparison to the existing conditions.

Ventilation Shaft Emissions

10.181 The NLE includes the location of operational ventilation shafts at the two proposed stations, and at two locations in Lambeth, off Kennington Road and Kennington Park Place.

10.182 Whilst data on the quantification of emissions from operational Underground ventilation shafts is limited, some studies have been published. Research undertaken on emissions from a ventilation shaft on the Victoria line, adjacent to Vauxhall station (Ref. 10-48), concluded that there was little evidence to suggest that ventilation emissions increased dust levels and dust deposition rates beyond baseline levels.

10.183 Emissions from operational Underground rail ventilation shafts have also been quantified and described within the ES for the Crossrail Ltd works at Bond Street (Ref. 10-49). That ES described monitoring undertaken at a ventilation shaft on the Jubilee line that recorded no significant emissions of PM_{10}. Mitigation measures proposed for the Crossrail works to reduce potential emissions of PM_{10}, included the regular cleaning of tunnels, the use of trains with regenerative braking to reduce the potential for generation of particulate, and the partitioning of station platforms from the main tunnels.

10.184 For the vast majority of the time, emissions from the NLE ventilation shafts will occur passively, as the ventilation strategy is designed to operate without mechanical assistance under normal operating procedures. Under certain circumstances (e.g. during testing of the fans or when temperatures reach certain levels), fans will be operated in order to purge air from the tunnels.

10.185 The air purged from the tunnels through the ventilation shafts will be a potential source of particulate matter which has the potential to increase short-term concentrations of PM_{10} at sensitive locations in close proximity to the vents.

10.186 The air quality of the LU is monitored regularly in order to ensure that no hazardous levels of gases and particulates occur. As long as this remains the case, it is considered that the concentration of these pollutants will be greatly diluted within a short distance of the above ground vents.

10.187 To mitigate any adverse effects from the operation of the NLE, a series of standard design and management procedures will be incorporated when selecting the proposed plant during the detailed design and the maintenance of the plant over the lifetime of the NLE. Examples include appropriate design of the flues to ensure adequate dispersion of pollutants and selection of equipment regarded as Best Available Technology; and regular inspection of the machinery, operation to the manufacturer's instructions, and ensuring that equipment is well maintained during operation.

10.188 The implementation of control measures as described above should be sufficient in reducing emissions associated with the operational ventilation shafts to a negligible level.

Residual Effects and Conclusions

10.189 Residual effects are summarised in Table 10-15. Each impact and residual effect is shown.

10.190 In general, construction activities have the potential to generate fugitive dust emissions as a result of demolition, construction, earthworks or trackout of material. For the construction phase of the NLE, the concentrations of any airborne particulate matter (dust) generated by these activities would be controlled using the on-site management practices described within the CoCP. As such, the NLE should give rise to dust related effects of **minor adverse** significance. Overall, the effect of construction dust is not considered to be significant with respect to potential effects on health and amenity.

10.191 During the construction phase, the operation of on site plant has the potential to increase emissions at locations immediately adjacent to the construction worksites. Similarly, the implementation of the CoCP will reduce emissions from such plant.

As such, any effects associated with emissions from on site plant will be of **negligible** significance and are unlikely to be significant.

10.192 The advanced dispersion model ADMS Roads has been used to quantify the change in pollutant concentrations at representative existing air quality sensitive receptors. Based on the assumption that all mitigation measures to manage traffic during construction of the NLE will be implemented, it is anticipated that annual mean concentrations of PM_{10}, $PM_{2.5}$ and the number of exceedances of the PM_{10} 24 hour objective will change by an imperceptible amount. Annual mean concentrations of NO_2 are also predicted to change by a small amount, which means that the road traffic emissions associated with the construction of the NLE would have a **minor adverse** effect on local air quality at the worst affected receptors. However, overall, the effect of construction road traffic is not considered to be significant.

10.193 When the NLE is in operation, the ventilation shafts have the potential to increase long and short-term concentrations of particulate matter and fine particulate matter at locations immediately adjacent to their point of emission. Similarly, it is assumed that mitigation measures to limit potential impacts will be implemented to manage emissions. As such, any effects on local air quality will be **negligible** and are unlikely to be significant.

10.194 Overall the NLE would have a **minor adverse** effect on local air quality. This would be a temporary effect that would last for the duration of the construction works only.

Table 10-15 Summary of Air Quality Construction and Operational Effects, Proposed Mitigation Measures and Residual Effects

Potential Impact	Significance of Effect (Pre-Mitigation)	Mitigation Measures	Significance of Effect (Post-Mitigation)
Construction			
Dust generation	N/A*	The assessment of the construction dust / particulate matter impacts assumes that a high level of mitigation will be implemented throughout construction works, as detailed within the CoCP. This includes the use of water suppression; the use of wheel cleaning facilities near site exits; and the use of enclosed loaded bins and skips. Provided that TfL implement these measures during the construction phase, it is anticipated that there will be a negligible to minor adverse effect in relation to construction dust.	Negligible to Minor Adverse
Generation of site plant emissions	N/A*	The assessment of the construction site plant emissions impacts assumes that a high level of mitigation will be implemented throughout construction works, as detailed within the CoCP.	Negligible
Generation of road traffic emissions	N/A*	The assessment of the construction road emissions impacts assumes that a high level of mitigation will be implemented throughout construction works, as detailed within the CoCP.	Minor Adverse
Operation			
Generation of ventilation shaft emissions	Negligible	The assessment of the operational ventilation shaft emissions impacts assumes that mitigation will be implemented during detailed design, including standard design and management procedures when proposed plant. Provided that TfL incorporate these mitigation measures during detailed design, it is anticipated that there will be a negligible effect in relation to operational ventilation shaft emissions.	Negligible

** Note that mitigation has been built into this assessment.*

Cumulative Effects

10.195 During the construction and operational phases of the NLE, there is the potential for cumulative effects that result from incremental changes caused by other developments, as described in *Chapter 2: EIA Methodology*, together with the NLE.

10.196 During the construction phase, cumulative effects associated with dust deposition and an increase to short-term concentrations of PM_{10} may occur at sensitive receptors located within 100m of NLE worksites and 100m of committed development worksites, when works are being undertaken simultaneously.

10.197 It is standard practice across London for construction works to be undertaken in accordance with the relevant London Borough's guidance documents on controlling emissions from construction sites, which are based on the Mayor of London's Guidance on Controlling Dust and Emissions from Construction and Demolition (Ref. 10-22). The implementation of control measures described within the guidance documents have a track record of successfully controlling the effects of dust and PM_{10} at well managed construction sites. Therefore, where the control measures are implemented correctly, the cumulative effect on dust soiling and short term concentrations of PM_{10} would be **minor adverse**, and would not be considered significant.

10 Air Quality

10.198 During the construction phase, cumulative effects may also occur at sensitive receptors located adjacent to the local road network, where construction vehicles associated with the NLE and other construction sites in the surrounding area, combine to increase concentrations of NO_2, PM_{10} and $PM_{2.5}$.

10.199 The construction phases of the NLE and any committed development in the surrounding area are temporary, with the number of vehicles associated with each site varying over the course of the construction works. Any increase in pollutant concentrations that may occur as a result of cumulative construction vehicle movements in the surrounding area would be **minor adverse** and would not be considered significant. In addition, this effect would be temporary in nature and limited to the period within which the construction phases coincide.

10.200 The operational emissions associated with the NLE are unlikely to have a significant effect on local air quality. Therefore, the cumulative effects as a result of the NLE would be **negligible**.

10 Air Quality

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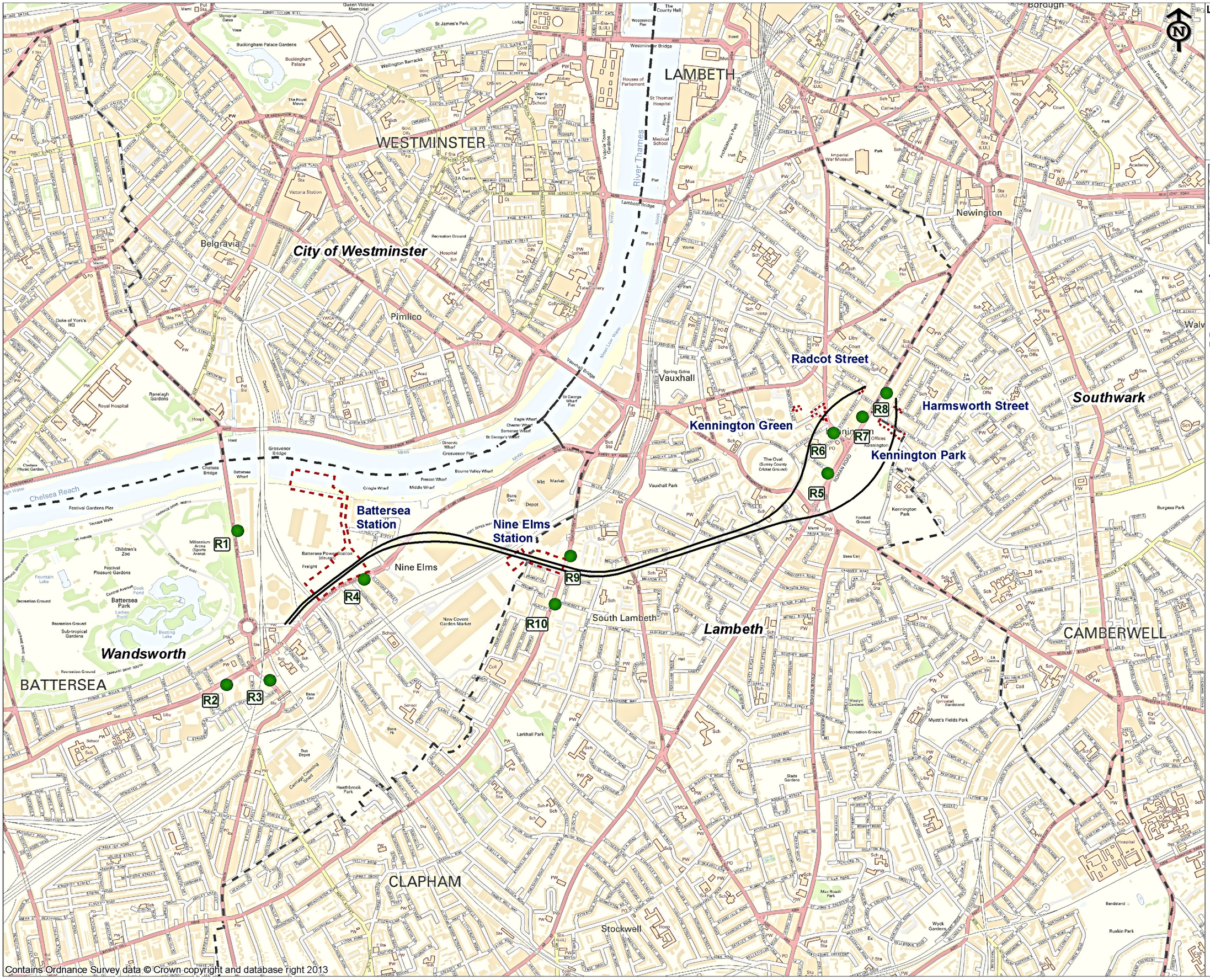
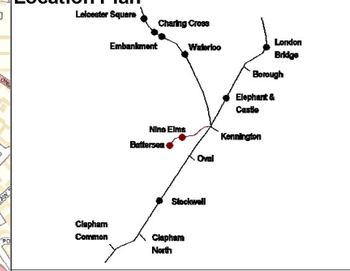
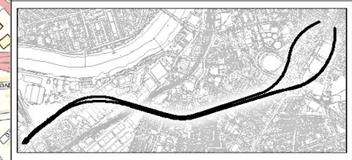


Location Plan





Key:

- Track Alignment
- Borough Boundary
- AQ Sensitive Receptors
- Indicative Construction Site

Client: **Transport for London**

URS

Project: NORTHERN LINE EXTENSION TO BATTERSEA TWAO FOR TfL

Drawing: AIR QUALITY STUDY AREA

Suitability: S4 FORMAL ISSUE TO CLIENT

Drawn by:	DT	Date:	04/03/2013
Checked by:	TW	Date:	04/03/2013
Approved by:	HW	Date:	04/03/2013

Drawing Scale: 1:15,000 @ A3

Drawing No: Figure 10-1

Revision: 01

11 Electromagnetic Compatibility

Environmental Statement

Volume I

11 Electromagnetic Compatibility

Introduction

11.1 This chapter of the Environmental Statement (ES) assesses the impacts of the proposed Northern Line Extension (NLE) on assets, infrastructure, buildings and equipment within a study corridor of 10 metres from the limit of deviation, from an electromagnetic compatibility (EMC) perspective. The chapter is supported by an EMC Technical Assessment Report, which can be seen in *ES Volume II: Appendix G*. The work has been undertaken by Technology International (Europe) Limited (TI), an Engineering Consultancy specialising in EMC and a Notified Body appointed by the Department for Business, Innovation and Skills in the United Kingdom (UK). A Notified Body, in the European Union (EU), is an organisation that has been accredited by a Member State of the EU to assess whether a product meets certain preordained standards.

11.2 The chapter contains a description of the legal framework for EMC and an assessment of the electromagnetic impact of the NLE on the surrounding area.

Initial Definitions

11.3 The following provides a description of the technical terms to be used in this chapter:

- EMC – the ability of equipment to operate adequately in a given electromagnetic environment, while not introducing intolerable electromagnetic disturbances itself. For example, the use of an industrial WiFi (wireless network) router may be electromagnetically compatible with the radio frequency environment found in an underground station, whereas a domestic WiFi router used in the same environment may exhibit data errors, poor transmission characteristics or experience frequent 'lock ups' or other maloperation due to aggressive interference disrupting data integrity by inducing unwanted currents and noise on internal circuits;
- Electromagnetic Interference (EMI) – a degradation of equipment performance due to disturbance from radio frequency, electric or magnetic fields. It is an unintended consequence of poor EMC of one piece of equipment with another, or with a piece of equipment with its installation environment (which it was perhaps not designed for); and
- Electromagnetic Fields (EMF) – generally applied under the concept of human health in the presence of high intensity electric and magnetic fields. Risks in the railway environment are generally low frequency threats, such as that from traction power equipment and high frequency radio transmissions. Low frequency magnetic threats can present a risk to implantable medical devices, such as pacemakers. Additionally, high frequency threats, such as those from high power radio transmitters can lead to a heating effect on biological tissue and other physiological effects such as radio frequency surface burns and micro-shocks. The long term effects of lower level exposure to EMFs are the subject of ongoing research. Generally, in the railway environment, high field strengths are only experienced very close (e.g. <0.1m) to heavy power equipment, traction motors and radio transmitting antennas.

Legal & Planning Policy Context

European & UK National EMC Legislation

11.4 Generally, all electrical and electronic apparatus, installations and systems being supplied in the UK come within the scope of the EU Electromagnetic Compatibility Directive 2004/108/EC (Ref. 11-1), which is transposed into UK Law by the corresponding UK Statutory Instrument 2006, No. 3418 'The Electromagnetic Compatibility Regulations' (Ref. 11-2).

11.5 Failure to comply with the UK EMC Regulations is a criminal offence. The UK EMC Regulations include the provisions for certain types of equipment and systems to be considered to be outside the scope of Regulations. Equipment that falls into this category generally comprises equipment that is regarded as benign, or equipment that falls within the scope of other controlling regulations or certification provisions. Equipment of this type includes medical devices and military equipment. Apparatus intended for railways is not outside the scope of the EMC Regulations and therefore must be certified in accordance with its provisions.

11.6 The only exceptions to this requirement are certain types of installations. These are installations that are assembled by a contractor on behalf of the user, but are not supplied as a single installation by a supplier, or manufacturer. These are referred to in UK SI 2006, No. 3418, Regulation 3(1) as 'fixed installations'. The provisions of the Regulations may still require the component parts of the installation to be certified as being compliant with the UK EMC Regulations. The NLE infrastructure and associated stations will be regarded as 'fixed installations' under the EMC Regulations.

European and International Guidance on EMFs

11.7 Although legislation has been proposed in the EU governing human exposure to EMFs (originally proposed under Directive 2004/40/EC (Ref. 11-3)), the implementation date has been postponed until 31st October 2013 at the earliest. Additionally, the legislation is only envisaged to cover the workplace, rather than the general public at large.

11.8 At the current time, international guidance on the matter is given by the International Commission on Non Ionising Radiation Protection (ICNIRP), under its document 7/99 as published in Health Physics 74 (4): 494-522; 1998 (Ref. 11-4). Reference Levels are published for the permissible occupational and public exposure limits to time varying electric and magnetic fields. It should be noted that the 7/99 is currently being reviewed by the ICNIRP with the stated aim of release of an update.

UK National and Regional Planning Policy

National Planning Policy Framework (NPPF)

11.9 The NPPF (Ref. 11-5) was published on 27 March 2012. It replaces many earlier guidance documents, including Planning Policy Guidance 8: *Telecommunications* (23 August 2001) (PPG8) (Ref. 11-6) which contained the policies specific to Electromagnetic Fields and Public Health (Policies 82; 83, 85 and 97), Interference Issues (Policies 102, 103, 104).

11.10 The NPPF rationalises the PPG8 policies above to the following, concentrating mainly on new telecommunications development:

11 Electromagnetic Compatibility

Policy 44 **:** "*Local planning authorities should not impose a ban on new telecommunications development in certain areas, impose blanket Article 4 directions over a wide area or a wide range of telecommunications development or insist on minimum distances between new telecommunications development and existing development. They should ensure that:*

- *they have evidence to demonstrate that telecommunications infrastructure will not cause significant and irremediable interference with other electrical equipment, air traffic services or instrumentation operated in the national interest; and*
- *they have considered the possibility of the construction of new buildings or other structures interfering with broadcast and telecommunications services*".

Policy 45 : "*Applications for telecommunications development (including for prior approval under Part 24 of the General Permitted Development Order) should be supported by the necessary evidence to justify the proposed development.*
This should include:

- *the outcome of consultations with organisations with an interest in the proposed development, in particular with the relevant body where a mast is to be installed near a school or college or within a statutory safeguarding zone surrounding an aerodrome or technical site; and*
- *for an addition to an existing mast or base station, a statement that self certifies that the cumulative exposure, when operational, will not exceed International Commission on non-ionising radiation protection guidelines; or*
- *for a new mast or base station, evidence that the applicant has explored the possibility of erecting antennas on an existing building, mast or other structure and a statement that self-certifies that, when operational, International Commission guidelines will be met*".

The London Plan, 2011

11.11 The London Plan was published in July 2011 (Ref. 11-8) setting out the Mayor's approach to planning, and provides guidance for Boroughs preparing their Local Development Frameworks (LDFs). Policy 7.7 of the London Plan discusses the 'Location & design of tall and large buildings' and relates to radio interference issues as follows:

Policy 7.7D: *"tall buildings should not affect adversely their surroundings in terms of …telecommunication interference*".

Local Planning Policy

London Borough of Wandsworth

11.12 The (LBW) is producing a LDF in particular a Core Strategy (2010) (Ref. 11-9).

11.13 This document does not provide any specific guidance relating to the planning considerations given to EMFs and Radio Interference issues generated by a particular scheme.

London Borough of Lambeth

11.14 The LBL's Unitary Development Plan (UDP) (Ref. 11-11) was adopted in 2007 and the Council adopted its core strategy on 19th January 2011 (Ref. 11-12), including planning guidance notes replaced by the National Planning Policy Framework that are still in effect and adhered to in Saved Lambeth Policies. The relevant policy in relation to telecommunications development is set out below:

Policy 55 Telecommunications Development – *"That a practicable remedy is available if there is clear evidence that significant electro-magnetic interference will or will probably arise; the absence of such remedy may be taken into account in determining a planning application".*

London Borough of Southwark

11.15 The Southwark Plan (Ref. 11-13), adopted on 28th July 2007, was the framework for all land use and development in Southwark. However, this has been superseded by the Core Strategy (Ref. 11-14) which was adopted in April 2011. However, a number of policies from the Southwark Plan have been 'saved' and are still of relevance. This document does not provide any specific guidance relating to the planning consideration given to EMFs and Radio Interference issues generated by a particular scheme.

Other Relevant Policies

London Underground Standards

11.16 As the NLE will be a capital project performed under the auspices of Transport for London (TfL), it is likely to require compliance with LUL Category 1 Standards throughout, except where concessions are negotiated for particular aspects. It is normally up to individual projects to establish a compliance framework whereby adherence to the individual requirements contained within LUL Category 1 Standards is achieved.

11.17 The relevant LUL Category 1 Standards governing Electromagnetic Compatibility are as follows:

- LUL S1222, EMC, Issue A2, dated November 2012 (Ref. 11-15);
- LUL 1-193, EMC with LU Signalling System Assets, Issue A2, dated 24.02.2009 (Ref. 11-16); and
- LUL S1196, Signalling and Signalling Control - Concept and Requirements, Issue A4, dated 01.11.2011 (Ref. 11-17).

11.18 The following is a LUL Category 2 Standard concerning EMC. Category 2 standards are advisory in nature:

- LUL S2514, Maximum allowable levels of EMI in safety signalling assets - Issue A4, dated 01.03.2012 (Ref. 11-18).

11.19 In addition, the following Guidance Document is published by LUL:

- LUL G-222, Manual of EMC Best Practice, Issue A1, dated 01.10.2007 (Ref. 11-19).

11 Electromagnetic Compatibility

Assessment Methodology and Significance Criteria

Assessment Methodology

11.20 The methodology used to determine the severity of any EMI impacts and the significance of the resultant effect is based on that typically used for environmental assessment. The method used to assess potential impacts included:

- A desktop evaluation of the existing EMI environment along the preferred route of the NLE along with the proposed sites for the new stations and infrastructure;
- Predicting the severity and likelihood of the likely development impacts upon the existing EMI environment; based upon previous data from similar projects;
- Considering the mitigation measures that have been included with the NLE (and any additional action that might be required in the design and construction or operational lifetime of the NLE) in order to reduce or eliminate any significant adverse effects upon the prevailing EMI environment and possible undesired effects on existing networks, apparatus and systems; and
- Quantifying any residual effects (those that might remain after mitigation) along with the overall cumulative effect.

11.21 There are two distinct construction options for the NLE (described in *Chapter 4: Description of the NLE*) however, for the purpose of the EMC assessment, the two options have been considered not to differ in terms of electromagnetic compatibility.

Significance Criteria

11.22 The significance of EMI effects can range from infrequent minor impacts or inconvenience to permanent impacts with possible risk to life through interference to implanted medical devices, structures or services. Significance is a function of severity and likelihood of occurrence.

Severity of Electromagnetic Impacts

11.23 It should be recognised that EMI rarely presents a direct threat by itself. It is normally the interaction with another system causing degraded operation, maloperation or total failure where the EMI effect becomes severe. The outcome of this in a railway context could be inconvenience, delay, interruption of service or accident.

11.24 EMFs are high intensity electric or magnetic fields at levels to which human exposure is considered undesirable and may result in severe risks to health. These are most commonly associated with heavy power distribution equipment and high power radio transmitters.

11.25 The severity of electromagnetic impacts is given in Table 11-1.

Table 11-1 Electromagnetic Impacts

Severity	Description of Impact/ Risk
High	Risk to life (EMF) Risk to permanent structures (EMI) Permanent loss of telecommunication or broadcast service (EMI) Permanent loss of function or damage to electrical/electronic systems (EMI) Failures to safety critical systems (EMI)
Medium	Risk of serious personal injury (EMF) Risk of damage to permanent structures (EMI) Degraded or intermittent loss of telecommunication or broadcast service (EMI) Degraded or intermittent loss of function to electrical/electronic systems (EMI) Failures to non-safety critical systems (EMI)
Low	Risk of personal injury (EMF) Temporary inconvenience to operational staff or public (EMI) Minor degradation to telecommunication or broadcast service (EMI) Minor degradation to performance of electrical/electronic systems (EMI)

Likelihood

11.26 Table 11-2 provides the criteria used to determine the likelihood of impact.

Table 11-2 Criteria for Determining Likelihood of Impact

Likelihood	Description of Event
High	Likely to occur frequently. EMI impact will be continually experienced
Moderate	Will occur several times. EMI impact can be expected to occur often
Low	Likely to occur sometime in the system life cycle. EMI impact can reasonably be expected to occur
Negligible	Unlikely to occur

Significance of Risk

11.27 Significance of EMI Risk is determined by the severity of the EMI or EMF events and likelihood of occurrence. For underground railways this is generally accepted to mean a quantifiable impact upon railway staff, customers, or the public at large. From an EMC perspective, EMI events do not cause a direct effect on people, but the subsequent actions that may occur as a result of an EMI based failure may result in inconvenience, delays, injuries or fatalities. Thus a failure of the signalling system due to EMI may result in two trains being in the same track circuit and a collision may occur. Failures to safety critical systems therefore have been

determined to represent the most severe form of EMI effect. Other events, such as interference with non-safety critical systems, are graded at lower severities and are based on the type of effect or possible injury that may occur.

11.28 The criteria for assessing the significance of EMI impacts are outlined in Table 11-3. As development results in an increase in the general level of EMI disturbance, the effects are usually adverse (rather than beneficial).

Table 11-3 Significance (Risk) of the EMI Effect

Likelihood	Severity		
	High	**Medium**	**Low**
High	major	major	moderate
Medium	major	moderate	minor
Low	major/ moderate	moderate/ minor	minor
Negligible	minor/none	negligible	negligible

Baseline Conditions

Prevailing EMI and EMF conditions

11.29 For the purposes of this assessment, the baseline EMI conditions have been estimated via desktop study and verified through site visits**.** The route of the NLE passes under and through some residential and mainly light industrial areas from the Kennington Loop to the site of the proposed new Battersea station in the vicinity of the disused BPS site.

11.30 The above ground EMI and EMF conditions were determined by desk study to be fairly benign, although consistent with that of an urban area. The survey conducted at street level confirmed this expectation, consisting of residential, commercial and light industrial premises. Notable sources of radio frequency energy (low range electromagnetic ranges) currently present are likely to be:

- Numerous mobile communication base station masts (EMI);
- Electrified railway lines of the London Overground Network; (EMI and low level EMF);
- High power broadcast services from the main Crystal Palace and Croydon masts, 7km to the southeast (EMI);
- Lower power local broadcast services, unlicensed 'pirate' stations and radio fixed links (EMI);
- Mobile transmissions from site radios, emergency services & public mobile telephones and devices (EMI);
- Mobile transmissions from vehicles such as buses, taxis and private licensed services (EMI);
- Light industrial and commercial activities (low level EMI);
- Domestic activities, e.g. wireless networks, microwave ovens, electronic noise (low level EMI); and
- Power frequency and pulsed magnetic fields associated with power infrastructure, cables, substations, transformers, switching events etc (low level EMF).

Potential Impacts

Construction Phase

11.31 The NLE would entail site preparation and construction methods (as described in *Chapter 4: Description of the NLE*) consistent with many other existing sites across London. Construction by its very nature is a transient activity; however, electromagnetic effects still need to be effectively managed through the construction phase.

11.32 Typical construction sites involve the use of Private Licensed Site Radios, Cable Avoidance Tools, Heavy Construction Plant and Tower Cranes. A particular feature of this project will be the use of Tunnel Boring Machines.

Private Licensed Site Radios

11.33 The threat from site radios at up to 5 watts, Amplitude Modulated using (usually) VHF 136-174MHz or UHF 403-470 MHz and site mobile phones - up to 2 watts EIRP, 900/1800/2100 MHz, is possible to some older electrical and electronic equipment (for example Network Rail equipment cabinets). Newer equipment manufactured since 1996 will have been tested to relevant EMC standards demonstrating an immunity of at least 3V/m. The field strength associated with mobile transmitters of this type falls away rapidly with distance to below 1V/m (120dBuV/m) beyond 3 metres.

Cable Avoidance Tool 'CAT' Scanners

11.34 Historically, some compatibility issues have been encountered with the use of CAT scanners, due to their frequency of operation and the operating frequency of certain signal and track circuit types on the LUL Network and Network Rail.

11.35 Most models of CAT scanning instruments can operate at various frequencies. They are factory configured to operate using induction frequencies of 8.192kHz, 32.768kHz, 65.536kHz, 83kHz or 200kHz, at inductive powers of up to 10 Watts. Units are compliant with the European Radio & Telecommunication Terminal Equipment Directive 99/5/EC.

11.36 As the system uses induction as its primary mode of operation, it relies on relatively low physical separations in order to operate. Therefore, widespread effects are not likely, although, it is possible a susceptible signal cable could be affected by scanning activities.

Heavy Construction Plant

11.37 The use of heavy construction plant is not a major source of EMI or EMF, particularly for diesel engined machines. Very large plant, such as mobile cranes or piling rigs could cause temporary disturbance to local television and radio reception by attenuating or reflecting the wanted signals for certain nearby locations.

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11.38 Electric power tools with brushed motors can be a source of broadband interference due to commutator sparking, which could cause low level temporary disruption to local television and radio reception. However, both these effects fall away with distance.

Tower Cranes

11.39 The height of tower crane structures generally exceeds that of any surrounding rooftops, and acts as a significant reflective structure at television and radio broadcast frequencies. Depending on the quality of reception in the area, this can cause localised disruption by introducing multipath reception and standing waves.

11.40 Digital systems are more tolerant of reflections and multipath distortion, with the switchover to digital television having occurred in April 2012. However, analogue FM radio will remain and it is possible that some local residential and commercial properties may experience temporary disruption.

Tunnel Boring Machines

11.41 TBMs require large amounts of electrical power and draw very heavy currents during their normal cutting and boring activities. Large currents in supply cables, motors and on board transformers are a typical source of large power and low frequency magnetic fields. Generally, when tunnelling near to other underground assets, other asset owners require assurance that magnetic perturbations caused by the TBM will not impact those other assets significantly. Since the proposed NLE route passes over LUL's Victoria line, it is possible that the magnetic and electric fields generated by the TBMs could cause interference to the signalling system and ATO (Automatic Train Operation) track codes in use on the Victoria line.

11.42 EMF aspects are only likely to be a consideration for TBM operators working a normal 8 hour shift pattern within the body of the machine. Assurance will be required that the EMI and EMF performance of the proposed TBM specification is within acceptable limits. Previous examples on similar projects have shown that EMF levels within the machines are below those defined in the ICNIRP recommendations for continuous exposure under occupational conditions.

11.43 A summary of the anticipated impacts is presented in Table 11-4.

Table 11-4 Construction Impacts Prior to Mitigation

Aspect	Severity	Likelihood	Significance
Use of private licensed Site Radios (EMI)	Low	Low	Minor Adverse
Use of 'CAT' Scanners during ground surveys. Potential temporary disturbance to buried communication infrastructure (EMI)	Medium	Low	Minor Adverse
Use of Heavy Construction Plant (EMI)	Low	Low	Minor Adverse
Use of Tower Cranes causing interference to local television reception (EMI)	Medium	Medium	Moderate Adverse
Potential Magnetic Field effects of TBMs on nearby buried infrastructure (EMI)	Medium	Low	Minor Adverse
Potential EMF internal to TBM on TBM operators	Medium	Low	Minor Adverse

Operational Phase

11.44 The majority of the operational NLE will involve below ground infrastructure, in terms of running rails, traction power equipment, communication cables and rolling stock (as described in *Chapter 4: Description of the NLE*). The main assets appearing above ground will be the station buildings and the head houses of the ventilation shafts. The potential impacts and mitigation associated with the operational phase of the NLE are described as follows:

Operation of Communications / Radio Systems

11.45 Communications systems in the stations and tunnels of the London Underground consist of a variety of long and short range wired and radio links, carrying data, audio/video and speech. Cabled communication systems are not considered to be EMI threats, since cables are usually formed from twisted pair or shielded such that only very low levels of signal leakage are experienced. In common with signalling cabling, communications cabling is given consideration in terms of EMI protection by mean of cable segregation and careful route selection. Radio communications systems that rely on the use of antennas and leaky feeders do, by their very nature, emit signals into the environment.

Operation of Mechanical and Electrical (M&E) Systems

11.46 The Mechanical and Electrical Systems installed as part of the NLE and stations will act as both emitters and receptors of EMI. This will be particularly true of heavy current equipment such as lifts and escalators. Items such as fluorescent lighting are acknowledged as possible emitters (albeit low level) of radio frequency noise and therefore careful placement in relation to sensitive receptors such as radio system leaky feeders will be essential as part of the design coordination.

11.47 However, in terms of overall M&E system noise exported to the environment outside the NLE, total levels are expected to be low, with field strengths of interfering signals falling away with distance for above ground assets, and being attenuated by tunnel shielding and / or the general mass of earth for below ground assets. Typical receptors of this noise might be local television and radio reception.

11.48 It is possible for harmonics of power frequency (multiples of the 50Hz fundamental) to be exported onto the local power network, should this be shared with nearby commercial and residential premises. Typical sources of this are six pulse rectifiers (a type of electrical circuit) used in lifts and escalators.

11 Electromagnetic Compatibility

Traction Power Arrangements

11.49 Traction power infrastructure has the potential to emit predominantly magnetic field disturbances, with highest emissions corresponding at the highest current loading. This is likely when two trains are accelerating on the same traction section.

11.50 Stray magnetic fields are likely to be confined to the immediate region surrounding the running tunnels, conductor rails and DC feeder cables. There is not likely to be any significant wider degradation caused by EMI from this source.

11.51 Typically, sensitive equipment is magnetically susceptible equipment, such as Cathode Ray Tube television screens, although these are gradually becoming less common.

11.52 In regard to human exposure to EMFs, the highest levels of predominantly magnetic field are likely to be found in the substations or where there is a concentration of traction supply cables and switchgear.

Rolling Stock

11.53 Rolling stock used on the Northern line is designated as 1995 Stock, which uses modern insulated gate bipolar transistor (IGBT) based traction equipment. Although there are many benefits, a side effect of this traction equipment is the generation of harmonic noise in the traction power supply system.

11.54 An additional EMI effect of rolling stock is the transient broadband interference caused by arcing of the current collector shoes. Arcing can occur in normal running, in addition to traversing gaps between traction power sectors, where it is perhaps most noticeable.

11.55 Systems sensitive to this type of transient disturbance are generally nearby electronic systems that do not have adequate immunity to such phenomena. Rolling stock also has various on board systems, such as train management, CCTV and radio systems which contribute to its overall EMI signature.

11.56 In general terms, the wider environmental impact of EMI from rolling stock is likely to be minimal above ground, since the proposed route runs exclusively in deep covered running tunnels. Impact on below ground assets (such as the Victoria line) is also likely to be minimal due to the attenuation of earth of high frequency electric fields and the lack of parallelism between the two lines.

11.57 EMF considerations are limited to driver and passenger exposure to low frequency magnetic fields sourced by traction power equipment and motors on the rolling stock. As part of the acceptance process for the rolling stock, levels of magnetic field are normally assessed in accordance with London Underground standards (currently Cat 1. 1-222), from the perspective of passengers with medical implants that could be affected.

11.58 Table 11-5 summarises the likely impacts prior to mitigation.

Table 11-5 Operational Impacts Prior to Mitigation

Aspect	Severity	Likelihood	Significance
Operation of Communications / Radio Systems (Stations & Tunnels) (EMI)	Low	Low	Minor Adverse
Operation of M&E	Medium	Low	Minor Adverse
Systems inc. Lifts & Escalators (Stations & Tunnels) (EMI)			
Traction power arrangements (EMI/ EMF)	Low	Low	Minor Adverse
Rolling Stock operation (EMI/EMF)	Medium	Low	Minor Adverse

Mitigation Measures

Construction Phase

11.59 Generally, production of EMC compliant designs in the first instance will minimise the requirement for mitigation of electromagnetic effects. Strategies such as specifying equipment with the appropriate level of EMC certification, suitable for the environment of use, observing accepted good practice for the segregation and routing of differing cable types and effective EMC management through the project lifecycle will assist in minimising the need for countermeasures and mitigation. This will normally be promulgated by means of an over arching EMC Management or Control Plan. Such a management plan will require preparation of other documents such as EMC Assurance Documents, Test Reports and Hazard Logs.

11.60 As part of the detailed design process an EMC Hazard Log will be produced as an output from an EMC Risk Workshop. Members of the detailed design team will provide input to the workshop, chaired by an EMC Specialist. Unintended interactions between new apparatus and systems and their surroundings (and each other) will be estimated and any mitigation measures required to reduce the EMI risk to As Low As Reasonably Practicable discussed. Appropriate design measures will then be undertaken in order to mitigate identified risks.

11.61 Following this, an EMC specialist will prepare or oversee preparation of assurance documents (including Control Plans, Design Reviews and Surveys) that discuss, analyse and form conclusions regarding acceptance of particular designs, interfaces, systems, apparatus and equipment from an EMC perspective. These impact management documents may comprise any or all of the following, depending on the project compliance framework:

- An EMC Strategy Document: An overarching high level document promulgating EMC Strategy for the NLE as a whole;
- An EMC Management Plan: A document that sets out in detail the legal requirements, contractual obligations, aims and objectives for achieving EMC for the NLE, sets roles and responsibilities for designers and contractors, sets specifications and standards to be met by equipment, systems and installations, details individual phenomena and defines the document hierarchy that will exist beneath it as supporting evidence of meeting the EMC objectives of the NLE;

- EMC Technical file (or files) for individual systems making individual claims for conformance to the EMC Directive;
- EMC Assurance documents for individual aspects including: cable segregation strategies, earthing and bonding designs, radio coverage plans, introduction of novel equipment into the LUL environment (for instance a gap analysis comparing equipment compliant to industrial EMC standards against the requirements of the relevant LUL standard);
- Site surveys to quantify the electromagnetic environment before the project and post completion. The post completion report may draw comparison with the railway EMC standard EN50121-5 for power infrastructure, or EN50121-2 for impact of the NLE on the outside world;
- EMC Test reports, either for mitigation as a result of a gap analysis (i.e.. 'upgrade' testing to LUL standards) or site survey reports;
- An EMF Report detailing measured values of any high intensity electric or magnetic fields in comparison to the reference values of the ICNIRP recommendations, with mitigation, including required protection distances or safe systems of work, where necessary; and
- An EMC Assurance File to collate all relevant EMC information and documentation, including that for all new assets specified and installed, such that the appointed 'responsible person' for the installation may carry out their obligations under the 'Fixed Installation' requirements of the EMC Directive 2004/108/EC and the UK EMC Regulations. Such documentation should demonstrate that the essential requirements of the EMC Directive are met and continue to be met during the installation's life.

11.62 It will be a requirement of the EMC management strategy for the NLE that evidence as to the EMC performance of the Traction power equipment (such as Declarations of Conformity or Technical Files) is obtained from the manufacturers or designers.

11.63 It is normal to rely on manufacturer's documentation and claims made in 'Declarations of Conformity' as to the EMC performance of equipment. Where sufficient confidence to mitigate a foreseen impact or risk does not exist, further laboratory based EMC testing will be commissioned by the detailed design team, under the guidance of an EMC Specialist as required.

11.64 In rare cases, where a particular EMI effect or EMC problem only becomes apparent during the installation or commissioning and acceptance phase, site specific mitigation will be required (such as the addition of filters or other suppression components, additional shielding or the re-routing of cables). This will be performed with the guidance of an EMC Specialist under the principles set out in the Project EMC Control Plan.

Operational Phase

11.65 The Operational Phase of the NLE will include the use of Communications / Radio Systems, Mechanical & Electrical Systems, Traction Power Equipment and Rolling Stock.

Operation of Communications/ Radio Systems

11.66 The radio and communications systems that LUL uses are are designed by LUL's Communications Private Funded Initiative (PFI) Contractor and are specifically intended to give very tightly controlled coverage over a desired area, by means of carefully controlled transmit powers and antenna beamwidths. Generally the intended coverage areas are the running tunnels, station areas, maintenance and service areas, specific rooms and so on. This means that overspill radio coverage into unintended areas is unlikely, particularly since the operating frequencies are re-used in various locations around the network. In any event, the frequencies used are licensed and allocated by the spectrum authorities, therefore environmental impact and likelihood of unintended EMI events and EMF exposures will be negligible. In addition, some attenuation by the tunnel lining and soil cover will occur, for those assets within the running tunnels. Estimated levels are shown in Table 11-6.

Operation of M&E Systems

11.67 In general, equipment and systems will be procured as CE marked to the EMC Directive 2004/108/EC by their respective manufacturers to using standards (including LUL standards) appropriate to the environment of use. In addition, EMC will be managed and co-ordinated throughout the design and construction phase by an EMC Specialist.

11.68 These considerations lead to the conclusion that the environmental impact and likelihood of unintended EMI events due to the M&E systems will be negligible.

Operation of Traction Power Arrangements

11.69 The traction power design will be subject to periodic review for EMC and EMF aspects. In particular, manufacturer information will be established as appropriate and valid, through assembly of an EMC Technical File. Additionally, any significant EMF sources will have confirmatory measurements recorded. Further, some attenuation by the tunnel lining and soil cover will occur, for those assets within the running tunnels. Estimated levels are shown in Table 11-6.

Rolling Stock Operation

11.70 Rolling stock will initially be as extant on the rest of the Northern line, so operation will be covered by any existing EMC and EMF validation forming part of the original Safety Case for introduction to service.

Summary of Operational Electromagnetic Impacts

11.71 The overall electromagnetic impacts from the running tunnels will be mitigated by the tunnel lining and surrounding soil. Typical examples of emissive sources in the LUL environment and the expected typical values of attenuation provided by a steel reinforced concrete tunnel buried 10 metres in earth can be seen in Table 11-6.

Table 11-6 Estimated Signal Strengths at ground level from a 10 metre deep tunnel

Electromagnetic noise source	Typical signal level in free space	Attenuation of tunnel lining and 10m path through soil	Estimated signal at ground level Post Attenuation
Rolling Stock Traction Equipment emitting at 10kHz	60dB(µA/m) (limit of EN50121-2:2006)	76dB +2dB = 77dB	-17dB(µA/m) (undetectable)
Connect Radio Antenna radiating at 395MHz @ 1meter	120dB(µV/m)	>150dB+>50dB = >200dB	<0dB(µV/m) (undetectable)

Residual Effects and Conclusions

11.72 Adverse effects caused by EMI issues within the NLE route would be removed or reduced to a negligible level through a programme of investigation and mitigation as set out in this chapter. This is summarised in Table 11-7.

Table 11-7 Summary of Residual Effects

Effect on Asset	Effect Prior to Mitigation	Proposed Mitigation	Mitigation Method	Significance of Residual Effect
Construction Phase				
Use of private licensed Site Radios (EMI)	Minor Adverse	Correct frequency licensing and toolbox talks regarding risks to sensitive equipment with metal doors open from site radios.	Correct administration and operating procedures to be observed as promulgated via a Construction Management Plan.	**Negligible**
Use of 'CAT' Scanners during ground surveys. Potential temporary disturbance to buried	Minor Adverse	Restrict use to railway engineering hours and scanner type limited to locations as	Correct administration and operating procedures to be observed as promulgated via a	**Negligible**
communication infrastructure (EMI)		informed by Project EMC HazID & Hazard Log.	Construction Management Plan and output of Project EMC HazID and Hazard Log.	
Use of Heavy Construction Plant (EMI)	Minor Adverse	Ensure tools, plant and machinery are CE marked to appropriate Directives, including EMC 2004/108/EC.	Review of compliance documentation and acceptance by EMC specialist.	**Negligible**
Use of Tower Cranes causing interference to local television reception (EMI)	Moderate Adverse	Ensure affected users/residents are remedied.	Provide case by case remedy via information, aerial adjustment or alternative reception method e.g. satellite/cable.	**Negligible**
Potential Magnetic Field effects of TBMs on nearby buried infrastructure (EMI)	Minor Adverse	Assessment of TBM EMC performance before launch.	Review and acceptance of compliance documentation by EMC specialist. Possible additional EMC tests & suppression.	**Negligible**
Potential EMF internal to TBM on TBM operators	Minor Adverse	Assessment of TBM EMC performance before launch.	Review and acceptance of compliance documentation by EMC	**Negligible**

Effect on Asset	Effect Prior to Mitigation	Proposed Mitigation	Mitigation Method	Significance of Residual Effect
			specialist. Possible additional EMC tests & suppression.	
Operational Phase				
Operation of Communications / Radio Systems (Stations & Tunnels) (EMI)	Minor Adverse	Ensure that the EMC Directive Requirements for Fixed Installations are met, in addition to the ICNIRP EMF human exposure requirements.	Appropriate EMC Management, Review and Administration by an EMC Specialist through the project lifecycle.	**Negligible**
Operation of M&E Systems inc. Lifts & Escalators (Stations & Tunnels) (EMI)	Minor Adverse	Ensure that the EMC Directive Requirements for Fixed Installations are met.	Appropriate EMC Management, Review and Administration by an EMC Specialist through the project lifecycle.	**Negligible**
Traction power arrangements (EMI/ EMF)	Minor Adverse	Ensure that the EMC Directive Requirements for Fixed Installations are met, in addition to the ICNIRP EMF human exposure requirements.	Appropriate EMC Management, Review and Administration by an EMC Specialist through the project lifecycle.	**Negligible**
Rolling Stock Operation (EMI/ EMF)	Minor Adverse	Ensure that the EMC Directive Requirements for Fixed Installations are met, in addition to the ICNIRP EMF human exposure requirements.	Appropriate EMC Management, Review and Administration by an EMC Specialist through the project lifecycle.	**Negligible**

Cumulative Effects Assessment

11.73 There would be no cumulative effects (for example, between the development of the Battersea Power Station site and the Battersea station site), since it would be incumbent on those developments to reach an electromagnetically compatible situation and comply with the Fixed Installation requirements of the EMC Directive and UK Regulations in their own right.

11.74 It would be expected that operational EMI impacts on the environment would be minimised through effective EMC management throughout the project lifecycle by an EMC Specialist and then through the infrastructure operator's own EMC engineers.

11 Electromagnetic Compatibility

References

Ref. 11-1 European Commission (2004); Directive 2004/108/EC The Electromagnetic Compatibility Directive

Ref. 11-2 Her Majesty's Stationery Office (HMSO) (2006); Statutory Instrument No. 3418 The Electromagnetic Compatibility Regulations 2006

Ref. 11-3 European Commission (2004); Directive 2004/40/EC on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (electromagnetic fields)

Ref. 11-4 Matthes R., Bernhardt J., McKinlay A., editors (1999); Guidelines on Limiting Exposure to Non-Ionizing Radiation, ICNIRP, (ICNIRP 7/99)

Ref. 11-5 Department for Communities and Local Government (March 2012); The National Planning Policy Framework

Ref. 11-6 Department for Communities and Local Government (DCLG) (March 2001); Planning Policy Guidance 8: Telecommunications. Her Majesty's Stationery Office

Ref. 11-7 Greater London Authority (2008); The London Plan: Spatial Development Strategy for Greater London (consolidated with alterations since 2004)

Ref. 11-8 Greater London Authority (July 2011); The London Plan: Spatial Development Strategy for Greater London

Ref. 11-9 London Borough of Wandsworth (LBW) (2009); Local Development Framework (LDF) Core Strategy. Adopted

Ref. 11-10 LBW (1991); Unitary Development Plan

Ref. 11-11 London Borough of Lambeth (LBL) (2007); UDP. Adopted

Ref. 11-12 LBL (2010); LDF Core Strategy. Submission Version

Ref. 11-13 London Borough of Southwark (LBS) (2007); The Southwark Plan. Adopted

Ref. 11-14 LBS (2011); LBS Core Strategy

Ref. 11-15 London Underground Limited (LUL) (October 2007); London Underground Category 1 Standards 1-222, Electromagnetic Compatibility, Issue A1

Ref. 11-16 LUL (February 2009); London Underground Category 1 Standards 1-193, Electromagnetic Compatibility (EMC) with LU Signalling System Assets, Issue A2

Ref. 11-17 LUL (November 2011); S1196, Signalling and Signalling Control - Concept and Requirements, Issue A4

Ref. 11-18 LUL (March 2012); S2514, Maximum allowable levels of electromagnetic interference in safety signalling assets - Issue A4

Ref. 11-19 LUL (October 2007); G-222, Manual of EMC Best Practice, Issue A1

12 Surface Water and Flood Risk

Environmental Statement

Volume I

12 Surface Water Resources and Flood Risk

Introduction

12.1 This chapter of the Environmental Statement (ES) assesses the likely significant effects of the proposed Northern Line Extension (NLE) on flood risk and surface water receptors.

12.2 The proposed NLE construction will involve six construction sites, at Radcot Street, Harmsworth Street, Kennington Green, Kennington Park, Battersea station and Nine Elms station (see *Chapter 4: Description of the NLE*). References to the site in this assessment refer to all six construction sites, unless specified otherwise.

12.3 This ES chapter identifies key surface water resources and features (the receptors), allocates an importance to identified receptors, identifies impact pathways from the proposed NLE to the receptors and thereby identifies the direct and indirect effects on these receptors. Consideration of effects is made in the context of existing site conditions; construction works; and once the NLE is complete and operational.

12.4 This chapter is accompanied by a Flood Risk Assessment (FRA), which has been undertaken by Buro Happold (BH) (see *ES Volume II: Appendix H1*). The FRA has been used to determine the significance of impact of the NLE on flood risk, and the significance of flood risk as an effect on the NLE. It is also supported by a Water Framework Directive Assessment (see *ES Volume II: Appendix H2*).

12.5 The need for mitigation measures with respect to surface water receptors and flood risk effects has been addressed and any residual effects are identified.

12.6 The assessment on the potential effects on groundwater receptors and contaminated land is covered in *Chapter 13: Land Quality and Groundwater* of this ES.

Legislative and Planning Policy Context

12.7 There is a wide range of legislation and policy pertaining to surface water resources and flood risk; however, this section only refers to related legislation and policy that is directly relevant to the NLE and the range of potential effects identified.

Water Framework Directive (WFD) (Directive 2000/60/EC)

12.8 The WFD (Ref. 12-1) establishes a framework for a European wide approach to action in the field of water policy. Its ultimate aim is to ensure no deterioration from current status for all inland and near shore watercourses and water bodies and to ensure attainment of 'Good' status or better, in terms of ecological, but also chemical, biological and physical parameters, by the year 2015. Therefore, any activities or developments that could cause detriment to a nearby water resource, or prevent the future ability of a water resource to reach its target status, must be mitigated so as to reduce the potential for harm and allow the aims of the WFD to be realised.

12.9 A water body is assessed for ecological status and chemical status as part of the WFD. The methodology for determining status has been set out by the United Kingdom Technical Advisory Group (UKTAG) on the WFD (Ref. 12-2). The Environment Agency is responsible for monitoring and ensuring that the targets are met. Water bodies are classed as either: High, Good, Moderate, Poor or Bad Status.

WFD Drinking Water Protected Area

12.10 The WFD requires a register of Drinking Water Protected Areas. The register includes surface water bodies:

- Used, or planned to be used, for the abstraction of water intended for human consumption; and
- Providing, or planned to provide, a total of more than 10 cubic metres (m^3) of water per day on average, or serving, or planned to serve, more than 50 people.

12.11 Drinking Water Protected Areas have to comply with the requirements of Article 7 of the WFD: they have to be protected with the aim of avoiding deterioration in their quality which would compromise a relevant abstraction of water intended for human consumption.

Acts of Parliament

12.12 Activities associated with the construction of the NLE will need to conform to existing water legislation in England, including the Environment Protection Act 1990 (Ref. 12-5), Environment Act 1995 (Ref. 12-6), Water Resources Act 1991 (Ref. 12-7), Land Drainage Act 1991 (Ref. 12-8), Flood and Water Management Act 2010 (Ref. 12-9) ,the Water Act 2003 (Ref. 12-10) and the Environmental Permitting Regulations (Ref. 12-34). This is particularly relevant in relation to discharges to water and any engineering works or impoundments. These include the following requirements:

- Any significant dewatering activity (including discharge of dewatering to surface waters) will be subject to licensing by the Environment Agency, under the Water Act 2003; and
- Any works in, under, over or within 7 metres (m) of a watercourse will require a Flood Defence consent.

National Planning Policy

National Planning Policy Framework (NPPF)

12.13 The NPPF (Ref. 12-11) was published in March 2012, and sets out the Government's planning policies for England and how they are expected to be applied.

12.14 The NPPF supersedes and replaces a number of planning policy documents that are applicable to the water environment, including Planning Policy Statement 25 Development and Flood Risk (PPS25) (Ref. 12-12) and PPS23 Planning and Pollution Control (Ref. 12-13). The following principles are directly applicable to the water environment:

- Section 10 – meeting the challenge of climate change, flooding and coastal change, taking account for climate change over the longer term including factors such as flood risk, coastal change, water supply and changes to

biodiversity and landscape. The flood risk elements are supplemented by an accompanying Technical Guide (Ref. 12-14) and the Practice Guide (Ref. 12-15) that supported PPS25 (Ref. 12-12) prior to its replacement; and

- Section 11 – conserving and enhancing the natural environment, development should minimise pollution and other adverse effects on the local and natural environment and should plan positively for the creation, protection, enhancement and management of networks of biodiversity and green infrastructure.

Regional Planning Policy

The London Plan (2011)

12.15 The London Plan (Ref. 12-24) sets out a number of key policies aimed to assist protection of the water environment during development and construction.

12.16 Policies of relevance to surface water resources and flood risk within the context of the NLE include:

- Policy 2.18 Green Infrastructure – The promotion of Sustainable Drainage Systems (SuDS) will improve water resources, flood mitigation and reduce flood risk;
- Policy 5.11 Green Roof and Development Site Environs – Major developments should include roof, wall and site planting in their design to achieve sustainable urban drainage by absorbing rainfall and thereby reduce flooding associated with surface water runoff;
- Policy 5.13 Sustainable Drainage – Developments should utilise SuDS, aim to achieve greenfield run off rates and manage surface water runoff close to source;
- Policy 5.14 Water Quality and Wastewater Infrastructure – Aims to protect and improve water quality; and
- Policy 5.15 Water Use and Supplies – Developments should minimise the use of treated water by incorporating water saving measures such as reducing water consumption. The use of water harvesting and grey water recycling schemes is to be promoted.

London Plan Supplementary Planning Guidance (SPG) – Sustainable Design and Construction (2006)

12.17 Section 2.4.4 of the SPG (Ref. 12-26) indicates that the essential standards for reducing water pollution and flooding require that all developments use SuDS wherever practical, and achieve 50% attenuation of the undeveloped site's surface water runoff at peak times where possible. The 'undeveloped site' is understood to be the site as it existed prior to the NLE (i.e. the existing site). The Mayor's preferred standards would achieve 100% attenuation of the undeveloped site's surface water runoff at peak times.

The Mayor's Water Strategy (2011)

12.18 The Mayor's Water Strategy (Ref. 12-27) details ways in which present water resources could be used more effectively, in order to tackle problems such as water supply, wastewater generation and flood risk across London. Actions of relevance to water resource and flood risk issues for the NLE are:

- Action 5 aims to make property more water efficient. The strategy aims to raise awareness of efficient non-domestic water use; and
- Action 18, which encourages the use of green roofs, rainwater harvesting, grey water recycling and sustainable drainage to relieve the pressures on the drainage systems, thereby reducing flood risk and water demand.

Local Planning Policy

Vauxhall Nine Elms Battersea Opportunity Area (VNEB OA) Planning Framework (2012)

12.19 The Greater London Authority's (GLA's) water strategy for VNEB OA (Ref. 12-28) is set out in Technical Appendix TA 7 – Water Strategy and provides a policy framework and baseline information in relation to flood risk and water conservation and management at a strategic, site-wide and building level.

12.20 The proposed public realms strategy for the OA includes a linear park and green fingers across it, which will provide excellent opportunity for flood risk mitigation. The public realm will include ponds, wetlands, swales, basins and drainage channels to reduce flood risk; although site specific consideration is still required. At the site specific level, schemes are expected through design to minimise surface water run off through the application of the London Plan Sustainable Drainage hierarchy, including the use of SuDS. It is noted that given the proximity of the River Thames, most rainwater should be discharged to the river rather than combined sewer. Measures to conserve the use of water through good strategic water management in line with the Mayor's water strategy and to promote rainwater capture and green roofs on both residential and commercial buildings.

12.21 The guidance recommends maximising the use of water and rail to deliver in construction materials in new developments as a medium priority.

Lambeth Local Development Framework Core Strategy (2011)

12.22 In response to the findings of the Lambeth Strategic Flood Risk Assessment (SFRA), Policy S6 – Flood Risk was included in the Local Development Framework.

12.23 The Council will work in partnership with the Environment Agency in order to manage and mitigate flood risk.

- Development will be steered towards areas of lowest flood risk through the application of the sequential test in PPS25, taking the vulnerability of the proposed uses into account.
- Development will only be considered in the areas of higher flood risk where it can be demonstrated that there are no reasonably available sites within Flood Zone 1 (low risk) appropriate to the type of use proposed.

- All new development in Flood Zones 2, 3a and 3b defined in the Strategic Flood Risk Assessment should contribute positively to actively reducing flood risk in line with PPS25, through avoidance, reduction, management and mitigation.
- Flood Risk Assessment (FRA) will be required for major development proposals within Flood Zone 1 and all new development within Flood Zones 2, 3a and 3b. The FRA should be proportionate with the degree of flood risk posed to and by the proposed development and take account of the advice and recommendations set out in the Strategic Flood Risk Assessment (SFRA).
- Where development is permitted within flood risk areas it must demonstrate that, where required, it will reduce fluvial, tidal and surface water flood risk and manage residual risks through appropriate flood risk measures. On sites adjacent to the River Thames and River Graveney, maintenance, remediation and improvements to the flood defence walls will be required where these are in poor condition.
- Measures to mitigate flooding from groundwater and sewers should be included in development proposals for which this is a risk.

12.24 The Level 2 SFRA (Ref. 12-35) analyses specific locations where development is proposed in areas at risk of flooding in Lambeth and provides sufficient information to allow the application of the PPS25 exception test. It should be read in conjunction with the Level 1 SFRA (Ref. 12-36). However, breach models within the SFRA are for guidance only and they should be verified by site specific breach models to determine more accurate flood zones. Areas identified in the SFRA as at highest risk of flooding in Lambeth are Waterloo, Vauxhall and adjacent to the River Graveney.

Other Relevant Policy

Pollution Prevention Guidelines

12.25 The Environment Agency produces Pollution Prevention Guidelines (PPGs) targeted at a particular industrial sector or activity and provides advice on the law and good environmental practice. The following guidance notes are considered relevant for the NLE:

- PPG1 – General Guide to the Prevention of Pollution (Ref. 12-16);
- PPG2 – Above Ground Oil Storage Tanks (Ref. 12-17);
- PPG3 – Use and Design of Oil Separators in Surface Water Drainage Systems (Ref. 12-18);
- PPG5 – Works In, Near or Liable to Affect Watercourses (Ref. 12-19);
- PPG6 – Working at Construction and Demolition Sites (Ref. 12-20);
- PPG8 – Safe Storage and Disposal of Used Oils (Ref. 12-21);
- PPG13 – Vehicle Washing and Cleaning (Ref. 12-22); and,
- PPG27 – Installation, Decommissioning and Removal of Underground Storage Tanks (Ref. 12-23).

London Underground Drainage Standard

12.26 The London Underground Gravity Drainage Systems standards document (Ref. 12-24) provides guidelines for the design of gravity drainage systems of internal and external systems, for track and off-track, stations, depots and operational buildings. The standards also cover flood protection requirements to London Underground assets, along with the use of SuDS. These standards are in line with National Planning Policy.

Assessment Methodology and Significance Criteria

12.27 This section refers to the data sources that have been reviewed in completing the surface water resources and flood risk chapter and the assessment methodology and significance criteria that have been used for the impact assessment.

Data Sources

12.28 Baseline conditions of potential receptors have been established through a desk study and consultation with the following bodies:

- Environment Agency;
- TWUL; and
- LBL, LBW, and LBS.

12.29 Additional data has also been collected from the following sources:

- BGS Geology Maps (Ref. 12-29);
- Environment Agency website (Accessed 2nd November 2012) (Ref. 12-30);
- Landmark Envirocheck Report (2008) (see *ES Volume II: Appendix I1*);
- Buro Happold, 2013, 'Northern Line Extension TWAO Flood Risk Assessment' (see *ES Volume II: Appendix H2*);
- WFD – Thames River Basin Management Plan (Ref. 12-31).
- Concept Site Investigation Report (see *ES Volume II: Appendix I3*);

Source Pathway Receptor Model

12.30 The determination of impacts has been undertaken using the Source-Pathway-Receptor model. This model identifies the potential sources or 'causes' of impact as well as the receptors (surface water resources) that could potentially be affected. However, the presence of a potential impact source and a potential receptor does not always infer an effect, there needs to be a pathway or 'mechanism' via which the source can have an effect on the receptor. For example, the presence of a sewer does not necessarily increase the risk of flooding on unless ground levels would facilitate the movement of surcharged water to the site.

12 Surface Water Resources and Flood Risk

12.31 The first stage in utilising the Source-Pathway-Receptor model is to identify the causes or 'sources' of potential impact from a development. The sources have been identified through a review of the details of the NLE, including its size and nature, potential construction methodologies and timescales (see *Chapter 4: Description of the NLE* for further details). Potential sources of existing contamination onsite have also been identified.

12.32 The next stage in the model is to undertake a baseline review of potential receptors, that is, the surface water resources themselves that have the potential to be affected. The final stage of the model is to determine if there is an impact pathway or 'mechanism' allowing an effect to potentially occur between source and receptor.

Significance Assessment Methodology for surface water resources

12.33 Once potential impacts on surface water resources are identified, it is necessary to determine how significant the effects are likely to be, to enable the identification of potential mitigation measures that can reduce or eliminate adverse impacts. The significance of the effect on the receptors depends largely on the sensitivity of the receptor and the magnitude of impact experienced.

12.34 An assessment of each potential effect's significance was undertaken using the methodology provided in the Web-based Transport Analysis Guidance (WebTAG); specifically the Water Environment Sub-Objective WebTAG Unit 3.3.11 (Ref. 12-32). The methodology set out in this WebTAG Unit provides an appraisal framework for taking the outputs of the EIA process and analysing the key information of relevance to the water environment. The guidance provides a method by which the significance of the identified potential effects can be appraised consistently by decision makers. It is based on guidance prepared by the Environment Agency and builds on the water assessment methodology in the Design Manual for Roads and Bridges (DMRB) Volume II (Ref. 12-33). Although this method was designed for transport projects, it is applicable to and widely used for other development types.

12.35 The methodology provides an assessment of the significance of an effect by firstly considering how important or how sensitive the receptor is and secondly, by considering the likely magnitude or extent of the impact on the receptor. By combining these two elements, the significance of an effect can be derived. If significant adverse effects are identified, mitigation measures can be proposed to offset them.

12.36 The sensitivity or importance of each water resource (the receptor) is based on its considered value, for example as an ecological habitat, a source of drinking water or a recreational resource (see Table 12-1).

12.37 The magnitude of a potential impact is then established based on the likely degree of impact relative to the nature and extent of the development (see Table 12-2). It is important to consider at this stage that potential impacts can be beneficial as well as adverse. The derivation of magnitude is carried out independently of the importance of the water resource.

12.38 Once the magnitude of an impact is understood, the significance of the potential effect can then be derived by combining the assessments of both the importance of the water resource and the magnitude of the impact in a simple matrix (see Table 12-3). The magnitude of the effect is based on a seven-point scale:

- Major adverse;
- Moderate adverse;
- Minor adverse;
- Negligible;
- Minor beneficial;
- Moderate beneficial; or
- Major beneficial.

Table 12-1 Derivation of Importance of Water Resource

Importance	Criteria	Example
Very High	Water resource with an importance and rarity at an international level with limited potential for substitution.	Watercourse supporting (or with potential to support) internationally important habitats; or supports water abstraction volumes for large urban areas; or nationally significant recreational activities.
High	Water resource with a high quality and rarity at a national or regional level and limited potential for substitution.	Watercourse supporting (or with potential to support) nationally important habitats; or supports water abstraction volumes for small urban areas or major industry or power generation; or regionally significant recreational activities.
Medium	Water resource with a high quality and rarity at a local scale; or Water resource with a medium quality and rarity at a regional or national scale.	Watercourse supporting (or with potential to support) locally important habitats; or supports water abstraction for local uses; or locally important recreational activities.
Low	Water resource with a low quality and rarity at a local scale.	A non 'main' river or stream without current or potential significant ecological habitat and limited resource availability for abstraction or recreation.

Table 12-2 Derivation of Magnitude of Impact

Magnitude of impact	Criteria	Example
High	Impact results in a shift in a water body's potential attributes.	Pollution / improvement of a river resulting in change in WFD status
Medium	Results in impact on integrity of attribute or loss of part of attribute.	Loss / gain in productivity of a fishery. Contribution / reduction of a significant proportion of the effluent in a receiving river, but insufficient to change its WFD Status.
Low	Results in minor impact on water body's attribute.	Measurable changes in attribute, but of limited size and / or proportion.
Negligible	Results in an impact on attribute but of insignificant magnitude to affect the use / integrity.	Physical impact to a water resource, is likely, but unlikely to be noticeable within natural variation

Table 12-3 Derivation of Effect Significance

Magnitude of impact	Importance of water resource (receptor)			
	Very high	**High**	**Medium**	**Low**
High	Major	Major	Moderate	Moderate
Medium	Major	Moderate	Moderate	Minor
Low	Moderate	Minor	Negligible	Negligible
Negligible	Minor	Negligible	Negligible	Negligible

12.39 Effects which are assessed to be major or moderate are considered to be significant; those that are minor and negligible are not considered to be significant.

Flood Risk Methodology

12.40 The specific methodology for defining and assessing flood risk is dictated by the requirements of the NPPF (Ref. 12-11) and its accompanying Technical Guide (Ref. 12-14). The full details of this methodology for assessing flood risk are outlined in the FRA document included within *ES Volume II: Appendix H2*.

12.41 For the purpose of this chapter, the NLE's effect on flood risk, to identified receptors, is considered in the context of existing site conditions, the construction phase and once the NLE is operational. The impact of the NLE on flood risk has been assessed using the findings of the FRA.

Water Framework Directive Assessment

12.42 A further assessment step has been taken to determine whether an impact is likely to have an effect that would result in a deterioration of a water body from its current status, or prevent a water body from achieving 'Good Status' (or potential) in the future. If either of these effects are predicted to occur, a major adverse significance of effect is applied to acknowledge that, under the WFD all water bodies must meet the objectives irrespective of its current status (and hence perceived 'importance' in an EIA context). A WFD assessment has been carried out (see *ES Volume II: Appendix H1*) and its conclusions are presented in this chapter.

Baseline Conditions

Introduction

12.43 This section summarises information on the baseline conditions of surface water resources that have the potential to be influenced by the NLE. It also considers abstractions and discharges linked to the watercourses (as secondary receptors) as well as sources of flood risk. Potential surface water resource receptors located within a 2km radius of the site (the study area) have been considered using data sources detailed in Sections 12.28 and 12.29.

12.44 Particular attention is given to identifying any notably sensitive water bodies with specific environmental targets or specific resource uses.

12.45 Baseline flood risk information is taken from the FRA included in *ES Volume II: Appendix H2*.

12.46 Baseline groundwater information is included in *Chapter 13: Land Quality and Groundwater*.

12.47 Due to the linear nature of the NLE, baseline conditions along the route are described from east to west. Where the baseline conditions and potential impacts relate to a specific above ground construction site or section of the below ground tunnel this is explained. Otherwise this is described more generally in terms of the NLE.

Surface Water Receptors

12.48 The only surface water receptor that could potentially be affected by the NLE is the River Thames.

River Thames

12.49 The River Thames is located at its closest point 350m to the north from the proposed NLE Battersea station and will be used to transport excavated material by barge from the existing jetty at Battersea Power Station. At these locations the river is tidal, and often referred to as the Tidal Thames or Thames Tideway and forms part of the River Thames and Tidal Tributaries Site of Metropolitan Importance for nature conservation (SMINC) and other non-statutory wildlife designations (see *Chapter 14: Ecology*).

12.50 The waters of the River Thames run the greatest risk of pollution during the summer months, when fluvial inputs to the river are at their lowest and temperatures are at their highest. During low flows, the water volume within the

river is not sufficient to dilute the pollutant loads that occasionally discharge from the Combined Sewer Outfalls (CSOs) during heavy storms, which comprise both storm and wastewater. Effluent from the CSOs serves to increase biological oxygen demand (BOD) and decrease the dissolved oxygen (DO) content of the river, both of which decrease the water's potential to support fish life. As a measure against oxygen depletion, TWUL runs a number of oxygenating vessels that can pump up to 30 tonnes of oxygen directly into the river per day.

WFD Classification

12.51 In 2007, the Environment Agency altered the way it assesses the status of waterbodies as a result of the requirements of the WFD. There are two classifications: ecological and chemical. These classifications have been assessed as part of the River Basin Management Plan (RBMP) (Ref. 12-31) for the Thames River Basin District. The plan identifies the pressures facing the water environment in the Thames River basin district and the actions that are required address them. It has been prepared under the WFD, and is the first of a series of six-year planning cycles.

12.52 The WFD ecological status is based on the following quality elements: biological quality, general chemical and physico-chemical quality, water quality with respect to specific pollutants, and hydromorphological quality. There are five classes of ecological status, high good, moderate, poor or bad.

12.53 The stretch of the River Thames nearest to the site is not assessed for status, but for 'potential'; this is on the basis that the river is considered to be a Heavily Modified Water Body (HMWB) and due to its modifications (for flood defence and navigation purposes) is limited in the ecological quality it can reach.

12.54 The River Thames in this location is classified as being of moderate ecological potential. This is based on a 'moderate' ecological quality and a 'fail' on chemical quality. It is predicted to remain at moderate ecological potential to 2015, the current target date for achieving Environmental Objectives, corresponding to the end of the first cycle of the RBMP process. This is on the basis that the measures required to move the waterbody to 'good' status are long term and cannot be achieved until the absolute end date of 2027.

12.55 The Landmark Envirocheck Report (see *ES Volume II: Appendix I1*) identifies approximately 20 pollution incidents to Controlled Waters within 1km of the proposed NLE. One of these incidents is a Category 1 (major incidents), one is a Category 2 (significant incidents) and the rest are Category 3 (minor incidents). The details of the most significant incidents are presented below:

- Category 1 - unknown sewage discharge to the River Thames approximately 500m north of the Battersea part site (upstream) (NGR 528500, 177995), on 2nd July 1995; and
- Category 2 - storm sewage discharge to the River Thames from the Western Pumping Station approximately 209m north of the Battersea part of the site (upstream) (NGR 528700, 177895) on 27th September 1998.

12.56 Of the minor incidents recorded a number are considered relevant, which are detailed below:

- Category 3 - minor oil discharge to the River Thames on 9th February 1999;
- Category 3 - storm sewage discharge 202m north west of the site (NGR 528800, 177900) on 11th July 1998; and
- Category 3 - sewage discharge 214m northwest of the site (NGR 528700, 177900) on 6th June 1997.

12.57 The Landmark Envirocheck Report (*Appendix I1 of ES Volume II*) identifies approximately six Substantiated Pollution Incidents. Five were considered to be classed as Significant Incidents to water from storm sewage, and one was considered to be a Major Incident in November 2003 approximately 700m north west of the proposed Battersea station from storm sewage.

12.58 The River Thames supports a wide range of fish species and acts as a nursery for many North Sea fish species. The inter-tidal fish community consists of 125 species, including grey mullet, bass, smelt, flounder, dace, roach, bream, eel and carp (Ref. 12-30). Up to 350 benthic invertebrate species have been found in the estuary and a number of invasive non-native species have been identified.

12.59 It also acts a source of abstraction for potable supply (the Thames Gateway Water Treatment Works) and industrial uses, and support recreation events of national importance. It therefore has a High importance.

Designated Sites

12.60 There is one statutory site within 1km of the proposed NLE, the Battersea Park Local Nature Reserve (LNR) which lies approximately 300m to the west of Battersea Power Station. There are eight non-statutory designated sites within 1 km of the proposed NLE, one of which is the River Thames & Tidal Tributaries SMINC, located approximately 150m north of the existing Battersea Power Station (*see ES Volume II: Appendix J1*).

Surface Water Abstractions (Supply) and Discharge

12.61 According to the Landmark Envirocheck Report there are surface water abstractions within the vicinity of the site at six notable locations. The sensitivity / importance of a surface abstraction has been characterised below. No information is available on the volume of abstraction. Notable surface water abstractions include:

- St James Homes abstracts tidal water from the Thames, approximately 550m northwest of the proposed Battersea station site, for navigation make-up or top up water;
- TWUL abstract river/stream water at Western Pumping station for public water supply, approximately 500m northwest of the proposed Battersea Station site;
- Westminster City Council abstract tidal water at Grosvenor Road for supply to canal, approximately 500m northwest of the proposed Battersea station site;
- RMC Aggregates abstract tidal water for gravel washing approximately 400m northeast of the proposed Battersea station site;
- Halycon Estates Limited holds a surface water (River Thames) abstraction licence on the BPS site, approximately 400m north of the proposed Battersea

station site. The water is licensed for use for non-evaporative cooling means; and

- Western Riverside Waste Authority abstract water for dust suppression approximately 200 north of the proposed Battersea station site.

12.62 There are numerous discharge consents currently in place in the vicinity of the site taking the form of site drainage, final treated sewage, treatment works overflows and storm sewer overflows.

Flood Risk

12.63 A FRA has been prepared by BH and is included in *ES Volume II: Appendix H2*. It details the full assessment of flood risk and the proposed mitigation for these risks. This section summarises the baseline flood risk to the NLE as set out in the FRA.

Fluvial and Tidal Flood Risk

12.64 The fluvial and tidal flood risk classifications have been obtained from the most current flood maps presented by the Environment Agency, which go to the year 2030. The route of the NLE, including the location of Battersea station and Nine Elms station, lies mainly within the floodplain of the River Thames and is designated as Flood Zone 3 (ignoring the presence of defences). This is defined as an area that could be flooded from a 1% Annual Exceedance Probability (AEP) (1 in 100) fluvial event or a 0.5% AEP (1 in 200) tidal event.

12.65 Environment Agency records show that parts of the proposed NLE to the east have previously been affected by flooding in January 1928 as a result of overtopping of flood defences at Battersea Power Station. This surge coincided with high fluvial flows and the water level in the River Thames reached a height of 5.16m AOD.

12.66 The floodplain is defended by the Thames Tidal Defences, generally to a standard that will accommodate a 0.1% AEP (1 in 1000) tidal event, including an allowance for sea level rise due to climate change. The Thames Tidal Defences include the Thames Barrier, which is operated by the Environment Agency. All of these defences are maintained to a high standard and the Environment Agency's Thames Estuary 2100 (TE2100) plan sets out how the standard of protection will be maintained for the next 100 years; therefore, the risk of failure is considered to be very low. Further information on climate change can be found in *Chapter 16: Climate Change Adaptation and Mitigation* of this ES.

12.67 Despite this there is a residual risk of either a breach or overtopping of flood defences. Breach modelling results contained within the Lambeth SFRA indicate that some parts of the study area are susceptible to flood depths in the range of 0.5m – 2m following a breach.

12.68 Liaison with the Environment Agency established multiple sites for breach analysis where a simulated breach in the Thames Tidal Defences has been modelled. A number of breach locations presented no risk to the NLE scheme, whilst two of the breach locations require integration of mitigation into the development design. Nine Elms station has been removed from the flood extent by raising the finished floor levels for the two entrances, whilst ensuring the central section of the station building has been lowered to minimise the impact of the station on the flood flow in the 1 in 1000 year event. The proposed station at Battersea has no effect on flooding as it is located outside the flood extent for any of the breach locations.

12.69 The FRA summarises the risk of fluvial or tidal flooding to be low (based on a low likelihood due to presence of defences), and with a residual low risk (based on consequence if a breach event or overtopping occurred).

Groundwater Flood Risk

12.70 Historic flooding records are anecdotal, the lack of reports of any groundwater related flooding problems suggests that flood risk from groundwater is considered to be low in the area.

12.71 The FRA concluded that groundwater flood risk is low based on a low likelihood and low consequence.

Surface Water Flood Risk

12.72 The risk of surface water flooding and overland flow flooding in the study area is considered to be low, as the runoff would be directed locally to lower areas and then drain into the TWUL public sewer system. Any surface water ponding would be localised.

12.73 However, overland flow routes can pose a risk to London Underground assets, particularly at vulnerable openings to the underground network, although London Underground standards for surface water drainage seek to control that risk. As per guidance in the London Plan, substantial improvement to the TWUL combined sewers will be provided in terms of storm water discharge for the Battersea station site, including the wider BPS site. This will increase capacity in the combined and surface water drainage network in the area of the development and therefore reduce the risk of surface water flooding.

12.74 The FRA concluded that surface water flood risk is low based on a low likelihood and low consequence.

Summary of Receptor Importance

12.75 Table 12-4 summarises the importance of the above identified surface water resource receptors in relation to the key attributes that could be affected by impacts.

Table 12-4 Importance of Water Resource Receptors

Water Resources	Importance
River Thames	High
TWUL water resources	High

Impact Assessment and Mitigation Measures

12.76 The following sections of this ES Chapter detail the assessment of potential impacts on the water environment from the construction phase and the completion and operation of the NLE.

Construction Impacts

12.77 Throughout the construction phase of the NLE, there are potential sources of pollution / contamination in addition to the construction processes themselves that may potentially affect water resource receptors. For each of the sources / processes, there are particular 'triggers' – these are on-site actions that cause the potential impacts. These are detailed in Table 12-5.

12 Surface Water Resources and Flood Risk

12.78 The likely pathways between the source of contamination and construction process and the associated water resources feature or attribute have been identified. The potential impacts (pre-mitigation) have been stated, and are fundamentally the result of the interaction between the contamination source / process and the water resource feature, via a defined pathway.

12.79 Pollution sources arising from construction works that could impact water resource receptors comprise the following:

- Suspended sediments;
- Leaks and spillages from oils/hydrocarbons;
- Concrete and cement products;
- Disturbance of contaminated land; and
- Disturbance to TWUL assets.

12 Surface Water Resources and Flood Risk

Table 12-5 Construction Potential Sources of Contamination and Processes – Associated Triggers, Features, Pathways and Potential Impacts

Source / Process	Triggers	Receptor	Pathways	Potential Impacts (Pre-mitigation)
Disturbance of on Site Historical Land Contamination	• Disturbance of historical contaminated land through subsurface works.	River Thames	• Contaminated surface water would drain into the TWUL sewer network with potential to enter the Thames via CSO outfall during heavy rain. • Contamination could infiltrate to shallow aquifer where it could migrate laterally to the Thames which is in connectivity with the shallow aquifer.	Pollution of River Thames via discharge from CSOs
Leaks and Spillages of Potential Pollutants due to construction activities	• Improper design/use/condition of underground and above ground fuel tanks. • Improper storage of diesel, other fuels, oils, lubricants and coolants; irregular maintenance of plant equipment and on site vehicles; improper use of diesel, other fuels and oils. • Improper storage, handling and disposal of general waste from welfare facilities and construction activities, and hazardous waste (including contaminated soil if defined as hazardous waste).	River Thames	• Runoff contaminated with suspended pollutants, or pollutants adsorbed to particulates, would drain into the TWUL sewer network with potential to enter the Thames via CSO outfall during heavy rain. • Pollutants could infiltrate to shallow aquifer where it could migrate laterally to the Thames which is in connectivity with the shallow aquifer.	Pollution of River Thames via discharge from CSOs
Suspended Sediments	• Disturbance of ground through subsurface works during rainfall. • Waste water from construction activities e.g. dust suppression techniques and wheel washing. • Exposed ground, excavations and stockpiles (could also contain contaminated material e.g. soils) producing sediment laden runoff.	River Thames	• Sediment laden runoff would drain into the TWUL sewer network with potential to enter the Thames via CSO outfall during heavy rain.	Pollution of River Thames via discharge from CSOs
		Property or land connected to the same catchment of the TWUL network serving the site	• Sediment laden runoff would drain into the TWUL sewer network with potential to cause sedimentation and silting of the sewer, reducing sewer carrying capacity and hence increased risk of surcharging and flooding via manholes.	Increase in flood risk to property and land in the TWUL sewer network sub-catchment

Source / Process	Triggers	Receptor	Pathways	Potential Impacts (Pre-mitigation)
Concrete and Cement	• Concrete mixing and washing down of areas where mixing has taken place.	River Thames	• Contaminated surface water would drain into the TWUL sewer network with potential to enter the Thames via CSO outfall during heavy rain.	Pollution of River Thames via discharge from CSOs
Disturbance to TWUL assets	• Ground or subsurface works.	River Thames	• Disturbance of existing on-site drainage systems and water supply network.	Pollution of River Thames via discharge from CSOs
Jetty construction works	• Dredging and in-river construction.	River Thames	• Changes to channel morphology and release of suspended sediments into the river.	Pollution of the River Thames
Water consumption during construction	• Increase in water demand from activities such as dust suppression techniques, wheel washing; construction techniques; and workers / on site welfare facilities.	TWUL water resources	• n/a	Increased pressure on local TWUL water resources (River Thames and deep groundwater).
Transportation of excavated material	• Accidental spillage of material from conveyor or barge. • Poorly maintained equipment.	River Thames	• Material falling or being blown into the river. • Poorly sealed barges and tugs allowing fuel to leak.	Pollution of the River Thames

Suspended Sediments

12.80 Potential sources of suspended sediments during the construction of the NLE include excavations and groundwater control of excavations, exposed ground and stockpiles, grouting, plant and wheel washing and dust and sediment generated. Groundwater control or depressurisation may be required during both the SCL running tunnels and the step plate junction construction to control the inflow of ground water during the construction. Similar local groundwater control will also be required for the Kennington Park and Kennington Green shafts and also the temporary shafts during shaft construction. Extracted groundwater can contain elevated levels of suspended sediments.

12.81 The major pathway for suspended sediments to reach water receptors is through the TWUL sewer network and is triggered by runoff during rainfall events or when areas are being washed down. This may cause sediment-laden water to enter the local drainage network and reach the River Thames via CSOs. Suspended sediments can result in the suffocation of fish, smothering of plants, reduced levels of light within water bodies and decreased water quality surface water abstractions. Any organic matter contained within the sediment can increase the BOD of the water and result in a lowering of DO. Suspended sediments are also a major transport mechanism for low-solubility contaminants that can bind to sediment particles and enter water bodies resulting in adverse impacts to the receiving water.

12.82 Due to the dilution provided within the sewer network and by the river itself, it is considered that there would be a minor impact on the River Thames via CSO discharges. Whilst there would potentially be locally measurable changes in the vicinity of the CSO outfall, the change would be of limited size and / or proportion and would not affect abstractions or WFD supporting elements.

12.83 A number of mitigation measures will be employed at the site to prevent the release of suspended sediments and reduce the impact magnitude, as described in the Code of Construction Practice (CoCP) (*see ES Volume II: Appendix N*). These include, but are not limited to:

- Cut-off ditches and/or geotextile silt-fences which will be installed around excavations or exposed ground and stockpiles to prevent the uncontrolled release of sediments from the site;
- Site access points which will be regularly cleaned to prevent build up of dust and mud;
- Earth movement will be controlled to reduce the risk of construction silt combining with the site run-off;
- Properly contained wheel wash facilities will be used where required, to isolate sediment rich run-off; and
- Drainage of surface run-off and groundwater control effluents to settling tanks to remove suspended solids prior to discharge to sewer.

12.84 Adoption of these mitigation measures will minimise the magnitude and the likelihood of uncontrolled release of sediment, therefore resulting in an impact of negligible magnitude and therefore have a negligible effect on the local drainage systems and the River Thames.

12.85 Table 12-6 below summarises the potential and residual impacts and effects on water resource as a result of the release of suspended sediments.

Table 12-6 Suspended Sediment: Summary of Impacts and Effects

Receptors	Receptor Importance	Magnitude of impact Pre Mitigation	Effect Significance Pre-Mitigation	Magnitude of impact Post Mitigation	Residual Effect Significance (Post Mitigation)
River Thames	High	Low	Minor	Negligible	**Negligible**

Leaks and Spillages – Oils and Hydrocarbons

12.86 The main source for oils and hydrocarbons at the site will be from spillages and leaks associated with plant and machinery and from fuel storage. The pathways for oils and hydrocarbons to reach receptors are via surface water runoff, into the drainage network.

12.87 If oils enter the River Thames via CSOs, the result can be fatal to fish and other aquatic organisms, due to the creation of oily surface films on water and a reduction in the quality of industrial and potable abstractions. Oils also bind to sediments, strata and organisms and can form emulsions that float on the water surface, and upon breakdown the action of microbes can lower the DO content of the water.

12.88 Due to the dilution provided within the sewer network, it is considered that there would be a minor impact on the River Thames via CSO discharges, as whilst there would potentially be locally measurable changes in the vicinity of the CSO outfall, the change would be of limited size and / or proportion and would not affect abstractions or WFD supporting elements.

12.89 Measures will be taken to protect controlled waters from the release of oils and hydrocarbons at the site, as described in the CoCP. These measures include, but are not limited to:

- Oils and hydrocarbons will be stored in designated locations with specific measures to prevent leakage and release of their contents, including the siting of storage areas away from surface water drains and on an impermeable base with an impermeable bund that has no outflow and is of adequate capacity to contain 110% of the contents. Valves and trigger guns will be protected from vandalism and kept locked when not in use;
- Wherever possible, plant and machinery will be kept away from the drainage system and will have drip trays beneath oil tanks/engines/gearboxes/hydraulics which will be checked and emptied regularly via a licensed waste disposal operator;
- Following the discharge of surface run-off and groundwater control effluents to settling tanks the drainage would be routed to oil interceptors prior to discharge to sewer; and
- An Emergency Preparedness Plan (EPP) that includes spill response will be produced, which site staff will have read and understood. On-site provisions will be

made to contain a serious spill or leak through the use of booms, bunding and absorbent material.

12.90 Implementation of the above mitigation measures would reduce the magnitude of the potential impact to the environment and thus result in a negligible residual effect on the River Thames.

12.91 Table 12-7 below summarises the potential and residual impacts and effects to water resource receptors as a result of the release of oils and hydrocarbons.

Table 12-7 Oil and Hydrocarbons: Summary of Impacts and Effects

Receptors	Receptor Importance	Magnitude of impact Pre Mitigation	Effect Significance Pre-Mitigation	Magnitude of impact Post Mitigation	Residual Effect Significance (Post Mitigation)
River Thames	High	Low	Minor	Negligible	**Negligible**

Concrete and Cement Products

12.92 Concrete and cement products are highly alkaline and their release into controlled waters could have an adverse impact on fauna in controlled waters and on the water quality in general, resulting in a poor taste and an increase in pH to levels above the legal drinking water standards.

12.93 Construction processes that can result in the release of concrete and cement include on-site concrete mixing and washing down of areas where mixing has taken place. This leads to large quantities of wastewater runoff which can flow into the surface water drainage system or infiltrate the ground.

12.94 Due to the dilution provided within the sewer network, it is considered that there would be a minor impact on the River Thames via CSO discharges. This could result in an adverse effect of minor significance on the River Thames, as whilst there would potentially be locally measurable changes in the vicinity of the CSO outfall, the change would be of limited size and / or proportion and would not affect abstractions or WFD supporting elements.

12.95 A number of precautions will be taken on the site to reduce the potential magnitude of an impact, as described in the CoCP. These include, but are not limited to:

- The majority of concrete used will be pre-mixed and delivered from an off-site source, thereby negating the need to mix concrete on-site and reducing the creation of alkaline wastewater;
- Wherever possible, any mixing and handling of wet concrete on-site will be undertaken in designated impermeable areas, away from any drainage channels or surface water; and
- A designated impermeable area will be used for any washing down or equipment cleaning associated with concrete or cementing processes and wastewater will be discharged to the foul drainage system or contained and removed by tanker to a suitable discharge location.

12.96 These control (mitigation) measures will reduce the volume of potentially contaminated wastewater and therefore the potential effect to the River Thames will be negligible.

12.97 Table 12-8 summarises the potential and residual impacts and effects to water resources as a result of concrete and cement products.

Table 12-8 Concrete and Cement: Summary of Impacts and Effects

Receptors	Receptor Importance	Magnitude of impact Pre Mitigation	Effect Significance Pre-Mitigation	Magnitude of impact Post Mitigation	Residual Effect Significance (Post Mitigation)
River Thames	High	Low	Minor	Negligible	**Negligible**

Disturbance of Contaminated Land

12.98 Disturbance of potentially contaminated soils during the construction works may adversely affect the River Thames. *Chapter 13: Land Quality and Groundwater* of this ES concludes that some areas of the site, namely Nine Elms and Battersea stations, have previously been used for activities that have had potential to cause a low-moderate level for soil contamination. A review of historical mapping of the sites at Radcot Street, Harmsworth Street, Kennington Green and Kennington Park indicate that the land has been in residential use since at least 1875 and there is therefore considered to be a low potential for contamination of soils.

12.99 It is possible that undiscovered areas of contamination could exist, with the potential for disturbance and the re-mobilisation of contaminants into the River Thames (via surface water runoff and the drainage network or via lateral movement in the shallow aquifer). Due to the distance of the site from the River Thames and dilution provided within the sewer network, it is considered that there would be a minor impact on the River Thames water quality via CSO discharges, as whilst there would potentially be locally measurable changes in the vicinity of the CSO outfall, the change would be of limited size and / or proportion and would not affect abstractions or WFD supporting elements.

12.100 In the event that contamination is discovered, work will stop immediately and measures will be taken to prevent disturbance and mobilisation of contaminants, until the contamination has been treated in-situ or removed for off-site disposal. Details of the measures that could be put in place are outlined in *Chapter 13: Land Quality and Groundwater* and are also described in the CoCP. Therefore, with the appropriate methodology and control (mitigation) measures in place, the potential magnitude of impact associated with the presence of undiscovered areas of contamination on-site will be reduced to negligible and the residual effect is therefore considered to be negligible (Table 12-9).

Table 12-9 Contaminated Land: Summary of Impacts and Effects

Receptors	Receptor Importance	Magnitude of impact Pre Mitigation	Effect Significance Pre-Mitigation	Magnitude of impact Post Mitigation	Residual Effect Significance (Post Mitigation)
River Thames	High	Low	Minor	Negligible	**Negligible**

Disturbance to TWUL Assets

12.101 The NLE Settlement Report (*see ES Volume II: Appendix I2*) provides an assessment of the effects of the NLE on existing infrastructure, including TWUL water and sewer mains. This identified four TWUL assets that could potentially be affected:

- Heathwall Sewer – Cast iron and concrete sewer main which lies in very close proximity to the proposed tunnelling;
- South West Storm Sewer - Cast iron and concrete sewer main which lies in very close proximity to proposed tunnelling;
- Low Level No 1 Sewer - Masonry construction sewer main with foundations within River Terrace Deposits; and
- Ring Main - High pressure (3-4.5 bar) water supply main, with a risk of potential leakage of high pressure water.

12.102 In the event of damage to the TWUL assets, there is the possibility of pollution to the River Thames from discharged foul sewage or treated water. However, the three mains foul sewers all lead to CSOs that discharge to the River Thames; a rupture to these sewers would therefore not create an additional direct pathway to the River Thames. There would be an indirect pathway if leakage of combined sewage to shallow aquifer migrated laterally to the River Thames, but due to the dilution in the groundwater and the river itself, the effects would only be felt locally and this is considered to be a minor impact and therefore would have a minor effect.

12.103 Should damage to the Ring Main occur, this could lead to the discharge of treated drinking water to the River Thames, via the surface water system. An EPP will be put in place and education/information on measures to be implemented in the event of damage to the TWUL assets will be included. However, given the treated nature of this water and the dilution available within the river, it is considered that this would have a negligible impact on the River Thames and thus have a negligible effect (Table 12-10).

Table 12-10 Disturbance of TWUL assets: Summary of Impacts and Effects

Receptors	Receptor Importance	Magnitude of impact Pre Mitigation	Effect Significance Pre-Mitigation	Magnitude of impact Post Mitigation	Residual Effect Significance (Post Mitigation)
River Thames	High	Low	Minor	Negligible	**Negligible**

River Works Associated with the Jetty

12.104 In order to facilitate the use of the River Thames for the movement of excavated materials by barge, during construction of the NLE, it is proposed that the works to be undertaken for the jetty at Battersea Power Station include the following:

- Creation of additional fenders for the jetty (estimation of seven sets of twin H piles, expected to be 350mm by 350mm or 400mm by 400m);
- Dredging: it is recommended that the berth pocket be dredged to -2.9m Chart Datum (CD); however, the specific extent and depth of dredging required will be established following an updated bathymetric survey;
- Refurbishment works to the footbridge;
- Potential provision of piled foundations for conveyors on the land side of the river wall and potential installation of piles from the river side.

12.105 Dredging and other works within the river channel could cause changes to channel morphology and result in the release of suspended sediments. However the changes to channel morphology are likely to be minimal, as no new jetties are being created and it is therefore considered that this would result in a negligible impact. In accordance with the Port of London Authority (PLA) guidance for dredging in the tidal Thames and its tributaries, dredging would be carried out during restricted periods to avoid sensitive periods for fish spawning (June to August), as outlined in the CoCP. In addition, monitoring of the river morphology at this point would be carried out, to ensure no emergency dredging would be required, particularly during the sensitive periods.

12.106 The River Thames is a high sediment environment and levels already present within the Tidal Thames are estimated to reach a peak of 4,000kg/s in the lower Thames estuary or more than 40,000t of sediment passing the site four times a day during spring tides (Ref. 12-37). In this context, the additional sediment likely to be produced by the proposed dredging and jetty works would not be detectable against natural fluctuations in sediments and would have a negligible impact (Table 12-11).

Table 12-11 River Works associated with the Jetty: Summary of Impacts and Effects

Receptors	Receptor Importance	Magnitude of impact Pre Mitigation	Effect Significance Pre-Mitigation	Magnitude of impact Post Mitigation	Residual Effect Significance (Post Mitigation)
River Thames	High	Negligible	Negligible	Negligible	**Negligible**

12.107 The jetty works have been assessed as part of a separate WFDa (see *ES Volume II: Appendix H1*). The WFDa screening process confirmed that the jetty works are the only impact source that has the potential to impact on any of the WFD supporting elements for the Thames Middle waterbody, and hence was subject to a preliminary assessment.

12.108 The WFDa preliminary assessment concluded that due to the limited physical extent of the intrusive works within the Thames Middle waterbody, the current ecological potential classification (Moderate) would not be impacted by the negligible change in morphology and habitat availability. It also concluded that the jetty works would not prevent any mitigation measures required to meet future Good potential classification from being implemented. No significant effects with regards to the WFD are therefore anticipated.

Water Consumption During Construction

12.109 Processes during the construction phase of the NLE which may require significant volumes of water supply include mixing, especially relating to concrete, supply for washing down and potable water for sanitary facilities for site staff. The most intensive use of water, for the mixing of concrete, will be done off-site where possible and therefore will not affect water supply to the site.

12.110 It is expected that water supply to the site during the demolition and construction phase will be provided by the existing TWUL network and an application to use an existing water supply for building purposes must be made to TWUL.

12.111 Water supply to the existing site is unknown, however, water supply for demolition and construction processes may represent a short term, increase in supply volumes to the site. This is assessed as having a temporary, low magnitude of impact on water supply infrastructure locally, and therefore an effect of minor adverse significance.

12.112 However water saving measures will be adopted where possible, thereby reducing the impact on the water supply network. Means of reducing water consumption include the following, as described in the CoCP:

- Selection and specification of equipment to reduce the amount of water required;
- Implementation of staff-based initiatives such as turning off taps, plant and equipment when not in use both on-site and within site offices;
- Use of recycling water systems such as wheel washes, site toilets hand wash;
- Potential use of a rainwater harvesting system for use in equipment and vehicle washing; and
- Preparation and implementation of a water conservation plan, based on the water hierarchy.

12.113 However, if TWUL grant the application for water supply for building purposes, then the impact on the TWUL water resources is considered to be negligible.

Table 12-12 Water consumption during construction: Summary of Impacts and Effects

Receptors	Receptor Importance	Magnitude of impact Pre Mitigation	Effect Significance Pre-Mitigation	Magnitude of impact Post Mitigation	Residual Effect Significance (Post Mitigation)
TWUL water resources	High	Low	Minor	Negligible	**Negligible**

Operation/Completed Development

12.114 The operation of the NLE once completed may potentially affect the features and attributes of surface water resource receptors. In line with the same methodology used for the construction impact assessment, for each completed and operational development source, there are particular 'triggers'. The likely pathways between the source and the associated surface water resources feature or attribute has been identified. These sources, triggers, features / attributes, and pathways are shown in Table 12-13. The impact (pre mitigation) has been stated, and is fundamentally the result of the interaction between the source and the surface water resources feature, via a defined pathway.

12.115 Operation of the NLE could increase potable water consumption, which could cause increased pressure on local TWUL water resources. However, the potential use of rainwater harvesting for toilet flushing and other non-potable uses, which could reduce overall water consumption, will be developed during detailed design in collaboration with over site developers.

12.116 Pollution sources arising from the operational use of the NLE which could affect surface and groundwater comprise the following:

- Leaks, spillages, application of fertilisers and pesticides within landscaped areas;
- Contamination from in-situ materials; and
- Flood risk.

Table 12-13 Completion and Operation of the NLE – Associated Sources, Triggers, Features, Pathways and Potential Impacts and Effects

Source	Triggers	Feature / Attribute	Pathways	Potential Impacts (Pre-mitigation)
Operational water use	• n/a	TWUL water resources	Water consumption during operation.	Increased pressure on local TWUL water resources (River Thames and deep groundwater).
Leaks and Spillages	• Improper storage and use of oils, lubricants and coolants. • Vehicles using the site access routes, and on-site car parks • Vehicle washing. • Improper storage, handling and disposal of general and hazardous waste from proposed site uses and activities.	River Thames	Infiltration and/or runoff into the local sewer network and into the Thames via CSOs during rainfall events.	Pollution of River Thames via discharge from CSOs.
Contamination from In-Situ Materials	• Increase in water usage from proposed on-site uses / activities.	River Thames	Infiltration and/or runoff into the local sewer network.	Pollution of River Thames via discharge from CSOs.
Impermeable land coverage	• Landscaping or presence of buildings increase in impermeable areas, reducing infiltration and increasing runoff.	Surrounding land or property	Increased runoff flowing as overland flow to adjacent land or property, or causing flooding of TWUL network via manholes.	Changes to the flood risk to or from the site.

Leaks and Spillages

12.117 Sources of pollution from developments include oil leaks and petrol spillages from vehicles or storage facilities. Pollutants can be mobilised in surface water runoff and enter the surface water drainage network. The release of chemicals in this way is anticipated to have an adverse impact of low magnitude as the quantities are likely to be relatively small and dilution will be available within the surface water runoff, the receiving sewer network and River Thames. In the unlikely event that pollutants enter the on-site drainage system, there is a risk of them entering the River Thames through CSOs associated with the TWUL network. Due to the distance of the site from the River Thames, the low volume (small magnitude) of any potential spill, and dilution provided within the sewer network, it is considered that there would be a negligible effect on the River Thames via CSO discharges.

12.118 As with the construction phase of the NLE, there remains a residual risk of a spillage of contaminating material, for example fuels and oils, which could potentially be released to the drainage network. The risk of this occurring will be managed by operational measures such as speed limits and road markings and procedures during delivery or movement of materials. The drainage system will also have cut-off measures that will allow a spill to be contained within the site, so that it can be effectively controlled and managed without leading to off-site effects. An EPP will be put in place and education/information on waste treatment/emergency events/spills etc will be provided to the staff. Interceptors will be used in association with the drainage network that serves high-risk areas as defined by the EA's PPG 3 (Ref. 12-18). In addition, planned preventative maintenance of the NLE will also be undertaken for all the assets, through adherence to legislation and best practice in the design and maintenance of the new assets, which will further reduce the risk of leaks and spillages.

12.119 Following the implementation of the aforementioned mitigation measures, the residual effect on water quality of the River Thames will be negligible.

Table 12-14 Leaks, Spillages, Application of Fertilisers and Pesticides: Summary of Impacts and Effects

Receptor	Receptor Importance	Magnitude of impact Pre Mitigation	Effect Significance Pre-Mitigation	Magnitude of impact Post Mitigation	Residual Effect Significance (Post Mitigation)
River Thames	High	Negligible	Negligible	Negligible	**Negligible**

Contamination from In-Situ Materials

12.120 The presence of below ground structures, such as the drainage network, basements, foundations and the Northern line tunnels themselves can present a source of pollutants, through water coming into contact with the materials used in foundations and basements leaking into the drainage network and then being discharged into the River Thames via CSOs. However, due to the dilution provided within the sewer network and the River Thames, it is considered that there would be a negligible impact on the River Thames via CSO discharges.

12.121 It is envisaged that all the proposed drainage/service runs will be surrounded by appropriate granular bedding materials and in addition confirmatory tests of the new systems may be carried out in accordance with statutory requirements. The drainage network installed on site will be constructed to meet with Building Regulations 2000, Part H (Ref. 12-38). As a consequence, leakage into the drainage network is likely to be negligible.

Flood Risk

12.122 A benefit to the TWUL combined sewers will be provided in terms of a reduction in storm water discharge volumes entering the system. The Promoter is committed to meeting the essential standard of the London Plan, requiring attenuation to 50% of the existing peak runoff. This will be achieved through a range of SuDS, re-routing drainage for 94% of the land of the Battersea NLE station site so that it drains directly to the River Thames as opposed to the TWUL network. Measures that will be incorporated through a range of SuDS into the design include the following:

- Living (green) roofs for water attenuation at the lodge in the northeastern corner of Kennington Park (hereafter referred to as 'Kennington Park Lodge');
- Incorporation of a water attenuation tank at Nine Elms station; and
- Other measures such as permeable areas.

12.123 This re-routing of drainage represents an improvement to the current situation; the reduction in surface water run-off will increase capacity in the surrounding sewer network and thereby reduce flood risk. This is a low magnitude of impact, which would be an effect of minor beneficial significance.

Residual Effects Assessment and Conclusions

12.124 No significant effects to surface water resources are expected through the construction works associated with the NLE, provided that the mitigation measures as discussed throughout this ES Chapter are applied.

12.125 The assessment concludes that the completed and operational NLE will have a minor beneficial effect on the volumes of surface water runoff, flood risk and the local TWUL sewer network.

12.126 Table 12-15 below summarises the residual effects on water resources.

Table 12-15 Summary of Residual Effects (post-mitigation)

Description	Impact Magnitude	Effect Significance
Construction		
Release of suspended sediment	**Negligible**	**Negligible**
Leaks and Spillages (oils and hydrocarbons)	**Negligible**	**Negligible**
Use of concrete and cement products	**Negligible**	**Negligible**
Disturbance of contaminated land	**Negligible**	**Negligible**
Disturbance to TWUL assets	**Minor**	**Minor**
Jetty construction works	**Negligible**	**Negligible**
Water consumption during construction	**Minor**	**Negligible**
Transport of excavated materials	**Negligible**	**Negligible**
Operation		
Leaks and Spillages	**Negligible**	**Negligible**
Contamination from In-situ Materials	**Negligible**	**Negligible**
Decreased surface water flood risk	**Minor**	**Minor beneficial**

Water Framework Directive Assessment

12.127 The WFDa preliminary assessment (see *ES Volume II: Appendix H2*) concluded that due to the limited physical extent of the intrusive works within the Thames Middle waterbody, the current ecological potential classification (Moderate) would not be impacted by the negligible change in morphology and habitat availability. It also concluded that the jetty works would not prevent any mitigation measures required to meet future Good potential classification from being implemented. The NLE project would therefore not impact on WFD objectives.

Cumulative Effects Assessment

12.128 This section of the ES Chapter assesses the effects of the NLE in combination with the potential effects of the 26 development sites that have been identified within 1km of the site for consideration within the cumulative assessment. These schemes have been identified and listed in *Chapter 2: EIA Methodology* and the majority of these are developments for mixed-use developments including offices, residential, hotels and retail units.

Construction Effects

12.129 Cumulative impacts to water resources during construction processes are associated with the generation of sediments and the release into the combined sewer drainage network; spillage and leakage of oils and fuels; leakage of wet concrete and cement; disturbance of contaminated land and foul drainage; and water consumption.

12.130 As outlined in previous sections of this ES Chapter, measures exist to manage and control these impacts and reduce their magnitude, and resulting significance of effects, to a minimum.

12.131 Therefore as a result of these control measures utilised in the NLE and in the schemes considered within this cumulative impact assessment, any cumulative effect is considered to be of negligible significance.

Operational Effects

12.132 The NLE will have a beneficial effect on the surface water runoff generated at the site. Generation of surface water runoff from the schemes considered within this cumulative assessment must, in line with the NPPF, provide betterment compared with existing rates and should meet the Essential Standard of the London Plan requiring attenuation to 50% of the existing peak runoff. It is anticipated that this can be achieved on the surrounding development sites, and therefore a cumulative effect will be observed and this could be an effect of minor beneficial significance to the local flood risk associated with the TWUL sewer network. This could provide a minor beneficial effect on the River Thames by contributing to the reduction of the number of spills from CSOs.

12.133 Cumulative impacts to water resources during operation are also associated with leaks and spillages of fuels and oils, and contamination from in-situ materials. However, providing that mitigation measures to manage and control these impacts and reduce their magnitude are implemented, it is considered that the resulting significance of effects will be negligible.

12 Surface Water Resources and Flood Risk

References

Ref. 12-1 Directive 2000/60/EC of the European Parliament and of the Council establishing a framework for the community action in the field of water

Ref. 12-2 UK Technical Advisory Group Water Framework Directive Site, Available at: http://www.wfduk.org/

Ref. 12-3 Council Directive of 12 December 1991 concerning the protection of water against pollution caused by nitrates from agriculture sources (91/676/EEC)

Ref. 12-4 Directive 2006/44/EC of the Journal of the European Parliament of the Council of 6 September 2006 on the quality of fresh water needing protection or improvement in order to support fish life

Ref. 12-5 HMSO (1990); Environmental Protection Act 1990

Ref. 12-6 HMSO (1995); Environment Act 1995

Ref. 12-7 HMSO (1991); Water Resources Act 1991

Ref. 12-8 HMSO (1991); Land Drainage Act 1991

Ref. 12-9 HMSO (2010); Flood and Water Management Act 2010

Ref. 12-10 HMSO (2003); Water Act 2003

Ref. 12-11 Department for Communities and Local Government (DCLG), (2012); National Planning Policy Framework, Communities and Local Government Publications

Ref. 12-12 DCLG (2010); Planning Policy Statement 25: Development and Flood Risk (PPS25), Her Majesty's Stationary Office (HMSO), London

Ref. 12-13 Office of the Deputy Prime Minister (OPDM), (2004); Planning Policy Statement 23: Planning and Pollution Control (PPS23), HMSO, London

Ref. 12-14 DCLG (2012); Technical Guidance to the National Planning Policy Framework, Communities and Local Government Publications

Ref. 12-15 DCLG (2009); Planning Policy Statement 25: Development and Flood Risk (PPS25) Practice Guide, DCLG Publications, Wetherby

Ref. 12-16 Environment Agency (2000); Pollution Prevention Guidelines (PPG) 1 General Guide to the Prevention of Pollution

Ref. 12-17 Environment Agency (2010); PPG2 Above Ground Oil Storage

Ref. 12-18 Environment Agency (2006); PPG3 Use and Design of Oil Separators in Surface Water Drainage Systems

Ref. 12-19 Environment Agency (2007); PPG5 Works In, Near or Liable to Affect Watercourses

Ref. 12-20 Environment Agency (2008); PPG6 Working at Construction and Demolition Sites

Ref. 12-21 Environment Agency (2004); PPG8 Safe Storage and Disposal of Used Oils

Ref. 12-22 Environment Agency (2007); PPG13: Vehicle Washing and Cleaning

Ref. 12-23 Environment Agency (2009); PPG27 Installation, Decommissioning and Removal of Underground Storage Tanks

Ref. 12-24 Transport for London – London Underground (2011); S1052 Civil Engineering – Gravity Drainage Systems, Category 1 Standard

Ref. 12-25 Greater London Authority (2011); 'The London Plan'

Ref. 12-26 Greater London Authority (GLA) (2006); 'Supplementary Planning Guidance – Sustainable Design and Construction'.

Ref. 12-27 Greater London Authority (2011); 'The Mayor's Water Strategy'.

Ref. 12-28 GLA (2012): Vauxhall Nine Elms Battersea Opportunity Area Planning Framework

Ref. 12-29 British Geological Survey (1991); Geological Map Sheet 270 South London, Scale 1:50,000.

Ref. 12-30 Environment Agency website http://www.environment-agency.gov.uk/

Ref. 12-31 Environment Agency (2009); 'River Basin Management Plan – Thames River Basin District'.

Ref. 12-32 Department for Transport (DfT) (2003); The Water Environment Sub-Objective Transport Analysis Guidance (TAG) Unit 3.3.11, http://www.dft.gov.uk/webtag/documents/expert/pdf/unit3.3.11.pdf

Ref. 12-33 Highways Agency (2009); Design Manual for Roads and Bridges Vol. 11 Environmental Assessment. Section 3 Environmental Assessment Techniques. Part 10 Road Drainage and the Water Environment. The Stationary Office (TSO)

Ref. 12-34 HMSO (2007); Environmental Permitting Regulations 2007

Ref. 12-35 London Borough of Lambeth (2008); Level 2 Strategic Flood Risk Assessment, Final, Scott Wilson, August 2008.

Ref. 12-36 London Borough of Lambeth (2008); Level 1 Strategic Flood Risk Assessment, Final, Scott Wilson, June 2008.

Ref. 12-37 HR Wallingford (report prepared for the Environment Agency) (2006): Thames Estuary 2100, Morphological changes in the Thames Estuary, Technical Note EP6.8, The development of an historical sediment budget

Ref. 12-38 HMSO (2010); Building Regulations 2010

13 Land Quality and Groundwater

Environmental Statement

Volume I

13 Land Quality and Groundwater

Introduction

13.1 This chapter of the Environmental Statement (ES) addresses the likely significant environmental impacts and effects of the proposed construction and operation of the Northern Line Extension (NLE) on the existing ground conditions, geology and hydrogeology of the site and the surrounding area, and on groundwater receptors. To understand these likely impacts and effects, the chapter:

- Outlines the key ground conditions, groundwater resources and features (the receptors);
- Allocates an importance to the identified receptors;
- Identifies impact pathways between the development and the receptors and allocates a magnitude to the likely impact; and
- Assigns significance to the likely direct and indirect effects of the NLE on these receptors, based on the importance of the identified receptor and on the magnitude of the likely impact.

13.2 Consideration of likely significant environmental effects of the NLE on ground conditions, geology and hydrogeology, including both groundwater quantity and quality, is made in the context of existing site conditions (i.e. baseline conditions), throughout the construction works and once the NLE is complete and operational. The effects of ground settlement on buildings and infrastructure in general is described in this chapter, the effects on above ground heritage assets and buried archaeology is described in ES *Chapter 8: Archaeology and Built Heritage*, and a ground settlement report produced by Halcrow is provided in *ES Volume II: Appendix I2*.

13.3 This chapter has been prepared by URS Infrastructure and Environment Ltd (URS) in collaboration with the wider design team, in particular Buro Happold (BH) on geotechnical investigation. The significance of effects is assessed pre-mitigation. The requirement for any mitigation measures throughout the construction stage and once the NLE is operational is then confirmed. Following the application of the mitigation measures, the resultant residual effects are assessed in accordance with described significance criteria.

13.4 As the NLE stretches over three London boroughs, consultation in relation to groundwater resources has been undertaken with the Environment Agency (EA). No specific external consultation has been undertaken with respect to land quality. In addition, a variety of data sources have been reviewed as part of the baseline research, such as published maps, relevant reports and a Landmark ® Envirocheck Report (hereafter referred to as 'the Envirocheck report') (See *ES Volume II: Appendix I1*), and have informed the assessment where relevant. These are listed in the 'Information Sources' section of this chapter below. All relevant data sources are referenced as relevant in the following sections. Bomb damage maps are included in *ES Volume II: Appendix I4*.

Legislative and Planning Policy Context

13.5 There is a wide range of legislation and policy pertaining to groundwater resources and risks to human health and the environment from historical land contamination. However, this section only summarises the key parts of legislation and policy that are directly relevant to the NLE and the range of potential impacts identified.

European Directives

The Water Framework Directive (WFD)

13.6 The WFD (Ref. 13-1) establishes a framework for a European-wide approach for achieving sustainable management of water in the UK and other EU member states. The WFD takes a holistic approach by considering groundwater in relation to its use as a water supply source (both in terms of chemical and quantitative status) and its interactions with surface water and wetland bodies. Article 4 of the WFD requires that all inland (including groundwater) and coastal waters achieve at least 'good status' by the year 2015 and ensure no deterioration from current status of all water bodies. The classification of groundwater status relies on the status and objectives of these associated waters and different standards may apply within a single groundwater body to reflect these varying sensitivities. Groundwater bodies are the management units for groundwater, which are associated with wider river basin districts (RBDs).

The Groundwater Directive

13.7 The existing Groundwater Directive (80/68/EEC) (Ref. 13-2) aims to protect groundwater from pollution by controlling discharges and disposal of certain dangerous substances to groundwater. This piece of legislation is to be repealed by the WFD 2000/60/EC (WFD) in 2013 and replaced by the Groundwater 'Daughter' Directive (2006/116/EC). In the UK, the Directive is implemented through the Environmental Permitting (England and Wales) Regulations 2010. The Directive aims to protect groundwater under these Regulations by preventing or limiting the inputs of polluting substances into groundwater.

National Legislation

The Environmental Permitting Regulations 2010

13.8 The Environmental Permitting (England and Wales) Regulations 2010 (Ref. 13-3) were created to standardise environmental permitting and compliance in England and Wales to protect human health and the environment, in particular in relation to the regulation of discharges to controlled waters (including groundwater). A permit is required for all discharges where activities include discharging of:

- a pollutant directly into groundwater,
- a pollutant that might indirectly enter groundwater; or,
- any other discharge that might cause a pollutant to enter groundwater, directly or indirectly.

Environmental Protection Act 1990, Water Resources Act 1991 and Town & Country Planning Act 1990

13.9 There are three key legislative drivers for dealing with risks to human health and the environment from historical land contamination, namely:

- Part IIA of the Environmental Protection Act (EPA) 1990 (the 'Contaminated Land' regime) (Ref. 13-4);
- The Water Resources Act 1991 and its amendments (Ref. 13-5); and
- The Town and Country Planning Act, 1990 and subsequent amendments (Ref. 13-6).

13.10 In the UK, Part IIA of the EPA, as introduced by Section 57 of the Environment Act 1995 (Ref. 13-7), provides the legislative framework within which site data are to be assessed. Under Part IIA of the EPA, sites are identified as 'contaminated land' if they are causing significant harm or if there is a significant possibility of significant harm or if the site is causing, or could cause, pollution of controlled waters (i.e. both surface and ground waters).

13.11 The Water Resources Act 1991 and its subsequent amendments (2003 and 2009) (Ref. 13-8) introduced a revision to the wording of the EPA, which now requires that a site is causing, or could cause significant pollution of controlled waters in order for it to be determined as contaminated land. Once a site is determined to be contaminated then remediation is required to render significant pollutant linkages insignificant (i.e. the source-pathway-receptor relationships that are associated with harm to human health and/or significant pollution of controlled waters), subject to a test of reasonableness. The Water Resources Act 1991 provides statutory protection for controlled waters (streams, rivers, canals, marine environment and groundwater) and makes it an offence to make a discharge to controlled waters without the permission or consent of the regulators of these areas.

National Planning Policy

The National Planning Policy Framework (NPPF), 2012

13.12 The NPPF (Ref. 13-9) became enforceable in March 2012 and outlines the Government's economic, environmental and social planning policies for England.

13.13 The NPPF supersedes and replaces a number of planning policy documents that are applicable to land quality, such as the Planning Policy Statement (PPS) 23: 'Planning and Pollution Control' (Ref. 13-10), and Planning Policy Guidance (PPG) 14 'Development on Unstable Land' (Ref. 13-11). The NPPF confirms that land contamination and its risk to health should be a material consideration under planning and development control. Of importance is land contamination and its risk to human health in the context of the intended end use of the site.

13.14 Section 109 of the NPPF states that:

"The planning system should contribute to and enhance the natural and local environment by:

- *Preventing both new and existing development from contributing to or being put at unacceptable risk from, or being adversely affected by unacceptable levels of soil, air, water or noise pollution or land instability; and*
- *Remediating and mitigating despoiled, degraded, derelict, contaminated and unstable land, where appropriate."*

13.15 A core planning principle described in Section 111 of the NPPF states that "Planning policies and decisions should encourage the effective use of land by re-using land that has been previously developed (brownfield land), provided that it is not of high environmental value."

13.16 In Section 121 it also states that:

"Planning policies and decisions should also ensure that:

- *The site is suitable for its new use taking account of ground conditions and land instability, including from natural hazards or former activities such as mining, pollution arising from previous uses and any proposals for mitigation including land remediation or impacts on the natural environment arising from that remediation;*
- *After remediation, as a minimum, land should not be capable of being determined as contaminated land under Part IIA of the Environmental Protection Act 1990; and*
- *Adequate site investigation information, prepared by a competent person is presented."*

13.17 The NPPF also supersedes and replaces a number of planning policy documents that are applicable to groundwater resources, such as PPS11: 'Conserving and enhancing the natural environment'. This policy states that *"development should minimise pollution and other adverse effects on the local and natural environment and should plan positively for the creation, protection, enhancement and management of networks of biodiversity and green infrastructure".*

Regional Planning Policy

The London Plan: Spatial Development Strategy for Greater London, 2011

13.18 The London Plan was published in July 2011 (Ref. 13-12). Of particular reference to ground conditions is Strategic Policy 5.21 – Contaminated Land. The policy states that:

"The Mayor supports the remediation of contaminated sites and will work with strategic partners to ensure that the development of brownfield land does not result in significant harm to human health or the environment and to bring contaminated land to beneficial use".

13.19 In addition, the policy requires that appropriate measures should be taken to ensure that development on previously contaminated land does not activate or spread contamination.

13.20 Of particular relevance to groundwater resources are Policy 5.14 – Water Quality and Wastewater Infrastructure, which outlines *"aims to protect and improve water quality and ensure adequate and appropriate sewerage infrastructure"* and Policy 5.15 Water Use and Supplies, which states that *"developments should minimise the use of treated water by incorporating water saving measures…".*

Local Planning Policy

13.21 The study corridor (defined as 1km either side of the sub-surface structures and tunnel alignment) falls within three local authorities, each of which has a local development plan (LDP) that sets out local planning policies. These plans are described in the following sections for each of the London Boroughs that the NLE falls within.

London Borough of Wandsworth (LBW)

13.22 The LBW adopted its Local Development Framework (LDF) Core Strategy in October 2010 (Ref. 13-13). Within this, part of Core Policy IS4 - Protecting and Enhancing Environmental Quality states the following:

"The Council will support measures to protect and enhance the environmental quality of the borough and work with partner agencies to help deliver this. In particular measures will be taken to: Ensure development is safe regarding the re-use of contaminated land, in relation to proposals involving hazardous processes and materials and development located close to hazardous installations."

London Borough of Lambeth (LBL)

13.23 The LBL adopted its LDF Core Strategy in January 2011 (Ref. 13-14). There are no specific policies relating to ground conditions or land contamination in either this document or within the saved policies contained within the Unitary Development Plan (UDP) (Ref. 13-15). At this stage, a draft of the Development Management Plan Documents is not available for review but it is anticipated that these will be adopted prior to the TWAOs submission.

London Borough of Southwark (LBS): Core Strategy (2011)

13.24 The Core Strategy (Ref. 13-16) was adopted in April 2011 and sets out how Southwark will change up to 2026. There are no specific policies related to land contamination. Notwithstanding, Strategic Policy 13 – High Environmental Standards states the following:

"Development will help us live and work in a way that respects the limits of the planet's natural resources, reduces pollution and damage to the environment and helps us adapt to climate change. We will do this by:

- *Setting high standards and supporting measures for reducing air, land, water, noise and light pollution and avoiding amenity and environmental problems that affect how we enjoy the environment in which we live and work. This includes making sure developments are designed to cope with climate conditions as they change during the development's lifetime."*

London Borough of Southwark: Contaminated Land Strategy (2001)

13.25 The LBS Contaminated Land Strategy 2001 (Ref. 13-17) established a programme to identify contaminated land and water in Southwark and to facilitate its remediation according to UK National Regulations (Environmental Protection Act 1990 Part IIA). In this strategy, the Council defines a methodological and strategic approach to identify contaminated land. It considered *"the characteristics of the area in respect to its geology and hydrogeological nature, historic industrial locations and polluting industries and similar criteria."*

London Borough of Southwark: Supplementary Planning Documents (SPD) (2009)

13.26 The LBS SPD on Sustainable Assessment (Ref. 13-18) provides guidance on how to carry out a sustainability assessment of planning applications. With regard to land contamination, the guidance stated the following:

- *"Sufficient information on the level and risks posed by contamination and whether it can be remediated to a safe level needs to be known before a development can proceed; and*
- *Where contamination is present, the site will need to be remediated to a level that is appropriate for the use being proposed. The most sensitive uses are housing, schools, nurseries, hospitals, children's play areas and allotments."*

13.27 Section 11.4 of the SPD also provides information on standards for avoiding pollution and environmental nuisance. With respect to land contamination it states:

- *"Where a sensitive use is proposed or on sites that have had or are adjacent to past industrial uses, a study must be submitted with the planning application that identifies the potential for contamination on the site based on past land uses and site conditions;*
- *Where there is a real potential for contamination, or not enough information is available to show there is no risk of contamination, a more detailed study will be required that determines whether contamination actually exists, its nature and the risks it may pose and whether these can be satisfactorily reduced to and acceptable level through remediation; and*
- *A report demonstrating the effectiveness of the remediation carried out will be required before building work can begin."*

Other Relevant Guidance

Environment Agency Pollution Prevention Guidance Notes

13.28 The EA Pollution Prevention Guidance Notes (PPGN) provide advice on statutory responsibilities and good environmental practice. The Guidance Notes of particular relevance to the NLE and ground conditions include:

- PPGN 1: General Guide to the Prevention of Pollution (Ref. 13-20), provides an introduction to pollution prevention and the pollution prevention guidance notes;
- PPGN 2: Above Ground Oil Storage Tanks (Ref. 13-21) provides guidance to those responsible for the storage of oil on construction sites. The document provides guidance on location, bunding, protection and operation of stored oils in addition to maintenance and brief guidance on dealing with spills;
- PPGN 5: Works In, Near or Liable to Affect Watercourses (Ref. 13-22), provides guidance on general precautions to take when working in the vicinity of a watercourse, along with more specific measures to prevent contamination and to minimise any adverse impacts;
- PPGN 6: Working at Construction or Demolition Sites (Ref. 13-23), is a document that mirrors much of Pollution Prevention Guidance 5, but with particular emphasis on the situations likely to occur at demolition and construction sites; and
- PPGN 21: Pollution Incident Response Planning (Ref. 13-24), assists those developing site-specific pollution incident response plans to prevent and mitigate damage to the environment caused by accidents such as spillages and fires.

13.29 Other relevant legislation and guidance includes:

- The Hazardous Waste (England and Wales) Regulations 2005 (amended 2009) (Ref. 13-25);
- Contaminated Land (England) (Amendment) Regulations 2012 (Ref. 13-26);
- Contaminated Land, DEFRA Circular 01/2006 (Ref. 13-27);

- Environmental Damage (Prevention and Remediation) Regulations 2009 (Ref. 13-28);
- EA Remedial Targets Methodology: Hydrogeological Risk Assessment for Land Contamination (Ref. 13-29);
- Human Health Toxicological Assessment of Contaminants in Soil, Science Report SC050021/SR2 (Ref. 13-30);
- EA, 2004; Model Procedures for the Management of Land Contamination, Contaminated Land Report 11 (CLR 11) (Ref. 13-31);
- EA, 2010; Guiding Principles for Land Contamination (GPLC 1, 2 and 3) (Ref. 13-32);
- Construction Industry Research and Information Association (CIRIA) Guidance C532, 'Control of Water Pollution from Construction Sites' (Ref. 13-33);
- The Chartered Institute of Environmental Health Local Authority Handbooks (Ref. 13-34);
- BS 8485:2007 Code of practice for the characterization and remediation from ground gas in affected developments (Ref.13-35); and
- Guidance C665, 'Assessing Risks Posed by Hazardous Ground Gases to Buildings' (Ref.13-36);
- EA, 2001; Piling and Penetrative Ground Improvement Methods on Land Affected by Contamination: Guidance on Pollution Prevention (Ref. 13-37).

Assessment Methodology and Significance Criteria

Information Sources

13.30 The following information sources have been consulted for consideration of the existing ground conditions and hydrogeology of the surrounding area:

- The Envirocheck Report (see *ES Volume II: Appendix I1*);
- British Geological Survey (1998); Geological map Sheet 270 South London, Scale 1:50,000;
- British Geological Survey website, www.bgs.ac.uk/geoindex/ ;
- National Rivers Authority, (1990); Groundwater Vulnerability Map Sheet 39, West London (Ref. 13-42);
- EA website, www.environment-agency.gov.uk 'What's in my backyard' tool (Ref. 13-43);
- BH (2013); NLE Reference Design TWAO, GRNLEB-BHD-00-XX-TNT-GEO-00049, Settlement Report, Rev 3 (see *ES Volume II: Appendix I2*);
- Concept Consultants Limited (CCL) (2010); NLE, Kennington Station to Battersea Power Station (BPS), Site Investigation Report (hereafter referred to as 'site investigation') (see *ES Volume II: Appendix I3*);
- British Geological Survey (2004); Geology of London (Ref. 13-44);
- Berry, F.G. (1979); Late Quaternary scour-hollows and related features in central London in Quarterly Journal of Engineering Geology and Hydrogeology, v. 12; p. 9-29 (Ref. 13-45);
- London Topographical Society (2005); The London County Council bomb Damage Maps 1939-1945 (see *ES Volume II: Appendix I4*);
- EA (2009); River Basin Management Plan, Thames River Basin District (Ref. 13-46);
- Scott Wilson (2008); London Borough of Lambeth Strategic Flood Risk Assessment (Ref. 13-47);
- Scott Wilson (2009); London Borough of Wandsworth Strategic Flood Risk Assessment (Ref. 13-48);
- BH (2009); 023000 Battersea Redevelopment Geo-environmental Interpretative Summary Report (see *ES Volume II: Appendix I5*);
- Natural England website; http://www.natureonthemap.naturalengland.org.uk/; "Nature on the Map" tool;
- EA (2009); Groundwater Source Protection Zones. A Review of Methods, Integrated catchment science programme. Science report: SC070004/SR1 (Ref. 13-50);
- Morley, M. (2009-2010); The Battersea Channel: a former course of the River Thames? London Archaeologist, Winter 2009/2010 (Ref. 13-51); and
- EA (2012); Management of the London Basin Chalk Aquifer (Ref. 13-52).

Assessment Methodology Overview

13.31 This chapter considers land quality and groundwater separately throughout.

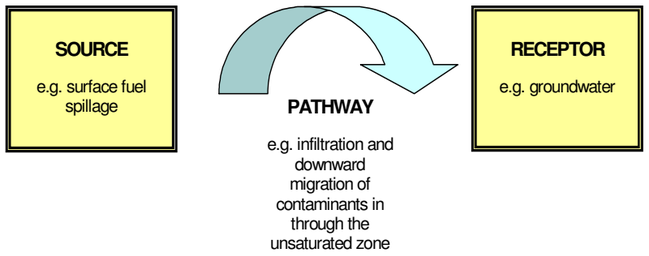
Land Quality

13.32 The land quality assessment has involved the review and collation of readily available information pertaining to the current condition of the soils and groundwater on/beneath the site. This information has been used to characterise the baseline conditions of the site in respect of ground conditions and contaminated land, which has then been reviewed in the context of the NLE to evaluate the temporary (short and medium term), and permanent (long-term) impacts to ground conditions, geology, hydrology and the hydrogeology of the site and the surrounding area.

13.33 Current UK guidance on the assessment of land contamination and associated risks to both human health and the environment advocates the use of a conceptual risk assessment model, otherwise known as a conceptual site model (CSM). The three conditions shown below comprise the basis of the approach in that, without each of the three elements (source, pathway and receptor), there can be no risk from exposure to contamination. Therefore, the presence of measurable concentrations of contaminants within the ground and subsurface environment does not automatically imply that a contamination problem exists, since the contamination must be defined in terms of pollutant linkages and unacceptable risk of harm. The conceptual model is illustrated in Figure 13-1.

13 Land Quality and Groundwater

Figure 13-1 Source-Pathway-Receptor Model

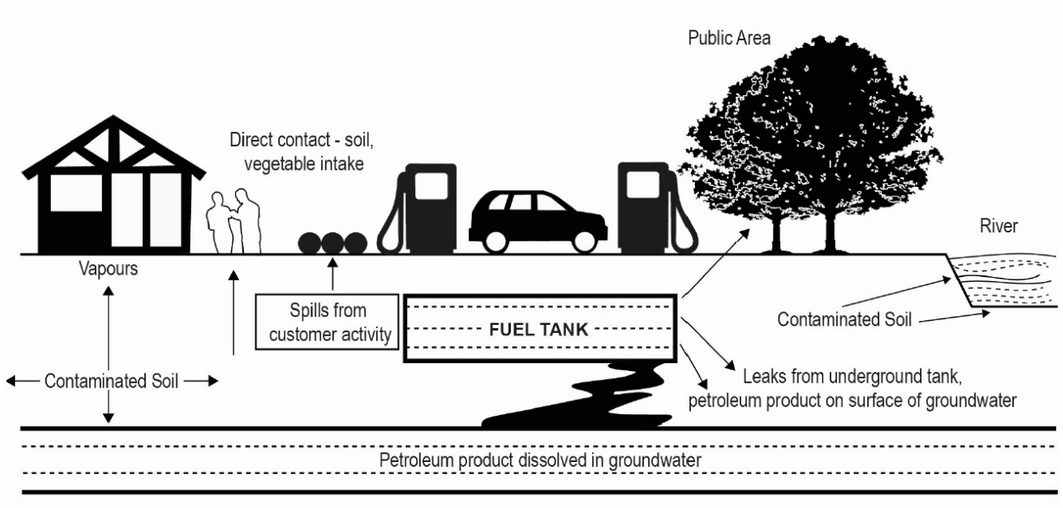


13.34 The nature and importance of both pathways and receptors, which are relevant to a particular site, will vary according to the intended use of the site, its characteristics and its surroundings. The potential for harm to occur requires the following conditions to be satisfied:

- The presence of substances (potential contaminants/pollutants) that may cause harm (source of pollution);
- The presence of a receptor which may be harmed (e.g. the water environment or humans, buildings, fauna and flora) (the receptor); and
- The existence of a linkage between the source and the receptor (the pathway).

13.35 If one of the above is not present then it is perceived that the risk from land contamination does not exist. Figure 13-2 provides a pictorial representation of a CSM, showing examples of sources, pathways and receptors.

Figure 13-2 Examples of a Conceptual Site Model



Adapted from the Institute of Petroleum (1998)

13.36 Following identification of the potential sources of ground contamination, other ground related aspects such as the presence or absence of above and below ground storage tanks (including other underground structures), asbestos, unexploded ordnance (UXO) and other sub surface utilities and structures are taken into consideration. Once this has been determined, the likely pathways between the source of contamination or other ground related aspects and the receptor have been identified.

13.37 After defining the sources, pathways and receptors, potential impacts (pre-mitigation) have been qualitatively defined.

13.38 Table 13-1 presents an example of the source-pathway-receptor interaction leading to a potential impact.

Table 13-1 Example of Source – Receptor – Pathway Interaction

Source	Receptor	Pathway	Potential Impact (Pre-mitigation)
Hydrocarbon contamination in soil materials	Demolition & Construction Site Workers	Inhalation and dermal contact with hydrocarbon impacted soils and dusts	Impact to human health
Contamination within upper strata such as Made Ground or perched groundwater	Deeper Aquifers associated with the Thanet Sands/Chalk	Vertical migration and drag down due to progression of shafts associated with the tunnelling works	Impact to controlled waters

Groundwater

13.39 The Source-Pathway-Receptor model, as illustrated in Figure 13-1, has also been used to determine the likely impacts of the construction and operation of the NLE on groundwater resources and receptors. This model identifies the potential sources or 'causes' of impact, the potential impact pathway or 'mechanism' via which the source can have an effect on the receptor and the receptors that could potentially be affected.

13.40 Once these elements of the risk model were identified, it has been necessary to determine the magnitude of the impacts and the sensitivity or value of the receptors. Criteria for this assessment has been based on the methodology given in the Department for Transport's document 'The Water Environment Sub-Objective' Transport Analysis Guidance UNIT 3.3.11 (Ref. 13-38), which brings together the 'New Approach to Transport Appraisal' document (Ref. 13-40) and the 'Guidance on the Methodology for Multi-Model Studies' document (Ref. 13-39). In addition to assigning magnitude and significance, an impact and subsequent effect can be temporary or permanent, with effects quantified as being short-term (0-5 years), medium term (6-10 years) or long term (>10 years).

13.41 After defining the sources, pathways and receptors, potential impacts (pre-mitigation) have been qualitatively defined.

13 Land Quality and Groundwater

Assessment of Baseline Conditions

13.42 The information used in the land quality assessment, for the baseline characterisation of ground conditions, has been obtained from those sources listed in section 13.30. A review of the baseline conditions has allowed for the identification of the potential sources of historic and current land contamination across the development sites.

13.43 Whilst the focus of the land quality assessment is on land contamination, other ground related aspects have been considered, including underground obstructions, the potential for UXO, underground structures and utilities, soil gas and other geotechnical considerations such as land stability.

13.44 The effects of ground settlement on buildings and infrastructure in general are considered within this chapter, however details on potential impacts to above ground heritage assets and buried archaeology are provided in *Chapter 8: Archaeology and Built Heritage* of this ES.

13.45 The groundwater information used in the groundwater assessment, for the baseline characterisation of the groundwater environment, has been obtained from those sources listed in section 13.30. A review of the NLE, including its size and nature, potential construction methodologies and timescales, has allowed for the identification of the potential impacts to groundwater, and a review of the current site environmental baseline conditions has allowed for the identification of groundwater receptors and the development of a robust hydrogeological conceptual model.

Receptor Sensitivity

13.46 Receptors potentially sensitive to changes in ground conditions and to groundwater have been identified following the assessment of the baseline conditions and the identified sources of land contamination and of potential impacts to groundwater resources.

13.47 In defining the criteria for receptor sensitivity, industry standards and good practice guidance have been taken into consideration.

13.48 The main focus for identification of potentially sensitive groundwater receptors has been as follows:

- Receptors lying within 1km of a shaft or subsurface structure;
- Receptors lying within 1km either side of the running tunnels alignment; and
- Aquifers through which the NLE would pass and any aquifer within approximately 10m of the anticipated lowest construction or groundwater control level.

13.49 The groundwater effects may extend further or less far away depending on the hydrogeological setting and the method of construction employed. Where there is the potential for an effect on, for example, an important public water supply, the search area has been increased to 2km.

13.50 The groundwater receptor sensitivity or value is based on its considered value, which takes account of EA aquifer classifications, national or local designations and of the protected rights of both licensed abstractions and private groundwater users. Table 13-2 presents the sensitivity of land quality and of groundwater receptors.

Table 13-2 Criteria for Assessing Magnitude of Sensitivity of Receptors

Sensitivity/ value	Criteria	Examples
Very high	Nationally significant attribute of high value	• Source Protection Zone 1 or 2 (SPZ1-2) with a principal aquifer • EU or nationally designated groundwater dependent wetland site (i.e. Site of Special Scientific Interest)
High	Locally significant attribute of high value or nationally significant attribute of medium value	• Principal aquifer • Licensed groundwater abstraction or private groundwater user • Locally designated groundwater dependent site • Low density development with gardens for growing vegetables for consumption and a children's play space
Moderate	Moderate quality and rarity	• Secondary aquifer important for base flow to rivers and local water supply • High density residential development without gardens, public open space
Low	Low quality and rarity	• Unproductive strata, such as London Clay • Commercial/industrial developments, areas of hard standing e.g. pavements and car parks

13.51 The effects of ground settlement on buildings is also considered, which would affect a range of receptors of various sensitivity.

Magnitude of Impact

13.52 Impact magnitude is determined by the degree of change from the baseline conditions, or the extent of risk to human health and groundwater receptors as a result of the NLE. The potential impacts have been classified as being of negligible, low, medium or high magnitude. These criteria are detailed further within Table 13-3.

13.53 With respect to ground settlement, the magnitude of potential change will vary depending on the specific ground conditions encountered, the construction methodology and the distance of the sensitive receptors from the excavation works. Therefore, for the purposes of this assessment, a range of magnitudes have been considered.

Table 13-3 Criteria for Assessing Magnitude of Impact

Magnitude of Change	Criteria	Examples of Adverse Impacts
High	Results in loss of attribute	• Change in WFD quantitative or chemical status of aquifer • Pollution of potable source of abstraction • Major pollution release[1] or create a pollutant linkage with a substantial pollutant source • Significant /serious risk to human health / life
Medium	Results in an impact that changes the integrity of an attribute or results in a loss of part of an attribute	• Reversible change in yield or quality of aquifer, affecting users but not changing WFD status • Moderate pollution release[2] or create a pollutant linkage with moderate pollutant source • Moderate risk to human health / life
Low	Results in a minor impact on an attribute	• Decrease in yield or quality of aquifer not affecting existing users or changing any WFD status • Minor pollution release[3] or create a pollutant linkage with a minor pollutant source • Temporary pathway or receptor is introduced during construction • Minor risk to human health
Negligible	Results in an impact on attribute but of insufficient magnitude to affect the use/ integrity	• Changes to an aquifer which lead to no change in the attribute's integrity • Insignificant pollution release or creation of a pathway with an insignificant pollutant source • No/reversible affect to human health • No foreseeable measurable change to the existing conditions. No appreciable / reversible effects

1. *A major pollution release corresponds to a Category 1 pollution incident, which is defined by the EA as having persistent and extensive effects on water, land and air quality, major damage to all ecosystems, closure of a potable abstraction, major effect on land, property, major impact on amenity value, major damage to agriculture and/ or commerce and serious impact upon man.*

2. *A moderate pollution release corresponds to a Category 2 pollution incident, which is defined by the EA as having a significant effect on water, land and air quality, significant damage to all ecosystems, non-routine notification of abstractors, significant effect on land, property, reduction in amenity value, significant damage to agriculture and/ or commerce and impact on man.*

3. *A minor pollution release corresponds to a Category 3 pollution incident, which is defined by the EA as having a minimal effect on water, land and air quality, minor damage to local ecosystems, marginal effect on amenity value and minimal impact to agriculture and/ or commerce.*

Significance of Effects

13.54 A level of significance has been assigned to both potential effects (pre-mitigation) and residual effects (post-mitigation). Essentially, the combination of the sensitivity of the receptor (Table 13-2) and the magnitude of the impact (Table 13-3) qualitatively determines the significance of the effect. Table 13-4 presents the matrix for defining significance of effect.

13.55 Impacts have the potential to be adverse, beneficial or negligible. For example, in terms of beneficial impacts, the NLE may remove a source of contamination or it may break a pathway that currently links a source to a receptor.

13.56 With regard to residual effects, the level of significance takes into account, not only the sensitivity of the receptor and the magnitude of the impact, but the mitigation measures applied to reduce the likelihood of significant effects on receptors. Mitigation measures do not tend to alter the receptor sensitivity, but they do alter the magnitude of impact.

Table 13-4 Criteria for Assessing Significance of Effects

Receptor Sensitivity	Magnitude of Impact			
	High	**Medium**	**Low**	**Negligible**
Very High	Major	Major	Moderate	Negligible
High	Major	Moderate	Minor	Negligible
Moderate	Moderate	Minor	Negligible	Negligible
Low	Minor	Negligible	Negligible	Negligible

Assumptions & Limitations

13.57 There is limited geological and hydrogeological information available for this assessment, within the study corridor, with which to understand the conditions likely to be encountered for areas of subsurface construction. The following limitations apply in this regard:

- Groundwater level data is limited to the readings taken as part of the CCL site investigation (see *ES Volume II: Appendix I3*). There are groundwater level records for five monitoring boreholes taken over the period of one month in 2010. Therefore the full range of groundwater levels or the likely depth at which groundwater would be encountered during construction remain unclear;
- There are no monitoring boreholes installed within the alluvium and River Terrace Deposits or 'upper aquifer'. Therefore the range of groundwater levels, the likely depth at which groundwater would be encountered during construction and flow direction in this aquifer remain unclear; and
- There are no ground permeabilities available with which to estimate the volumes of groundwater likely to be encountered during subsurface construction or to understand the magnitude of construction groundwater control potentially required.

13.58 The assessment assumes that a separation distance of approximately 10m between the anticipated lowest construction or groundwater control level and the top of the lower aquifer is sufficient to avoid the depressurisation or groundwater control of the lower aquifer.

13.59 In the absence of detailed quantitative groundwater modelling, the impacts of depressurisation and groundwater control on the lower aquifer and on nearby licensed groundwater abstractions is assessed qualitatively and is based on experience of groundwater control impacts on other London based tunnelling projects.

Summary of the NLE

13.60 The NLE connects to the existing Northern line tunnels on each side of the Kennington Loop and proceeds via an intermediate station at Nine Elms to a terminus station at BPS. Further details of the NLE are provided in *Chapter 4: Description of the NLE* of this ES.

13.61 The following sections summarise the main infrastructural elements of the NLE with relevance to land quality and groundwater resources.

Subsurface

13.62 The following subsurface design elements are proposed as part of the NLE and are of relevance to land quality and groundwater resources:

- Northbound and southbound running tunnels;
- Intermediate station at Nine Elms;
- Terminus and crossover box at the BPS site (Battersea station);
- Overrun and platform tunnels at Battersea station;
- Cross passages from the overrun tunnels, ventilation shafts and stations;
- Two ventilation shafts located just off the Kennington Loop at Kennington Green and within Kennington Park;
- Two running tunnels from ventilation shafts to step-plate junction;
- Two gallery tunnels from ventilation shafts to step-plate junction (for Construction Option B); and
- Two temporary grouting shafts at Radcot Street and Harmsworth Street (for Construction Option A).

13.63 Table 13-5 summarises these design elements, the approximate construction depths and methods of construction relevant to ground conditions and groundwater.

Above Ground

13.64 The following above ground design elements are proposed as part of the NLE and are relevant to land quality and groundwater resources:

- Head house building to replace the lodge in the northeastern corner of Kennington Park (Kennington Park Lodge) and public open space at Kennington Park;
- Head house building at the Beefeater Gin Distillery and area of public open space at Kennington Green;
- Over ground element of the intermediate station at Nine Elms (Sainsbury's car park on the Wandsworth Road); and
- Over ground element of the terminus station (Battersea station) at BPS.

Table 13-5 Subsurface Design Elements and Anticipated Geology

Indicative Scheme Chainage	Design Elements	Construction Option A - Approximate Construction Depth	Construction Option B – Approximate Construction Depth	Anticipated Geology*	Relevant Methods of Construction
-150 to 2900m	• 5.2m Internal Diameter (ID) northbound running tunnel between Battersea station and Kennington Loop	• -14 metres above Ordnance Datum (mAOD) (20m deep) at Battersea • -25.4mAOD (27m deep) at Nine Elms station • -17mAOD (22m deep) at Kennington Loop	• Same as Option A	• London Clay at Battersea and Nine Elms station (chainage -150 and 1870m) • London Clay and Lambeth Group at Kennington Loop (chainage 1870 and 2940m) • Based on site investigation boreholes BH01-BH10	• Earth Pressure Balance Machine • Sprayed Concrete Lining (SCL) • Depressurisation of Lambeth Group
-150 to 3050m	• 5.2m ID southbound running tunnel between Battersea station and Kennington Loop	• Same as above	• Same as Option A	• Same as above	• Same as above
0 to 245m	• Terminus station and crossover box at BPS	• -17.3mAOD (22.5m deep) for box structure • -55mAOD (60m deep) for diaphragm walls	• Same as Option A	• London Clay (box structure) • Lambeth Group, Thanet Sands and Chalk Formation (diaphragm walls) • Based on site investigation borehole BH01	• Box structure with diaphragm walls into ‘lower aquifer’
0 to 245m	• 6m ID overrun and 8m ID platform tunnels at Battersea station	• Constructed within box structure for Battersea station	• Same as Option A	• Same as above	• SCL
0 to 245m	• 6m ID cross passages in overrun tunnels	• Constructed within box structure for Battersea station	• Same as Option A	• Same as above	• SCL
1030 to 1200m	• Intermediate station at Nine Elms	• -23.55mAOD (28m deep) for box structure • -55mAOD (60m deep) for diaphragm walls	• Same as Option A	• London Clay (box structure) • Lambeth Group, Thanet Sands and Chalk Formation (diaphragm walls) • Based on site investigation boreholes BH02 and BH03	• Box structure with diaphragm walls into ‘lower aquifer’
2880m (shaft 1) 3000m (shaft 2)	• 5m ID temporary grouting shafts at Radcot Street (shaft 1) and Harmsworth Street (shaft 2)	• -22.5mAOD (27m deep) at Radcot and Harmsworth Street*	• Same as Option A	• London Clay and Harwich Formation • Less than 0.5m from top of Lambeth Group • Within 7m of top of Thanet Sands • Based on site investigation boreholes BH08 and BH09	• Underpinning and pre-cast concrete segments • Depressurisation of Lambeth Group • Local groundwater control within London Tertiaries (Upnor Formation and Thanet Sands)
2680m (shaft 3) 2890m (shaft	• 13.5m ID ventilation shafts at Kennington Green (shaft 3) and Kennington Park	• -22mAOD (26m deep) at Kennington Green • -22.3mAOD (25.8m deep) at	• 21mAOD at Kennington Green and to -21.5mAOD at Kennington Park (25m deep)	• London Clay and within 3-4m of top of Upnor Formation (Kennington Green) • Lambeth Group (Kennington Park)	• Underpinning and pre-cast concrete segments

Indicative Scheme Chainage	Design Elements	Construction Option A - Approximate Construction Depth	Construction Option B – Approximate Construction Depth	Anticipated Geology*	Relevant Methods of Construction
4)	(shaft 4)	Kennington Park		and within 0.7-1.5m of top of Thanet Sands • Based on site investigation boreholes BH07 and BH10	• Secant piling • Depressurisation of Lambeth Group • Local groundwater control within London Tertiaries (Upnor Formation and Thanet Sands)
2087m (northbound); 2070m (southbound)	• 4.2m ID cross passage (cross passage 1) between lowest point and Kennington ventilation shafts	• Up to -25.4mAOD (27m deep)	• Same as Option A	• London Clay and Lambeth Group • Based on site investigation boreholes BH07 and BH10	• SCL • Depressurisation of Lambeth Group
1990m (northbound); 1974m (southbound)	• 4.4m ID cross passage (cross passage 2) at lowest point with pump sump	• Up to -25.4mAOD (27m deep)	• Same as Option A	• London Clay and Lambeth Group • Based on site investigation boreholes BH02 and BH03	• SCL • Depressurisation of Lambeth Group
1679m (northbound); 1663m (southbound)	• 4.2m ID cross passage (cross passage 3) between Nine Elms and cross passage 2	• Up to -25.4mAOD (27m deep)	• Same as Option A	• London Clay and Lambeth Group • Based on site investigation boreholes BH02 and BH03	• Segmental cast-iron tunnel lining (Spheroid Graphite Iron (SGI)) • Depressurisation of Lambeth Group
600m (northbound) 583m (southbound)	• 4.2m ID cross passage (cross passage 4) between Battersea station and Nine Elms intermediate station	• Up to -23.55mAOD (28m deep)	• Same as Option A	• London Clay and Lambeth Group • Based on site investigation boreholes BH01, BH02 and BH03	• SGI • Depressurisation of Lambeth Group
2680m (shaft 3) 2890m (shaft 4)	• 5.2m ID running tunnels from Kennington shafts to step-plate junction	• Not included	• 21mAOD at Kennington Green and to -21.5mAOD at Kennington Park (25m deep)	• London Clay and within 3-4m of top of Upnor Formation (Kennington Green) • Lambeth Group (Kennington Park) and within 0.7-1.5m of top of Thanet Sands • Based on site investigation boreholes BH07 and BH10	• SCL • Secant piling • Depressurisation of Lambeth Group • Local groundwater control within London Tertiaries (Upnor Formation and Thanet Sands)
2680m (shaft 3) 2890m (shaft 4)	• 3.5m ID gallery tunnels from Kennington shafts to step-plate junction	• Not included	• 21mAOD at Kennington Green and to -21.5mAOD at Kennington Park (25m deep)	• London Clay and within 3-4m of top of Upnor Formation (Kennington Green) • Lambeth Group (Kennington Park) and within 0.7-1.5m of top of Thanet Sands • Based on site investigation boreholes BH07 and BH10	• SCL • Secant piling • Depressurisation of Lambeth Group • Local groundwater control within London Tertiaries (Upnor Formation and Thanet Sands)

** Based on the ground investigation boreholes undertaken by CCL (see ES Volume II: Appendix I3)*

13 Land Quality and Groundwater

Baseline Conditions - Groundwater

Introduction

13.65 This section of the ES summarises the information on the baseline conditions of land quality and groundwater resources that have the potential to be influenced by the NLE.

13.66 The baseline conditions for the study corridor described in the following paragraphs address the site from east (Kennington station) to west (BPS).

Geological Conditions

Published Information

13.67 According to the British Geological Survey (BGS) superficial geology mapping (BGS GeoIndex), the study corridor is underlain by alluvium and Kempton Park Gravel Formation. The Kempton Park Gravel forms part of the River Terrace Deposits, which were laid down in terraces by a broad braided river system since the Anglian glaciation (Ref. 13-44). The alluvium, where present, overlies the River Terrace Deposits and forms a nearly flat surface in the River Thames valley floor (Ref. 13-44).

13.68 The thickness of alluvium increases in the western part of the proposed NLE route, which marks the location of a palate-channel, a broad buried channel, known as the Battersea Channel (Ref. 13-44). The proposed tunnel alignment may traverse the mapped position of this channel between chainage 450 and 1250m (Ref.13-50). In addition, published geological mapping highlights the presence of a 33m deep scour filled hollow in the London Clay within the footprint of the BPS (Ref. 13-44). These scour hollows typically are infilled with sand, gravel and some clayey beds (Ref. 13-45). It is unclear whether the proposed tunnel alignment and terminus station traverse or overlie the mapped position of this hollow.

13.69 According to BGS bedrock geology mapping (BGS GeoIndex), the superficial geology of the study corridor is underlain by London Clay, Harwich Formation, Lambeth Group, Thanet Sands and Upper Chalk Formation successively. Table 13-6 details the anticipated geological succession within central London.

Site Investigation

13.70 In 2010, CCL undertook intrusive investigation works along the study corridor in order to gain information on the geology, hydrogeology and ground conditions along the proposed NLE route (see *ES Volume II: Appendix I3*). This comprised the drilling of ten (10) boreholes up to a maximum depth of 40m below ground level (bgl) along key areas of the route. In-situ testing was undertaken in the boreholes in order to build up a model of the properties of the underlying geology.

13.71 Table 13-7 describes the locations of the boreholes undertaken as part of this investigation together with the depths drilled to and ground level of each exploratory hole location. Figure 13-3 illustrates the locations of these boreholes.

Table 13-6 Anticipated Geological Succession within Central London

Period	Series	Group	Formation	London**	Central London***
Quaternary	Holocene	Superficial deposits	Made ground		
			Alluvium		
	Pleistocene		River Terrace Deposits		
Palaeogene	Eocene	Thames	Bagshot Beds	10-25	
			London Clay	90-130	
			Harwich	0-10	
	Palaeocene	Lambeth	Upper Shelly Beds	10-20 (total)	0-20
			Upper Mottled Beds		
			Upper Shelly Beds		0-3
			Laminated Beds		0-5
			Mid-Lambeth Hiatus*		
			Lower Mottled Beds		0-6
			Upnor Formation		0-12
		No group	Thanet Sands	0-30	
Cretaceous	Upper Cretaceous	White Chalk Subgroup	Undivided mainly Seaford Chalk	Up to 70	32-47
			Lewes Nodular Chalk	25-35***	34-46

** Not a formation but an important depositional feature*
*** Source: Ellison, R.A., et al. (2004); Geology of London, British Geological Survey (Ref. 13-44)*
**** Source: Royse, K.R. (2008); The London Chalk Model, British Geological Survey (Ref. 13-53)*

13.72 Table 13-8 presents the ground model for the study corridor built up from information gained from the CCL site investigation. The italicised values in brackets after the thickness of strata encountered at each borehole represent the elevation of the top of the stratum at that particular location (in mAOD).

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Table 13-7 Location of CCL's Boreholes

Borehole Number	OS Grid Reference		Ground Level (mAOD)	Drilled Depth (mAOD)	Drilled Depth (mbgl)	Location
	Easting (m)	Northing (m)				
BH01	529448.3	177496.7	+4.08	-35.08	40.00	NLE crosses deep TWUL and EDF Energy assets
BH02	529969.6	177326.4	+1.68	-38.68	40.00	Nine Elms station
BH03	530174.8	177326.6	+5.49	-33.79	38.70	Original Nine Elms Switches and Crossings Box
BH04	530703.4	177270.5	+4.49	-35.49	40.00	NLE Crosses Victoria line
BH05	530920.7	177502.0	+4.39	-31.29	35.10	Claylands Road
BH06	531238.4	177554.7	+4.54	-33.54	37.00	NLE crosses Northern line at Oval station
BH07	531187.8	178024.3	+3.25	-28.25	31.00	Kennington Green ventilation shaft
BH08	531388.7	178144.5	+3.86	-31.56	34.30	Inbound step-plate junction and grout shaft
BH09	531591.9	178135.8	+3.95	-28.45	31.50	Outbound step-plate junction and grout shaft
BH10	531522.1	177927.8	+3.64	-28.64	31.00	Kennington Park ventilation shaft

Table 13-8 Ground Model of Reference Design for the NLE Study Corridor

Borehole Number	Range of Thicknesses Encountered (m)						
	Made Ground	Alluvium	River Terrace Gravels	London Clay	Harwich Formation	Lambeth Group	Thanet Sands
BH01	2.40 *(+4.08)*	0.20 *(+1.68)*	5.70 *(+1.48)*	31.40 *(-4.22)*	0.10 *(-35.62)*	>0.20 *(-35.72)*	n/e
BH02	0.68 *(+1.66)*	2.92 *(+0.98)*	1.25 *(-1.94)*	28.65 *(-3.19)*	n/e	>6.60 *(-31.84)*	n/e
BH03	0.90 *(+5.49)*	n/e	5.40 *(+4.59)*	30.60 *(-0.81)*	0.20 *(-31.41)*	>1.60 *(-31.61)*	n/e
BH04	0.95 *(+4.49)*	n/e	4.50 *(+3.54)*	25.25 *(-0.96)*	n/e	>9.30 *(-26.21)*	n/e
BH05	2.00 *(+4.39)*	0.2 *(+2.39)*	5.70 *(+2.19)*	19.45 *(-3.51)*	n/e	>7.75 *(-22.96)*	n/e
BH06	2.35 *(+4.54)*	n/e	4.95 *(+2.19)*	16.70 *(-2.76)*	0.50 *(-19.46)*	>12.50 *(-19.96)*	n/e
BH07	2.10 *(+3.25)*	n/e	5.10 *(+1.15)*	21.00 *(-3.95)*	n/e	>2.80 *(-24.95)*	n/e
BH08	1.65 *(+3.86)*	n/e	5.55 *(+2.21)*	20.63 *(-3.34)*	0.17 *(-23.97)*	5.60 *(-24.14)*	>0.70 *(-29.74)*
BH09	1.30 *(+3.95)*	n/e	5.30 *(+2.65)*	17.95 *(-2.65)*	2.25 *(-20.60)*	>4.70 *(-22.85)*	n/e
BH10	2.10 *(3.64)*	n/e	5.25 *(+1.54)*	15.45 *(-3.71)*	0.90 *(-19.16)*	3.00 *(-20.06)*	>4.30 *(-23.06)*

Note: n/e = not encountered, > = base of stratum not proven at this location

13.73 As summarised in the table above, the made ground varies in thickness across the borehole locations, the alluvium was only encountered at three borehole locations and the London Clay increases in thickness from east to west. The site investigation did not record the Lambeth Group as separate deposits or units; therefore it is unclear which deposits or units were encountered during drilling. In addition to this, the Upper Chalk Formation was not encountered during the site investigation; however it was encountered at approximately 66mAOD beneath the BPS site during the 2002 and 2004 BH site investigations (see *ES Volume II: Appendix I5*).

13.74 The list below provides a brief description of the successive geological strata underlying the BPS site (see *ES Volume II: Appendix I5*):

- **Made Ground**: Loose to dense clayey sandy gravel with occasional cobbles to soft to firm sandy gravelly clay. Gravel and cobbles comprise flint, brick, and concrete with occasional ash, clinker, metal and timber;
- **Alluvium**: Soft grey clay with varying quantities of organic material including localised bands of fibrous peat;
- **River Terrace Gravels**: Loose to dense brown sandy gravel varying to sand and gravel or locally very gravelly sand. Gravel is predominantly flint;
- **London Clay Formation**: Stiff to very stiff grey brown becoming bluey grey fissured clay with sand and silt laminations, thin bands and nodules of calcareous material, pyrite or selenite, and fragments of wood;
- **Harwich Formation**: Sandy gravely clay;
- **Lambeth Group**: A complex accumulation of deposits including:
  - Very stiff/hard shelly clay with occasional limestone concretions (Upper Shelly Clay);
  - Very dense interbedded silts, sands and very stiff/hard clays (Laminated beds);
  - Very stiff/hard shelly clay with numerous calcareous nodules (Lower Shelly Clay);
  - Very stiff/hard mottled clays with thin bands of very dense silt (Lower Mottled Clay); and
  - Rounded gravel pebbles over very dense green fine to medium sand (Upnor Formation), the base of the Lambeth Group is often misinterpreted as Thanet Sand.
- **Thanet Sand**: Very dense greyish green silty fine sand; and
- **Upper Chalk**: Moderately weak to moderately strong medium density white chalk with flint bands.

13.75 Based on the results of the CCL site investigation, a Geological Profile of the NLE route design has been developed by Halcrow. The profile suggests that the tunnels and subsurface structures of the NLE, for the most part, would extend through the River Terrace Deposits and into the London Clay (see Figure 13-4). However, around the Kennington Loop, the tunnels and structures would extend into the top of the Lambeth Group.

13.76 The site investigation results also suggest that the tunnels and subsurface structures would not extend into the Upnor Formation at the base of the Lambeth Group, which forms part of the lower aquifer. However the results suggest that the Kennington shafts, and associated running and gallery tunnels, and the temporary grouting shafts would extend to within less than 1m and 7m of the top of the Thanet Sands respectively (see Table 13-5).

Hydrogeological Conditions

13.77 Groundwater strikes and levels were recorded in standpipes installed during the CCL site investigation to enable the long term monitoring of groundwater levels. It should be noted that groundwater strikes are the levels at which groundwater was encountered or recorded during drilling and may not reflect the 'rest' water level. The rest water level is the natural groundwater level in a borehole when not influenced by abstraction or by artificial recharge. Rest water levels are never truly static as they continually respond to recharge, discharge and abstraction. The range of groundwater strikes recorded during drilling are summarised in Table 13-9 below.

Table 13-9 Summary of Groundwater Strikes

Horizon	Range of Recorded Groundwater strikes
Made ground/ alluvium	Not encountered
River Terrace Deposits	-0.42 to -3.16mAOD (3.6 to 6.8mbgl)
London Clay	-19.42 to -24.19mAOD (18.6 to 28.05mbgl)
Harwich Formation	-19.46 to -19.76mAOD (23.1 to 24.3mbgl)
Lambeth Group	-23.21 to -37.44mAOD (27.6 to 39.1mbgl)

13.78 Five standpipes were installed during this site investigation, two solely within the Lambeth Group, two at the base of the London Clay and extending into the Lambeth Group, and one in the Lambeth Group and extending into the Thanet Sands. The site investigation did not record the Lambeth Group as separate deposits or units; therefore it is unclear into which deposits or units the standpipes were installed. Groundwater levels were monitored between 28th April and 28th June 2010, the results of which are provided below in Table 13-10.

Table 13-10 Summary of Standpipes and Monitored Groundwater Levels

Borehole ID	Range of Monitored Groundwater Levels	Monitored Horizon	Top of Monitored Horizon	Top of Screened Interval
BH05	-16.12 to -14.58mAOD (18.97 to 20.51mbGL)	Lambeth Group	-22.96mAOD (27.35mbGL)	28.61mAOD (33mbGL)
BH06	-8.92 to -8.38mAOD (12.92 to 13.46mbGL)	Harwich Formation and Lambeth Group	-19.46mAOD (24mbGL)	-19.46mAOD (24mbGL)
BH07	-7.45 to -5.83mAOD (9.08 to 10.7mbGL)	London Clay and Lambeth Group	-3.95mAOD (7.2mbGL)	-23.75mAOD (27mbGL)
BH09	-7.60 to -6.39mAOD (10.34 to	London Clay and Harwich Formation	-2.65mAOD (6.6mbGL)	-18.05mAOD (22mbGL)

Borehole ID	Range of Monitored Groundwater Levels	Monitored Horizon	Top of Monitored Horizon	Top of Screened Interval
	11.55mbGL)			
BH10	-7.69 to -6.43mAOD (10.07 to 11.33mbGL)	Harwich Formation, Lambeth Group and Thanet Sands	-19.16mAOD (22.8mbGL)	-19.26mAOD (23mbGL)

13.79 The following section summarises the main points with regard to the groundwater level monitoring undertaken:

- The monitored groundwater levels in BH05, BH06 and BH10 are above the top of the monitored horizon, suggesting that the groundwater bodies encountered in the Harwich Formation, the Lambeth Group and the Thanet Sands are under hydraulic pressure at the locations;
- The monitored groundwater levels in BH07 and BH09 remain below the top of the monitored horizon, suggesting that the groundwater bodies encountered in the London Clay, Lambeth Group and Harwich Formation are not completely saturated at these locations;
- In addition, the monitored groundwater levels in BH07, BH09 and BH10 are very similar and may be influenced by hydraulic pressures within the underlying Thanet Sands;
- The monitored groundwater levels for the London Clay, Lambeth Group and Thanet Sands suggest that the groundwater direction across the study area is to the west. This flow direction is likely to be influenced by an abstraction at a large groundwater source in the Nine Elms area, the Battersea Pumping Station, for which inner and outer SPZ's are delineated; and
- There were no standpipes installed within the River Terrace deposits and therefore it is not possible to provide an accurate direction of groundwater flow in this aquifer. However given the study corridor's proximity to the River Thames and the fact that there is likely to be hydraulic continuity between the river and this 'upper aquifer', it is anticipated that groundwater flow is towards the River Thames to the north and north east. Notwithstanding, due to the highly developed nature of the area and the likelihood of significant underground obstructions such as basements, this may not be the case.

13.80 Groundwater strikes and levels were recorded at the BPS site during the BH site investigations in 2001 and 2002 (see *ES Volume II: Appendix I5*). The following section summarises the main points with regard to the groundwater level monitoring undertaken:

- Groundwater levels were recorded in the River Terrace Deposits at between 0.5 and 1mAOD or 3.5mbGL and showed a tidal response at up to 200m distance from the River Thames;
- Groundwater inflows in the London Clay were recorded as minor seepages within slightly sandy horizons or around claystone bands. The London Clay is known to contain small discontinuous groundwater bodies within isolated sandy layers of the London Clay; and
- Groundwater inflows in the Lambeth Group were recorded in several perched groundwater bodies within the more permeable or sandy horizons of the group.

13.81 Groundwater levels are monitored across London by the EA as part of a strategy to control groundwater levels and manage the London Basin Chalk aquifer. Monitored groundwater levels for January 2010 show water levels at between approximately -18 and -22mAOD along the proposed NLE route (Ref. 13-52). This is the most up to date publicly available information. According to the ground model for the NLE study corridor (see Table 13-8), these water levels are at a similar elevation to the top of the Harwich Formation and Lambeth Group.

Aquifer Classification

13.82 According to EA aquifer classification mapping (Ref. 13-43), the alluvium underlying the central section of the study corridor is designated as a secondary undifferentiated aquifer, while the River Terrace Deposits to the north and south of the study corridor are designated as a secondary A aquifer. The EA defines a secondary undifferentiated aquifer as "*having been assigned in cases where it has not been possible to attribute either category A or B to a rock type. In most cases, this means that the layer in question has previously been designated as both minor and non-aquifer in different locations due to the variable characteristics of the rock type*". Secondary A aquifers are defined as "*permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important source of base flow to rivers. These are generally aquifers formerly classified as minor aquifers*".

13.83 The underlying London Clay is designated by the EA as unproductive strata, which are defined as *"rock layers or drift deposits with low permeability that have negligible significance for water supply or river base flow".* Unproductive strata are considered to have low vulnerability to pollutants, due to limited permeability.

13.84 The lower unit of the Lambeth Group, known as the Upnor Formation, and the underlying Thanet Sands are known collectively as the 'London Tertiaries' and are both designated by the EA as secondary A aquifers.

13.85 The Upper Chalk Formation, which is at depth beneath the London Tertiaries, is classified as a principal aquifer. These are defined as *"layers of rock or drift deposits that have inter-granular and/or fracture permeability and can often provide a high level of water storage. They may support water supply and/or river base flow in a strategic scale".* Due to their high permeability, principal aquifers are considered to be highly vulnerable to pollutants.

Groundwater WFD Status

13.86 The Thames River Basin Management Plan (Ref. 13-46) shows that the Lambeth Group (Upnor Formation only), Thanet Sands and Upper Chalk Formation underlying the study area and outcropping further to the east are designated as the Greenwich Chalk and Tertiaries groundwater body. This groundwater body also includes the alluvium and River Terrace Deposits where in hydraulic continuity with the lower aquifer.

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13.87 The current WFD groundwater quantitative status is classified as poor, due to failures for impacts on surface waters and for saline intrusions. The current WFD chemical status is classified as poor, due to failures for saline intrusions and drinking water protected status. The predicted quantitative and chemical status for 2015 is poor due to treatment or improvement being disproportionately expensive or technically infeasible.

13.88 The alluvium and River Terrace Deposits are not part of a designated groundwater body within the study corridor and therefore no baseline assessment for chemical or quantitative status is available for this aquifer.

Groundwater Quality

13.89 No groundwater sampling or analysis was undertaken during the CCL site investigation; however some groundwater sampling was undertaken from the River Terrace Deposits at the BPS site during the BH 2001 and 2002 site investigations. The results showed exceedances of the screening thresholds for arsenic, mercury, nickel, copper, zinc, benzo(a)pyrene and Polycyclic Aromatic Hydrocarbons (PAHs) (UK4) within this aquifer.

13.90 In addition, the area around the proposed Nine Elms station in particular has historically been used for industrial purposes and is likely to be contaminated.

13.91 While there is little published information on groundwater quality available to this study, the WFD chemical status indicates that the Upnor Formation, Thanet Sands and Upper Chalk Formation are subject to the effects of saline intrusion. This is most likely where these aquifers outcrop and where large groundwater sources are located; this area is outside of the study corridor.

Groundwater Flood Risk

13.92 There are no reported incidences of groundwater flooding within the part of the study area in the LBL (Ref. 13-47). However there have been instances of groundwater flooding in close surrounding areas, such as Vauxhall and South Lambeth.

13.93 There are several reported incidences of groundwater flooding within the part of the study area in the LBW (Ref. 13-48). These tend to be concentrated in the eastern half of the Borough at Battersea and tend not to be underlain on London Clay or alluvium, but rather the River Terrace Deposits. However groundwater flooding is most likely to occur where an interface between the Chalk and the River Terrace deposits allows groundwater to rise up through these permeable strata to the surface. According to the site investigation results, this does not occur across the study area.

Interaction with Surface Water

13.94 Groundwater level monitoring undertaken during the BH 2001 and 2002 site investigations showed a tidal response in the River Terrace Deposits at a distance of up to 200m from the River Thames. Therefore the River Terrace Deposits are considered to be in hydraulic continuity with the River Thames, with anticipated groundwater flow in this aquifer moving towards the river.

Groundwater Dependent Terrestrial Ecosystems

13.95 According to Natural England mapping, there are no designated groundwater dependent terrestrial ecosystems located within 1km of the study area (Ref. 13-49).

Licensed Groundwater Abstractions & Discharge Consents

13.96 There are numerous groundwater abstraction licences identified in the Envirocheck report within the study area, i.e. 1km from the subsurface structures and tunnel alignment. Several are licences for drinking water supplies, the closest and most important is Battersea Pumping Station located within 50m northwest of the proposed Battersea station (see *ES Volume II: Appendix I1*) This abstraction is operated by TWUL and was constructed to manage the rising groundwater levels in the deep chalk aquifer.

13.97 Table 13-11 summarises the details of these licensed abstractions provided by the Envirocheck report. All of the licensed sources abstract groundwater from the Chalk aquifer, with the exception of the licence at the Royal Horticultural Society which abstracts groundwater from the River Terrace Deposits aquifer.

Table 13-11 Summary of Licensed Abstractions within Study Corridor

Licence No.	Licence Holder	Purpose	Distance from route (m)
28/39/42/0072	TWUL	Drinking Water Supply	50
28/39/42/0061	TWUL	Drinking Water Supply	50
28/39/42/0033	Allied Distillers	Evaporative Cooling	110
28/39/42/0074	Halcyon Estates Limited	Drinking, Cooking, Sanitary, Washing & Small Garden	340
28/39/42/0066	Parkview International London Plc	Drinking, Cooking, Sanitary, Washing & Small Garden	340
28/39/39/0141	Mantilla Limited	Drinking, Cooking, Sanitary, Washing & Small Garden	450
28/39/42/0070	Tarmac Limited	General use relating to Secondary Category (High Loss)	600
28/39/42/0057	Tarmac Limited	Dust Suppression	600
28/39/39/0139	Panoramic Management Co Ltd	Non-Evaporative Cooling	810
28/39/42/0060	LBW	Ornamental Pond Transfer	850
28/39/42/0052	LBW	Make up or Top up Water	850
28/39/39/0225	Royal Horticultural Society	Horticultural Watering	900

13.98 The Envirocheck report indicates that there is one licensed discharge consent to groundwater located along the study corridor. This is located at Montford Place, approximately 130m west of the proposed Kennington Green ventilation shaft, and is for the discharge of cooling water from trade discharges to land. The receiving water is described as a 'sand strata'.

Groundwater Source Protection Zones

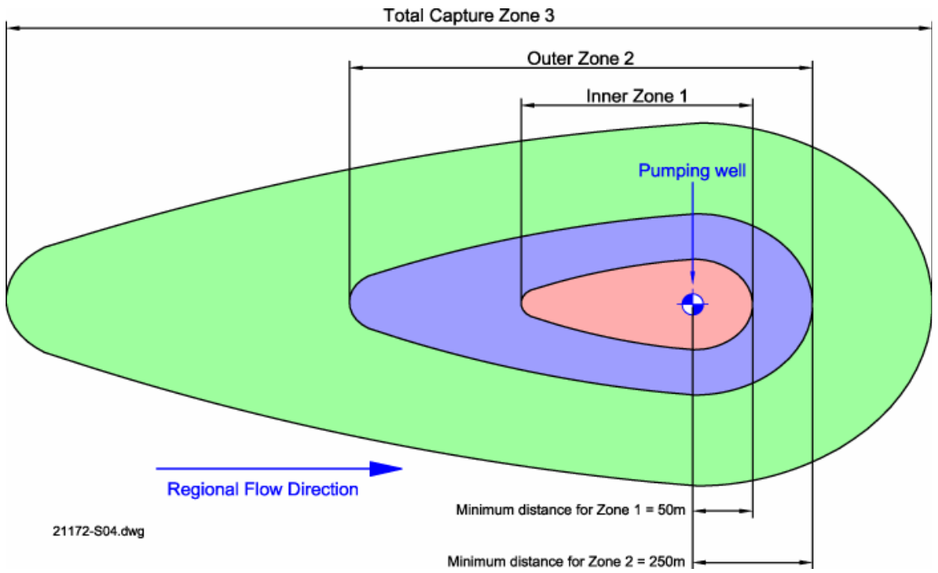
13.99 According to EA SPZ mapping (What's in my backyard) (Ref. 13-43), the proposed NLE route between chainage -150 and 800m approximately lies within an inner (Zone 1) SPZ. This SPZ1 is designated to protect the TWUL source at the Battersea Pumping Station, which abstracts from the underlying principal aquifer. The proposed Battersea (terminus) station and Nine Elms station also lie within this SPZ1. An inner SPZ is defined as the 50 day travel time from any point below the water table to the source or as a minimum distance of 50m.

13.100 The proposed route between 800 and 2350m approximately lies within the corresponding outer (Zone 2) SPZ. An outer SPZ is defined by a 400 day travel time from a point below the water table or as a minimum distance of 250m.

13.101 The temporary shafts at Radcot Street and Harmsworth Street, Kennington ventilation shafts, associated cross passages, running tunnels and gallery tunnels are located outside of these SPZ's.

13.102 A schematic representation of inner and outer SPZ's is provided in Figure 13-5.

Figure 13-5 Schematic Representation of Inner, Outer and Source Catchment Protection Zones (Ref. 13-50)



Groundwater Vulnerability

13.103 A review of the published groundwater vulnerability map for the study corridor, detailed in the Envirocheck report, suggests that soils overlying the London Clay have been assigned soil leaching potential class 'HU'. This indicates they have been assigned a high leaching potential as a worst case scenario due to the limited amount of data available within any urban area. Soils of a high leaching potential are considered to have little ability to attenuate 'diffuse source' pollutants and to allow liquid discharges to move rapidly to underlying strata and to shallow groundwater.

Hydrogeological Conceptual Model

13.104 The Chalk is the main aquifer of the London Basin and is confined over much of the area by the Palaeogene formations (the London Clay, Lambeth Group and Thanet Sands) and by the Quaternary superficial deposits (alluvium and River Terrace Deposits).

13.105 The superficial deposits (alluvium and River Terrace Deposits) are classified as secondary aquifers and are referred to as the 'upper aquifer'. This aquifer is likely to be hydraulic continuity with the River Thames, which at the closest point lies approximately 150m north of the running tunnels at Nine Elms. Therefore groundwater flow in this upper aquifer is likely to be shallow and towards the River Thames.

13.106 The upper aquifer is generally hydraulically separated from the Lambeth Group, Thanet Sands and Chalk Formation by the London Clay. This horizon is considered to act as an aquiclude or a barrier to groundwater flow due to its impermeability. Any groundwater present is likely to consist of localised seepages and/ or minor inflows.

13.107 The Harwich Formation was only identified at six of the drilled borehole locations and is considered to form an aquifer unit of limited extent where it is isolated from the lower aquifer by the Lambeth Group.

13.108 The Lambeth Group generally contains several groundwater bodies within the more permeable horizons, which are under hydraulic pressure but are limited in extent. Groundwater is likely to be encountered within the Upper Shelly Beds and Upper Mottled Beds and under high pressure within the Laminated Beds. It is unclear from the available site investigation work if these water-bearing units are likely to be encountered during construction for the NLE.

13.109 The Upnor Formation and the Thanet Sands are known collectively as the 'London Tertiaries'. These are generally in hydraulic continuity with the underlying Chalk Formation and together are referred to as the 'lower aquifer'. The lower aquifer is classified as a principal aquifer on the basis of the high yielding Chalk. While the Thanet Sands can contribute significantly to the storage properties of the lower aquifer, it is of low permeability relative to the Chalk Formation and therefore is unlikely to contribute significantly to flows.

Groundwater Receptors

13.110 The groundwater receptors that could potentially be affected by the NLE are the upper and lower aquifers, nearby licensed groundwater abstractions and the River Thames. Table 13-12 summarises the sensitivity or value of these identified groundwater receptors.

13.111 While the lower aquifer is not anticipated to be penetrated by the NLE, groundwater levels, flows and quality in this aquifer may be impacted by depressurisation in the overlying Lambeth Group. All of the identified licensed groundwater sources abstract from the underlying lower aquifer, with the exception of the Royal Horticultural Society (see Table 13-11), and yields and groundwater quality may also be affected by depressurisation in the overlying Lambeth Group.

13.112 The River Thames is a surface water receptor, but is likely to be in hydraulic continuity with the upper aquifer. Therefore, potential impacts of the NLE on this receptor by way of groundwater pathways are considered here. The receptor sensitivity of the River Thames is considered to be high – see *Chapter 12: Surface Water Resources and Flood Risk* of this ES.

Table 13-12 Groundwater Receptors

Receptor	Criteria	Sensitivity/ value
Upper aquifer – Alluvium & River Terrace Deposits	Secondary A aquifer	Medium
London Tertiaries (Upnor Formation and Thanet Sands)	Secondary A aquifers	Medium
Chalk Formation	Principal aquifer	High
Licensed groundwater abstractions	Protected rights	High
River Thames	WFD classified	High

Baseline Conditions – Land Quality

Contamination Potential

13.113 The potential for on-site soil and groundwater contamination (a source of potential impact) has been based on a review of the land-use history at the temporary grouting and ventilation shaft construction sites, the proposed new stations associated with the NLE and the general area through which the running tunnels are to be constructed.

13.114 For ease of reference, the contamination potential for each proposed shaft construction site and new station sites are described from east to west. The main historic and current contaminating land uses in the general vicinity of the running tunnels is also described from east to west.

13.115 The historic maps reviewed are included within the Envirocheck report.

Historic On-site Uses

Radcot Street and Harmsworth Temporary Grouting Shafts

13.116 The areas around both of these proposed temporary grouting shaft locations appear to be predominantly residential in nature from the earliest available map editions (1875) until the present day. The mapping does not indicate any significant changes in development footprints.

Kennington Green and Kennington Park Ventilation Shafts

13.117 There appears to be very little change in the land uses of these two ventilation shaft sites from earliest available mapping until the present day. Both sites appear to be in use as open space.

Nine Elms Station

13.118 The area appears to be developed to an industrial land use from earliest available mapping. Mapping from 1875 indicates that there is a Timber Yard, Stores and Vauxhall Works. The nature of Vauxhall Works is not evident from this map edition.

13.119 1916 mapping shows that the site has undergone some redevelopment, the Timber Yard, Stores and Vauxhall Works are no longer annotated but a small blacksmiths is in evidence to the north of Pascal Street.

13.120 The next available map edition is from 1951 which identifies the site as having undergone significant industrial/commercial development in the intervening years with a Saw Mills, Button Factory and Wandsworth Stonemasonry Works in evidence. There are a number of gantries, capstans and cranes identified within this complex of land uses.

13.121 The 1960s and 1970s mapping identifies the area to be occupied by various buildings identified as 'works' and 'depots'. The nature of these is not annotated.

13.122 The 1980s and 1990s mapping indicates that the site is part of a Sainsbury's car park.

Battersea Station and Battersea Crossover

13.123 This area appears to be in use as part of the wider Southwark and Vauxhall Water Works in the earliest available map editions (1875-1896).

13.124 Mapping from 1916 identifies the site to be in use as Great Western Railways (GWR) goods depot with a number of railway tracks present running across the site. The next available mapping (1951) indicates that the site is in use as the South Lambeth Goods Depot with a number of railway tracks and travelling cranes associated with this.

13.125 No significant change in land use is identified until the 1984 map edition which identifies the South Lambeth Goods Depot (now called the Nine Elms (South Lambeth) Freight Depot) is disused. Mapping from 1989 indicates that the site appears to have been cleared with no change in land use evident in subsequent map editions.

Historic Off-site Uses

13.126 Much of the study corridor runs through areas that have been subject to significant industrial past land uses. In particular, the Nine Elms area has seen a number of particularly potentially contaminating land uses. In order to provide a clear and succinct picture of historical land uses in the immediate vicinity of the proposed NLE route, the study corridor has been split up into the following areas from east to west and the potentially most contaminating historic land uses have been summarised:

- Kennington Park to The Oval;
- Clapham Road to South Lambeth Road;
- South Lambeth Road to Wandsworth Road; and

- Wandsworth Road to Queenstown Road.

13.127 Potentially contaminating land uses within approximately 250m of the study corridor have been described, as these have the largest potential to affect the NLE.

Kennington Park to the Oval

13.128 Earliest available mapping (1875) indicates that this area appears to be developed predominantly to a residential end use. In this map edition a large chemical works is in evidence immediately to the east of Kennington Park, however by 1896, this appears to have been redeveloped to a residential end use with 1916 mapping identifying a laundry at the centre of this site.

13.129 1896 mapping indicates that a large timber yard is in evidence to the south of Camberwell Road and to the north of Cranmer Road. By the 1950s this appears to have been developed to a light industrial/commercial end use with land uses including a cardboard box works, an electrical engineering works, a printing works, a motor cab works and a garage. By the late 1990s this area appears to have been developed to a more modern light industrial/commercial land use, however, the nature of the businesses operating within its footprint are not identified in the available mapping.

13.130 The area immediately to the south east of Kennington Park appears to be predominantly residential in nature from 1875 to the 1950s. The next available map edition (1962) indicates that this area appears to be undergoing building clearance for the expansion of the park, which is in evidence in mapping from 1969 onwards.

Clapham Road to South Lambeth Road

13.131 This section describes the general development history of the roughly triangular parcel of land that the NLE route runs through that is bounded to the east and south by Clapham Road, to the south and west by South Lambeth Road and to the north by Harleyford Road and Kennington Oval.

13.132 Earliest available mapping identifies a gasworks (Kennington Lane Gasworks) immediately to the north of Surrey Cricket Ground (The Oval). This land use remains relatively unchanged in the intervening years, with most recent mapping noting it to be a gasholder station.

13.133 The area to the south of The Oval appears to have been predominantly developed to a residential end use from earliest available mapping right up to the present day. Land uses within this particular area have included the Phoenix Brewery (1877 only), blacksmiths (1916 only) and engineering works (1950s to 1970s).

13.134 Further east towards South Lambeth Road, a Vinegar and British Wine Manufactory is in evidence in the map edition from 1875. Mapping from 1896 identifies this site to also be occupied by a timber yard and a mineral water manufactory. By the 1950s, the timber yard appears to have been redeveloped as a joinery works. Mapping from the 1970s indicates that the site has undergone some redevelopment and land uses annotated include a factory, a garage and a 'works', the nature of which is not identified. By the 1980s this area appears to have been cleared and mapping from the 1990s indicates that it's been redeveloped and rebuilt and annotated as Regents Bridge Gardens.

South Lambeth Road to Wandsworth Road

13.135 Mapping from 1896 indicates that the area between these two roads and within the immediate vicinity of the study corridor includes window blind works, timber yards, breweries, blacksmiths and laundries as well as railways associated with GWR running south west from Waterloo to the north and through the Nine Elms area. The potential exists to encounter underground structures associated with the historic breweries in the area.

13.136 Further light industrial development appears to have been undertaken in the 1916 map edition with an 'Essence of Beef Manufactory' being in evidence immediately to the south of the railway in this area and a mineral water manufactory to the north.

13.137 The next available map edition (1951) indicates that the 'Essence of Beef Manufactory' is now annotated as the Mayfair Works (food) and that the 'Lotus Works' are located to the north of the railway and to the south of Miles Street. Further north on the western side of the railway an engineering works and a clothing factory are in evidence in this map edition. Residential development that was in evidence in previous map editions to the south of the railway and Wyvill Road appears to have been cleared in the 1951 mapping with redevelopment identified in subsequent mapping as high density residential.

13.138 The 1960s maps show that the site of the Mayfair Works and the general area to the north of Wyvill Road appears to have been redeveloped and is annotated as a 'works', the nature of which is not identified. This area then appears to have been cleared in the early 1970s with further redevelopment being noted in the 1976 map edition, which identifies the site as Keybridge House and depots. No further significant changes are evident in subsequent map editions.

13.139 The area to the north of the railway appears to have undergone very little re-development or change in land use until the 1980s. By the mid-1980s it appears that the factories and depots have been cleared and a more modern commercial/light industrial development has been constructed in their place. The nature of this development is not annotated in subsequent available map editions reviewed.

Wandsworth Road to Queenstown Road

13.140 This area of the study corridor has seen the most potentially contaminating land use history. The parcel of land between these two roads includes the wider Nine Elms area and the BPS site.

13.141 Earliest available mapping identifies that the area to the west of Wandsworth Road has already undergone significant industrial development. Historic land uses from east to west toward Queenstown Road include:

- A large concentration of railways/railway sidings associated with a large goods shed;
- Running sheds and tanks associated with railway land use;
- London Gas Works;
- Various wharves from east to west fronting the River Thames;
- Breweries;
- Field gasholder station;

- Southwark and Vauxhall Waterworks; and
- Railway land and associated engine sheds.

13.142 This general area appears to remain heavily industrialised, and in 1916 the area to the north of Battersea Park Road includes a two large engineering works, a jam factory and a paint and colour works. Subsequent mapping through the 1950s to 1980s identifies this general area to be occupied by works, cement works, a refuse transfer station, depots, warehouses and offices.

13.143 The large goods shed is identified in 1916 as the Nine Elms North Goods Depot. This area remains relatively unchanged until the mid-1970s when it has been redeveloped as part of the New Covent Market.

13.144 The London Gas Works site appears to remain in operation until the mid-1970s with later map editions annotating it as the Nine Elms Gas Works. This site then underwent redevelopment and is currently a Royal Mail sorting and delivery depot.

13.145 By the 1950s the site that was annotated as the Southwark and Vauxhall Waterworks in previous map editions is now occupied by the BPS site.

13.146 To the south of this, the field gas holder station identified in the bulleted list above is identified as the Battersea Gas Holder Station in subsequent mapping, with little change in site configuration in the intervening years to the present day.

Underground Structures

13.147 Given the development history of the area surrounding the proposed NLE route, there is likely to be a number of underground structures associated with previous and current developments. These may include basements and foundations associated with previous and current developments. It is assumed that an underground oil storage tank is present at Nine Elms which supplies the existing incinerator.

13.148 Liaison with third parties has indicated that the proposed railway alignment crosses over and under the following key infrastructure which are described in more detail below:

- TWUL London Main Ring and trunk sewers;
- UK Power Network (UKPN) Cable Tunnel;
- Network Rail at-grade tracks at Battersea and elevated viaduct at Nine Elms; and
- The Victoria line.

Thames Water Utilities Limited

13.149 There are four TWUL sewers and the London Ring Main (LRM) located just north of the proposed crossover box structure at Battersea station. These are all predicted to fall within 1km of the NLE works (stations and running tunnel construction). Table 13-12 summarises the deep level TWUL assets that have been identified as those which, prior to mitigation that will be implemented during construction, could experience some degree of impact from the proposed NLE civil engineering works.

UK Power Network

13.150 The running tunnels associated with the NLE will pass above a UKPN cable tunnel and on each side of an UKPN shaft just outside the proposed Battersea station at the end of Cringle Street

Network Rail

13.151 The running tunnels will affect two sections of Network Rail infrastructure. The overrun tunnels at Battersea station will pass beneath the lines out of Victoria station immediately to the west of the site. The running tunnels will also pass under the Network Rail viaduct carrying the lines into Waterloo station close to the new mid station.

London Underground

13.152 The proposed NLE running tunnels are designed to run beneath the level of the current north and southbound Victoria line tunnels which lie to the east of the proposed Nine Elms station.

Other Utilities

13.153 It is anticipated that other less significant utility infrastructure may be adversely affected by the tunnelling works. For example shallow water mains, gas mains and sewers may be susceptible to minor ground movements thus requiring diversions and enabling works utility diversions will be required at the shaft and station sites.

Unexploded Ordnance

13.154 Another source of potential impact is from UXO. The London County Council Bomb Damage Maps (See *ES Volume II: Appendix I4*) indicates that the study corridor has been subject to varying degrees of bomb damage during the Second World War, which implies there may still be UXO as bombs were dropped in this area.

13.155 The general area around the proposed Harmsworth Street grouting shaft ranges from minor blast damage in nature to total destruction on the north western border of Kennington Park. The area around Radcot Street grouting shaft is also recorded to have suffered damage ranging from minor blast damage to total destruction. A V1 flying bomb is reported to have hit the area just to the north west of the junction of Kennington Road and Kennington Park Road, approximately 100 m south west of the proposed Kennington Green ventilation shaft site.

Table 13-12 Thames Water Assets Potentially Impacted by the NLE

Asset	Invert Level (mAOD)/ID (m)	Structural Lining Type	Date Built	Above or Below Thames Water Asset?	Clearance (m)*	Thames Water Asset Geology
South Western Storm Relief	-10.0/3.45	11'-7" Cast iron ring lined down to 11'-4"	1923	Below	2.0	London Clay

Asset	Invert Level (mAOD)/ID (m)	Structural Lining Type	Date Built	Above or Below Thames Water Asset?	Clearance (m)*	Thames Water Asset Geology
Sewer		with mass concrete				
Heathwall Sewer (new line)	-5.53/1.90	Cast iron ring concrete lined with a brick invert	1960	Below	5.6	River Terrace Gravels/London Clay
Low Level No. 1	-2.10/1.60	Masonry	1863	Below	9.5	River Terrace Gravels
Heathwall Sewer (old line)	-2.21/1.21	Cast iron (believed lined with concrete masonry invert)***	1865	Below	11.0	River Terrace Gravels
LRM**	-25.70/2.54	Wedge-block	1990	Above	7.7****	London Clay

Source – Halcrow
Notes:
** = extrados to extrados (average value)*
*** = TWUL LRM*
**** = Original masonry section under post office sorting office re-built in cast iron*
***** = clearance to NLE tunnel*

13.156 The general area around the proposed Harmsworth Street grouting shaft ranges from minor blast damage in nature to total destruction on the north western border of Kennington Park. The area around Radcot Street grouting shaft is also recorded to have suffered damage ranging from minor blast damage to total destruction. A V1 flying bomb is reported to have hit the area just to the north west of the junction of Kennington Road and Kennington Park Road, approximately 100 m south west of the proposed Kennington Green ventilation shaft site.

13.157 The general area to the south east of the Oval itself appeared to have suffered varying degrees of damage, including damage beyond repair. A V1 flying bomb is recorded as having hit the south east side of the Oval building itself.

13.158 The general area between Clapham Road and South Lambeth road, which is predominantly residential in nature, is recorded as having undergone damage ranging from minor blast damage to damage beyond repair. Two V1 flying bomb hits are noted within this general area, one to the west of Carrou Road and to the south of Fentiman Road and the other to the east of Carrou Road and to the north of Richborne Terrace.

13.159 Like the area described immediately above, the area of the proposed NLE route that passes between South Lambeth and Wandsworth Roads is reported as having undergone bomb damage to varying degrees. A V1 flying bomb hit is recorded as having occurred on the junction of Davidson Gardens and Wandsworth Road with the buildings in this area suffering damage beyond repair.

13.160 The site of the proposed Nine Elms station also appears to have undergone bombing with damage being recorded as being beyond repair. The former Nine Elms Gasworks site is recorded as having suffered two direct hits by V1 flying bombs with one of the gasholders suffering total destruction.

13.161 The site of the proposed Battersea station is recorded as having suffered minor blast damage.

Summary of Land Quality Baseline Conditions

13.162 The historical land uses of the NLE, including any existing Made Ground, all present potential contamination sources. A summary of the anticipated contamination status associated with the new stations, shaft sites and running tunnels is described from east to west below.

Radcot Street and Harmsworth Grouting Shafts /Kennington Green and Kennington Park Ventilation Shafts

13.163 A review of historical mapping indicates that the areas around the two temporary grouting shaft sites have comprised residential land-use since at least 1875. Land-use at both ventilation shaft sites has comprised open space from at least the late 1800s to present day.

13.164 Potential historical contaminative activities in the surrounding area (approximately 200m to 500m away from all the shaft sites) have included a large chemical works, various works and a garage.

13.165 In view of the non-contaminative activities onsite and the distance of off-site contaminative industries, there is considered to be a low potential for contamination of soils.

Nine Elms Station

13.166 The area of Nine Elms has been occupied by industrial activities since earliest mapping data. Onsite activities have included timber yards, various works, factories and depots. Surrounding land use has historically been heavily industrialised particularly in relation to the former Nine Elms Goods Depot (a large railway depot) and the high concentration of railway lines associated with it. Other contaminative industries in the vicinity have included garages, numerous works, factories, depots and breweries. Taking this into consideration a moderate to high potential for contamination exists in this area.

Battersea Station and Battersea Crossover

13.167 Historical contaminative activities on-site have included a railway goods depot, railway lines and a freight depot. The surrounding area has a history of industrial use, the most pertinent contaminative industries comprising the former BPS, a paint and colour works, engineering works, tanks, wharves, depots and railway

lines. In view of the industrial activities onsite and in the vicinity of the site, a moderate to high potential for contamination exists.

Potential Impacts

Summary of Contamination Sources

13.168 Sources of potential contamination have been identified from historic maps, Envirocheck data and a site investigation by CCL (which did not include any contamination testing) (see *ES Volume II: Appendix I3*).

13.169 It is considered that the running tunnels, overrun tunnels, cross passages and step plate junctions are sufficiently deep that the likelihood of encountering contamination is very low. The temporary and permanent ventilation shafts are located in areas where soil contamination would not be expected.

13.170 The potential to encounter contaminated soils exists whilst conducting subsurface construction works at the proposed Battersea station and Nine Elms station sites based on the historical industrial land use. If present, contamination would be expected at shallow depths within Made Ground and potentially Alluvial deposits. The construction of the new stations will involve excavating through superficial deposits and into the London Clay, therefore construction workers may be exposed to impacted soils and shallow groundwater.

13.171 Demolition works comprise the removal of the lodge in the northeastern corner of Kennington Park (Kennington Park Lodge) and the boundary wall of the Beefeater Gin Distillery at Kennington Green. Since demolition works will take place above ground and in areas where contamination is not expected, risk to demolition workers is considered to be low, however the demolition activities themselves may impact on the environment.

13.172 From the baseline data, potential contamination sources and associated chemicals of concern comprised the following:

Onsite (Nine Elms Station and Battersea Station)

- Made ground imported to the site as part of its historic development – PAHs, Total Petroleum Hydrocarbons (TPH),metals, ground-gas and asbestos;
- Former works, factories and depots - PAHs, TPH and metals; and
- Former railway lines - TPH, PAHs and metals.

Offsite (Nine Elms station and Battersea station)

- Ash, clinker and metal identified during the CCL site investigation in the Made Ground underlying the BPS site – PAHs and metals;
- Former above ground tanks – PAHs, TPH and metals;
- Former BPS – solvents, TPH, PAHs, asbestos and metals;
- Historic and current railway lines– TPH, PAHs and metals;
- Wharf activities - PAHs, TPH, metals, solvents and asbestos;
- Various works and depots - PAHs, TPH and metals;
- Breweries - PAHs, TPH, metals and sulphur compounds; and
- Garages - PAHs, TPH and metals.

13.173 Potential off-site derived contamination sources are unlikely to significantly impact on the sites as the proposed development areas of the sites are assumed to be predominantly covered in hardstanding. Consequently, migration on-site would be restricted to and dependent on the presence, extent and flow direction of any shallow groundwater beneath the site, with exposure pathways limited to inhalation of any potentially present volatiles.

Impact Assessment and Mitigation Measures – Land Quality

Potential Impacts

13.174 Impacts have been assessed during both the construction and operational phases of the NLE, based on an assessment of the magnitude of contamination sources as obtained from the desktop study and assessment of the pathway-receptor linkages from the description of the NLE, provided in *Chapter 4: Description of the NLE* of this ES. The receptors potentially at risk from land contamination that could be present are indicated below and their sensitivity is assessed in the table which follows.

Table 13-13 Summary of Receptors Sensitivity Pre-Mitigation

Receptor	Sensitivity	Comments
Construction / maintenance workers	High - Low	Construction workers involved in below ground construction will have a high sensitivity; those involved with minimal intrusion and above ground works a low sensitivity.
Adjacent site users	Moderate	Includes high density residential housing adjacent to the proposed NLE.
Future site users	Low	Includes employees, visitors i.e. commercial/industrial setting with minimal exposure opportunity to contamination sources.
Existing built environment	Moderate	None
New built environment	Moderate	Includes the NLE buildings, services, and landscaping.
Surface Water	Low	The River Thames is located *c.*150m north of the running tunnels at its closest point.
Groundwater	High - Moderate	The deeper chalk aquifer has a high sensitivity whilst the River Terrace Deposits have a moderate sensitivity.

Construction Effects – Land Quality

Risk to Construction Workers and Adjacent Site Users

13.175 Risks to construction workers and adjacent site users during construction may arise from dermal contact and ingestion of contaminated soil and shallow groundwater on site which may be encountered during the construction works. The sensitivity of the receptors could be up to high and unmitigated the magnitude of

impact could also be high, potentially leading to a major adverse effect pre-mitigation.

Risk to Groundwater

13.176 Groundwater sampling from the River Terrace Deposits (Secondary A Aquifer) at BPS by BH (2001 – 2002; see *ES Volume II: Appendix I*5) indicates that shallow groundwater is likely to be already contaminated with metals and PAHs at the proposed Battersea station site. The historical industrial uses at the proposed Nine Elms station site indicate that shallow groundwater may also be polluted in this area. In view of this, shallow groundwater is considered to be of relatively low sensitivity. Where present, Alluvium would be expected to prevent significant leaching of contaminants from Made Ground to the Secondary A aquifer. Taking the above into consideration, the magnitude of impact on the Secondary A aquifer is considered to be negligible.

13.177 The Battersea station and Nine Elms station lie within a SPZ1 which relates to a potable groundwater abstraction at Battersea Pumping Station (c. 50m north-west of the proposed Battersea station). The London Clay is considered to act as a barrier to leaching of contaminants to the underlying Chalk aquifer (Principal Aquifer) due to its impermeability. Therefore, the potential for contaminants in shallow soils to impact on the Chalk aquifer via leaching is very limited. In addition, the Thanet Sands and the Chalk Formation are not anticipated to be penetrated by the NLE. Earthworks for the Battersea and Nine Elms station boxes (identified as having the highest contamination potential) are proposed to terminate in the London Clay, approximately 24m and 9m above the top of the Lambeth Group which is in turn underlain by the Lambeth Group Formation and the Upper Chalk formation at depth (top of strata not proven). Therefore potential risk to the underlying Chalk by driving of solid contaminants into the aquifer during piling (if required) is considered low and the subsequent effect on this aquifer is considered to be negligible.

Risk to Surface Waters

13.178 The upper aquifer is considered to be in hydraulic continuity with the River Thames around the Battersea area and therefore contaminated groundwater may be currently impacting controlled watercourses. During construction, the infiltration pathway will be temporarily opened with the removal of hardstanding, therefore increasing the risk of contaminated groundwater migration. The magnitude of change in the quality of the river is anticipated to be low due to the dilution of contaminants and the subsequent effect to be negligible.

13.179 Due to the distance of the River Thames to the NLE (150m north of the running tunnels at its closest point), the potential for it to be impacted by surface water run-off and groundwater (due to dilution) (e.g. from fuel/oil spills) during construction works is negligible.

Ground Settlement

13.180 Ground settlement may occur as a result of excavating material to construct the running tunnels of the NLE.

13.181 Results of the analysis within the Ground Settlement Report (see *ES Volume II: Appendix I2*) indicate that, depending on whether construction option A or B is employed, the maximum settlement to occur at any point along the route of the NLE will range from approximately 50mm to 70mm. As a result of this anticipated ground settlement, damages ranging from very slight to moderate damage categories to the existing built environment, including above ground buildings, may occur. In addition, this includes potential damage to National Rail Assets such as the Victoria line. Further details are presented in the Ground Settlement Report.

13.182 Ground settlement as a result of the NLE has the potential to affect a range of buildings directly above and along the route of the NLE, however, the extent of effects will depend on the construction methodology, the distance of above ground buildings from the excavations works and specific ground conditions encountered under the various sensitive receptors. Therefore, buildings of various sensitivities may experience ground settlement of various magnitudes. Further analysis has established that the Victoria line, however, will not be affected by any ground settlement effects.

13.183 As a result, a range of potentially significant effects can occur; however, mitigation will be implemented to reduce any ground settlement effects as far as reasonably practicable, as detailed within the Ground Settlement Report.

Construction Mitigation Measures – Land Quality

13.184 The Battersea and Nine Elms areas of the development have a history of industrial land use which suggests the potential for moderate contamination. A geo-environmental ground investigation would allow further assessment of contamination risks during construction. In accordance with the Code of Construction Practice (CoCP) (presented in *Appendix N of ES Volume II*), where the investigation reveals any presence of contaminated land, an appropriate remedial strategy will be developed to identify the most appropriate option for managing the contamination.

13.185 A summary of further required mitigation measures during the construction phase is provided below. A scheme to manage identified contaminated land will be produced pursuant to a proposed planning condition, in line with Part A of the CoCP, and will be prepared in accordance with relevant legislation, regulations and best practice. The procedure for dealing with unforeseen contamination will be detailed in the scheme and if contamination is encountered during site works, it should be reported to the relevant Local Authority with advice sought from a contamination specialist.

13.186 Construction / demolition workers should be supplied with appropriate personal protective equipment (PPE) to protect their health. The PPE should include wearing chemical-resistant gloves when handling soils and wearing dust masks during dry, windy conditions.

13.187 In addition to PPE, site controls should be in place (e.g. having designated areas for drinking and eating on the site). All trench workings / tunnels and shafts should be kept well ventilated and dust suppression should be implemented during periods of dry, windy weather. Stockpiles of site-derived material may/will also need to be covered over during these periods if dust suppression proves to be unworkable at the site.

13.188 All bulk storage tanks used during construction works should/will be appropriately bunded and located on areas of hard standing. These will be inspected frequently for damage, maintained and remedial works conducted if necessary. Spill kits should be available and staff trained in their use.

13.189 Ground-gas monitoring undertaken as a condition of planning approval would provide information on the ground-gas regime for the NLE. Monitoring should be undertaken where buildings are proposed to allow for an assessment of risk posed by ground-gas and volatile vapours associated with Made Ground and Alluvium. This data will then inform on design requirements for special precautions/gas protective measures in the construction in buildings.

Management of Soils and Groundwater Arisings

13.190 Any excavated soils removed from site for disposal to a landfill should/will undergo Waste Acceptance Criteria (WAC) testing in order to correctly classify the material in terms of waste disposal. The results of the WAC testing will be reviewed at an early stage of the development in order to identify a suitable disposal facility, as described in the Materials Management Strategy (see *ES Volume II: Appendix B*); clean excavated material will be rescued off site.

13.191 Groundwater level monitoring indicates that shallow groundwater is likely to be encountered within the River Terrace Deposits during excavation works. As such, groundwater control operations are anticipated to be required. A review of desk study information indicates that impacts to shallow groundwater can be expected in the Battersea and Nine Elms areas. Depending on the concentrations of pollutants present, this water may not be accepted into public drains. As such, allowance should be made for discussions with the water board and / or specialist disposal of impacted groundwater.

Ground Settlement

13.192 As stated in the Ground Settlement Report, further analysis will be required during the final detailed design stage to gain a clearer understanding of which structures and utilities will require remedial work. However, any potential ground settlement effects will be reduced as far as reasonably practicable, in line with the mitigation measures set out within the Ground Settlement Report (see *ES Volume II: Appendix I2*).

13.193 In line with the CoCP, the design and construction of the NLE will be undertaken in a manner that will minimise damage to land and property as a result of ground movement. Appropriate techniques will be implemented in order to control and limit, as far as reasonably practicable, the effects of settlement. Mitigation measures include:

- Strengthening the ground below the affected buildings, either by injecting grout or freezing;
- Strengthening the structure of the building affected;
- Installing a physical barrier between the foundation of the affected building and tunnel, to modify the settlement trough and reduce ground movements;
- Compensation grouting; and
- Diversion or replacement of locally existing services.

Construction Residual Effects and Conclusion – Land Quality

13.194 With the construction mitigation measures applied as indicated, and following indicated guidance, the residual effects from construction due to contaminated ground or groundwater, or ground settlement are considered to be **negligible**.

Operational Impacts – Land Quality

Risks to Future Site Users

13.195 Future site users (including regular employees, site maintenance workers and visitors) are locally at risk from any contamination within the soils and groundwater in any areas of soft landscaping. Intrusive and ground investigation works would allow for a further assessment of risk.

13.196 If identified during construction works, localised concentrations of contamination in areas of soft landscaping will be adequately mitigated through techniques such as capping or localised source removal, thereby removing the source, or the pathway to the receptor.

Risk to Surface Water and Groundwater Receptors

13.197 It is assumed that hardstanding cover at the site will remain generally unchanged and hence the NLE is not considered to appreciably increase the amount of surface water discharge to the underlying ground in outdoor areas over the current scenario.

Risk to Proposed Buildings and Below Ground Services

13.198 Certain contaminants in soil or groundwater (hydrocarbons, solvents, ammoniacal nitrogen) can permeate through / corrode pipe work and possibly contaminate water supplies, and plastic water supply pipes can be at risk of attack from oils and phenols. Additionally, concrete infrastructure can be subject to attack from acids and high sulphate concentrations in soils.

13.199 A review of historical land use in the Battersea and Nine Elms areas identified a potential to encounter hydrocarbon impacted soils and shallow groundwater at these proposed station sites, therefore consideration must be given to increased potable water pipe specification. Risks will be adequately mitigated through the following:

- With regards to risks to underground services, a UK Water Industries Research document (10/W/M/03/21 January 2011) provides guidance on potential requirements for protection measures in the selection of water supply pipes; and
- Concrete infrastructure can be protected from sulphate attack by adopting an appropriate design of concrete class in accordance with Building Research Establishment (BRE) Special Digest 1:2005 (Ref. 13-54).

Operational Mitigation Measures – Land Quality

13.200 The NLE is assumed to comprise a large proportion of hardstanding, i.e. tarmac and concrete cover. There will, therefore, be a reduced pathway between any contamination and site receptors. As such no contamination specific mitigation measures are considered necessary during the operational phase of the NLE beyond regular inspection and maintenance of infrastructure to ensure that no pathways to underlying soil, groundwater or surface water occur as a result of disrepair.

13 Land Quality and Groundwater

Operational Residual Effects and Conclusion – Land Quality

13.201 With the mitigation work carried out as indicated, and following indicated guidance, the operational residual effects from the NLE due to contaminated ground or groundwater are considered to be **negligible**.

Summary of Effects- Land Quality

13.202 An assessment of baseline information for the site has determined a low potential for contamination in relation to the running tunnels and ventilation shafts, and a moderate to high potential at the proposed Battersea and Nine Elms station sites based on former and current land use.

13.203 Ground investigation works along the study area were undertaken in 2010 by CCL to provide geotechnical data. Soils and groundwater were not analysed for contamination and ground-gas was not monitored therefore a data gap is present. Groundwater testing by BH (2001 – 2002) recorded elevated concentrations of metals and PAHs at the proposed Battersea station site. It is recommended that geo-environmental ground investigation works are undertaken in the Battersea and Nine Elms Station sites in order to close the data gaps identified and allow a quantitative assessment of risk from contamination to be made.

13.204 At present, the main contamination risks from the NLE are assessed as being risks to construction workers during development works (construction phase). These risks can be appropriately mitigated by ensuring compliance with the EMPs which, in accordance with Part B the CoCP, will be produced once the main contractor has been appointed.

13.205 Operational contamination risks associated with the NLE are assessed as being **negligible**. This is due to the reduction in exposure pathways to soils or groundwater following completion of the NLE providing that potential soft landscaping areas have been remediated. Should ground-gas monitoring indicate a risk to future users from site derived ground-gas, this could be adequately mitigated through the incorporation of gas protection measures into the design and construction of the buildings.

13.206 Therefore, based on the data currently available, at the present time it is concluded that contamination does not pose an unacceptable constraint to the NLE.

13.207 It is considered that, provided appropriate mitigation measures are employed during construction and operation, the NLE will not increase the risk to health, or harm to the environment, and consequently the effects are not considered to be significant.

13.208 Table 13-14 provides a summary of the identified construction and operational effects, the mitigation measures proposed and the subsequent residual effects.

Cumulative Effects Assessment – Land Quality

13.209 A number of development schemes are proposed within approximately 1km of the site, as outlined in *Chapter 2: EIA Methodology* of this ES.

13.210 It is considered that the residual effect of the cumulative schemes on geotechnical ground conditions will be **negligible** provided that the requirements of relevant policy and legislation relating to land contamination and remediation are adopted in design and that appropriate mitigation measures are applied. Should remediation of sites occur in the redevelopment process due to identified contamination, this will add to the **beneficial** effect of reducing the stock of contaminated land within the boroughs.

13.211 The following sections detail the assessment of potential impacts and effects on the groundwater resources from the construction and operational phases of the NLE.

Table 13-14 Summary of Potential Impacts from Contaminated Soil and Groundwater

Receptor	Receptor Sensitivity	Source/Pathway	Magnitude of Change (Pre-Mitigation)	Significance of Effect (Pre-Mitigation)	Mitigation	Significance of Effect (Residual)
Contaminated Soil and Groundwater – Moderate to High hazard in the absence of contaminated land testing based on industrial land use at Battersea and Nine Elms station sites						
Construction Workers	Low - High	Health impacts from direct contact, dermal uptake, soil ingestion and dust inhalation	Medium	Major Adverse	• PPE, activities to be undertaken under EMP with appropriate site controls	**Negligible**
Adjacent Residential Site Users	Moderate	Health impacts from inhalation and ingestion of contaminated dust particles	Medium	Moderate Adverse	• Activities to be undertaken under EMP with appropriate site controls	**Negligible**
River Terrace Deposits (Secondary A Aquifer)	Moderate	Degradation of aquifer via increased leaching and mobilisation of contaminants during excavation	Medium	Moderate Adverse	• Adoption of Appropriate EA Piling/Ground Improvement Techniques if required	**Negligible**
Upper Chalk (Principal Aquifer)	High	Degradation of aquifer via the creation of temporary preferential pathways (through piling), or the driving of contaminants down into the aquifer	Medium	Major Adverse		**Negligible**
River Thames	Low	Contamination of local surface water features via shallow groundwater migration	Medium	Moderate Adverse	• Remediation where required of existing contaminated hotspots to be undertaken as component of construction works	**Negligible**
Future Site Users	Low	Inhalation, ingestion and dermal contact with contaminated soils	Medium	Moderate Adverse	• Remediation in soft landscaped areas if required e.g. a cover system	**Negligible**
Proposed Buildings and Below Ground services	Moderate	Chemical attack from sulphates and organics potentially present in soils	Medium	Moderate Adverse	• Protection measures for water supply pipes (10/W/M/03/21 January 2011) and design of concrete class in accordance with BRE Special Digest 1:2005	**Negligible**
Ground Gases – Moderate hazard in the absence of ground gas data based on past industrial use and the presence of Alluvium						
Future Site Users	Moderate	Health impacts from increased mobilisation of ground gases off-site.	Medium	Moderate Adverse	• Adoption of appropriate ground gas protection measures if required	**Negligible**
Construction Workers	Low - High	Health impacts from gas/vapour inhalation	Medium	Moderate Adverse	• Ground-gas monitoring. If required, appropriate PPE and construction controls	**Negligible**
Ground Settlement						
Existing Built Environment	Low - High	Ground settlement as a result of tunnel, cross passage and station box excavation	Negligible - High	Negligible – Major Adverse	• Installation of a physical barrier between foundations of affected buildings and tunnel, to modify the settlement trough and reduce ground movements	**Negligible**

Construction Effects – Groundwater Resources

13.212 The proposed construction methods have been reviewed and the following sources of potential impacts to groundwater levels, flows and quality during construction have been identified:

- Lowering of groundwater levels by groundwater control or depressurisation of aquifer units;
- Mobilisation of existing poor quality groundwater;
- Introduction of contamination to the groundwater environment by chemical spillages and contaminative construction materials;
- Creation or significantly altering existing pathways; and
- Deterioration of groundwater quality by groundwater control or depressurisation of aquifer units.

Lowering of Groundwater Levels

13.213 Groundwater control of the upper aquifer is anticipated to be required for construction of the ventilation and grouting shafts, the proposed Battersea station, the intermediate Nine Elms station and the associated entry / exit of the TBM (see Table 13-5 for anticipated geologies). Any pumped discharge would be directed to an appropriate sewer onsite, following any necessary treatment and subject to TWUL approval. The duration of pumping and groundwater volumes would be determined by further site investigation. The magnitude of impact to groundwater levels and flows in the upper aquifer is anticipated to be low, resulting in a decrease in the yield of an aquifer but not affecting the existing users or changing the WFD status, and the subsequent effect to be negligible. No impacts or subsequent effects are anticipated on the identified licensed groundwater source which abstracts from this aquifer, as it is located at over 900m from the construction works (see Table 13-11).

13.214 The upper aquifer is considered to be in hydraulic continuity with the River Thames around the Battersea area and therefore the lowering of groundwater levels within the upper aquifer during construction has the potential to reduce groundwater contributions to the river. The magnitude of impact on the River Thames is anticipated to be low, and the subsequent effect to be minor adverse.

13.215 Depressurisation[i] of the Lambeth Group is anticipated to be required for construction of the ventilation and grouting shafts and the step plate junction, where the water-bearing units of the Lambeth Group are intercepted. This would involve drilling wells into the Lambeth Group from the base of the temporary shafts at Radcot Street and Harmsworth Street and pumping to lower the hydraulic pressure in the vicinity of the construction sites. Any pumped discharge would be directed to an appropriate sewer onsite, following any necessary treatment and subject to TWUL approval. The duration of pumping and groundwater volumes would be determined by further site investigation. The Lambeth Group is not classified by the EA as an aquifer and therefore is not considered as a groundwater receptor. Therefore the impacts of depressurisation on groundwater levels in the Lambeth Group are not assessed here.

13.216 The Thanet Sands and the Chalk Formation of the lower aquifer are not anticipated to be penetrated by the NLE. The depth at which the Upnor Formation is likely to be encountered along the route alignment remains unclear as the units of the Lambeth Group were not differentiated during the CCL site investigation; therefore the Upnor Formation of the lower aquifer may be penetrated by the NLE. In addition, the ventilation shafts and the step plate junction would extend to within less than 1m of the top of the Thanet Sands, while the temporary grouting shafts would extend to within 7m of the top of the Thanet Sands. Therefore local groundwater control, such as sump pumping or ground treatment, may be required in the London Tertiaries to prevent or reduce heave (uplift) at these locations during construction. Any pumped discharge would be directed to an appropriate sewer onsite, following any necessary treatment and subject to TWUL approval. The magnitude of impact to groundwater levels and flows in the London Tertiaries is anticipated to be low, resulting in a decrease in the yield of an aquifer but not affecting the existing users or changing the WFD status, and the subsequent effect to be negligible.

13.217 No groundwater control or depressurisation of the Chalk Formation is anticipated to be required due to the likely separation distance between the subsurface structures at up to -25.4m AOD and the top of the Chalk Formation at -66m AOD, and the depth of EA monitored groundwater levels in the Chalk of -18 to -22m AOD along the proposed NLE route. Therefore the magnitude of impact on groundwater levels and flows in the Chalk Formation, as a result of local groundwater control in the London Tertiaries is anticipated to be negligible, resulting in an impact of insufficient magnitude to affect the aquifers use and the subsequent effect to be negligible.

13.218 The magnitude of impact and significance of the subsequent effect on groundwater levels and yields at the nearby licensed groundwater abstraction, 28/39/42/0033, are also anticipated to be negligible. The remaining licensed groundwater abstractions identified in Table 13-11 are at over 1km from the ventilation shafts and the step plate junction and therefore no impacts or subsequent effects are anticipated.

Mobilisation of Poor Quality Groundwater

13.219 Groundwater control of the upper aquifer is anticipated to be required for construction of the ventilation and grouting shafts, the proposed Battersea station, the intermediate Nine Elms station and the associated entry / exit of the TBM; therefore there is some potential for mobilising poor quality groundwater identified in the River Terrace Deposits at the BPS site and anticipated to be encountered at the Nine Elms station site. The magnitude of impact to the groundwater quality of the upper aquifer is anticipated to be low, and the subsequent effect to be negligible.

13.220 Groundwater control of the upper aquifer would draw groundwater towards the construction sites and away from the River Thames. Therefore no impacts or subsequent effects are anticipated on the water quality of the River Thames in this regard.

13.221 Depressurisation of the Lambeth Group is anticipated to lower groundwater levels and hydraulic pressures within the water-bearing units of this group. This has the potential to mobilise poor quality groundwater downwards from the River Terrace Deposits into the underlying London Clay. The London Clay is considered to act as an aquiclude or a barrier to groundwater flow due to its impermeability and to

[i] Depressurisation – a term used to describe groundwater control or lowering of hydraulic pressures in a confined aquifer.

protect the underlying formations from the downward migration of poor quality groundwater. Therefore, the potential to mobilise poor quality groundwater through this horizon and into the underlying Lambeth Group, London Tertiaries and Chalk Formation is very limited. The London Clay and the Lambeth Group are not classified by the EA as aquifers and therefore are not considered as groundwater receptors. In addition, no impacts or subsequent effects are anticipated as a result of the mobilisation of poor quality groundwater downwards from the River Terrace Deposits on the London Tertiaries and Chalk Formation.

13.222 Local groundwater control may be required in the London Tertiaries for the construction of ventilation shafts, temporary grouting shafts and the step plate junction. The magnitude of impact to groundwater levels and flows in these aquifers is low and therefore the potential for mobilising poor quality groundwater within these aquifers is also considered to be limited. There are no results of groundwater quality sampling in these formations available to this assessment. The magnitude of impact on the London Tertiaries as a result of mobilising poor quality groundwater within these aquifers is anticipated to be low and subsequent effect to be negligible.

13.223 No groundwater control or depressurisation of the Chalk Formation is anticipated to be required. The magnitude of impact and significance of the subsequent effect on groundwater quality in the Chalk as a result of local groundwater control in the London Tertiaries are anticipated to be negligible.

Introduction of Contamination

13.224 All of the areas of subsurface construction have the potential to introduce potentially contaminative materials, such as fuels, oils, hydraulic fluids and bentonite based slurries with a variety of additives associated with diaphragm walling and some major piling activities, to the ground and natural groundwater environment. In order to avoid the entry of any hazardous substances, consultation would take place with the EA regarding the Environmental Permit required for this work. The magnitude of impact on the upper aquifer as a result of introducing potentially contaminative materials to the groundwater environment is anticipated to be low. The subsequent effects are anticipated to be negligible for the upper aquifer.

13.225 The Thanet Sands and the Chalk Formation are not anticipated to be penetrated by the NLE; however the Upnor Formation may be penetrated. Therefore the magnitude of impact on the Upnor Formation as a result of introducing potentially contaminative materials to the groundwater environment is anticipated to be low. The subsequent effect is anticipated to be negligible.

13.226 Should the NLE cause contaminative materials to enter a water body other than the source water body, this would result in a failure of the WFD objectives. The upper aquifer is considered to be in hydraulic continuity with the River Thames around the Battersea area and therefore contaminative materials entering the upper aquifer here have the potential to deteriorate water quality in the river. The magnitude of change in the quality of the river is anticipated to be low and the subsequent effect to be minor adverse.

13.227 The Thanet Sands and the Chalk Formation are not anticipated to be penetrated by the NLE; however the Upnor Formation may be penetrated. This formation is part of the designated Greenwich Chalk and Tertiaries groundwater body. However the potential for contaminative materials to enter another groundwater body is very limited. In this regard, no failures of the WFD objectives are anticipated.

Creation or Altering of Pathways

13.228 All of the areas of subsurface construction have the potential to create pathways along which introduced contaminants or existing poor quality groundwater can migrate. There is the potential for these contaminants or poor quality groundwater to migrate laterally and to degrade groundwater quality in the River Thames or to migrate downwards to degrade groundwater quality in the London Tertiaries and Chalk Formation. In the absence of detailed information on groundwater quality in the River Terrace Deposits, the magnitude of impact on the upper aquifer and on the River Thames is anticipated to be low and subsequent effects to be negligible and minor adverse respectively.

13.229 The London Clay is considered to act as an aquiclude and therefore to protect the London Tertiaries and Chalk Formation from the downward migration of poor quality groundwater. Therefore the magnitude of impact and subsequent effect on these aquifers are anticipated to be negligible.

Deterioration of Groundwater Quality

13.230 The EA aims to manage groundwater abstractions to keep water levels above the top of the Thanet Sands. The lowering of groundwater levels below the top of the Thanet Sands may lead to deterioration in groundwater quality due to the oxidation of pyretic minerals in this formation. Local groundwater control in the London Tertiaries for the construction of the ventilation shafts, step plate junction and temporary grouting shafts would draw groundwater levels down within these aquifers in the vicinity of the construction sites. This has the potential to lower groundwater levels below the top of the Thanet Sands at these locations.

13.231 However the Thanet Sand has historically been subject to groundwater control in places and further deterioration of groundwater quality is unlikely to be significant. The water table geology mapping illustrated in the EA status report *Management of the London Basin Chalk Aquifer* shows that groundwater levels were below the top of Thanet Sand at Blackfriars Bridge Foreshore in 1965 (Ref. 13-52). Therefore the magnitude of impact on groundwater quality in the London Tertiaries is anticipated to be negligible and subsequent effect to be negligible.

Construction Mitigation Measures - Groundwater

13.232 The effects from the construction phase that are anticipated to be negligible will not require any mitigation. However, the effects from the construction phase that are anticipated to be minor adverse will require mitigation measures to reduce the effects as far as reasonably practicable.

13.233 Mitigation measures will be implemented to reduce the abovementioned minor adverse effects and protect groundwater resources, as detailed within the CoCP (see *Appendix N of ES Volume II*). These include, but are not limited to:

- Management of construction operations would take account of the guidance contained within the relevant EA PPGNs and CIRIA documents and would be based on accepted industry practice. EA guidance e.g. piling into contaminated ground, would be followed if relevant;
- TfL would follow best practice on all activities which could affect the water environment and risks would be mitigated to as low as possible. Contingency

plans to deal with major pollution incidents at the work sites would be included within the overall emergency planning;

- Site drainage, including surface runoff and groundwater control effluents, would be subject to appropriate treatment and discharged to sewers where appropriate and relevant permissions would be obtained from the sewerage undertaker;
- All reasonably practicable measures would be taken to prevent the pollution by sediment of, any existing watercourse, borehole, aquifer or catchment area, arising from work operations;
- Records of water pumped would be kept at all major groundwater control sites where required under the terms of a discharge consent;
- Water quality at all major groundwater control sites would be monitored in accordance with the requirements of the discharge permit;
- Investigations and/or risk assessments would be carried out wherever construction work is planned in order to assess the potential for contamination in both the land and groundwater and in accordance with EA and local authority requirements; and
- Piling or diaphragm walls would be installed to seal out the upper aquifer during construction.

13.234 To overcome any impacts on River Thames from piling or diaphragm wall techniques, a precautionary approach including risk assessments would be undertaken if contamination encountered. If necessary mitigation measures (including monitoring of groundwater and surface water) would be adopted to avoid any risk to the River Thames.

Construction Residual Effects and Conclusion - Groundwater

13.235 The abovementioned mitigation measures, if adopted, would reduce all the residual construction effects to **negligible**.

Operational Impacts - Groundwater

13.236 The proposed operational plans have been reviewed and the following sources of potential impacts to groundwater levels, flows and quality during operation have been identified:

- Creation of pathways;
- Physical obstruction to groundwater flow; and
- Seepage into tunnels and shafts.

Creation Pathways

13.237 All of the permanent subsurface structures, namely the stations at Battersea and Nine Elms and the ventilation shafts, have the potential to create pathways along which introduced contaminants or existing poor quality groundwater can migrate. There is the potential for these contaminants or poor quality groundwater to migrate laterally and degrade groundwater quality in the River Thames or to migrate downwards to degrade groundwater quality in the London Tertiaries and Chalk Formation. In the absence of detailed information on groundwater quality in the River Terrace Deposits, the magnitude of impact on the upper aquifer and on the River Thames is anticipated to be low and subsequent effects to be negligible and minor adverse respectively.

13.238 The London Clay is considered to act as an aquiclude and therefore to protect the London Tertiaries and Chalk Formation from the downward migration of poor quality groundwater. Therefore the magnitude of impact and subsequent effect on these aquifers are anticipated to be negligible.

Physical Obstruction to Groundwater Flow

13.239 All of the permanent subsurface structures have the potential to disrupt groundwater flow and alter groundwater levels within the upper aquifer. There is limited information on groundwater levels in the alluvium and River Terrace Deposits available to this assessment; groundwater levels were recorded in the River Terrace Deposits at 3.5mbGL at the BPS site (see *ES Volume II: Appendix I5*). Using the proposed station and shaft dimensions and a range of typical hydraulic gradients for the River Terrace Deposits of 0.001 to 0.004, groundwater modelling work suggests that the increase in groundwater levels in the upper aquifer would be in the region of 0.015 to 0.4m within 250m of these structures. This is likely to remain below the natural range of groundwater level fluctuation at these locations. Therefore the magnitude of impact to groundwater flow in the upper aquifer is anticipated to be negligible and subsequent effects to be negligible.

13.240 The Thanet Sands and Chalk Formation are not anticipated to be penetrated by the NLE; however the Upnor Formation may be penetrated. The groundwater levels in this aquifer are confined or under hydrostatic pressure and any increase in groundwater levels as a result of the permanent subsurface structures would result in an increased hydraulic pressure within the aquifer rather than an increase of the water table. Therefore, no impact or subsequent effect to groundwater flow in the Upnor Formation is anticipated.

Seepage into Tunnels and Shafts

13.241 The presence of the tunnels and shafts within saturated ground, i.e. the upper aquifer, the Lambeth Group, London Tertiaries and Chalk Formation, may result in very minor seepage into these subsurface structures and a loss of groundwater resources. The Thanet Sands and Chalk Formation are not anticipated to be penetrated by the NLE; however the upper aquifer and the Upnor Formation may be penetrated and the ventilation shafts and step plate junction would extend to within less than 1m of the top of the Thanet Sands. This assessment has assumed that the lining of the shafts and associated tunnels would be designed to have a rate of seepage of 1l/day/m^2. The magnitude of impact and significance of the subsequent effect on groundwater resources in the upper aquifer and the Upnor Formation are anticipated to be negligible.

Operational Mitigation Measures - Groundwater

13.242 The effects from the operational phase that are anticipated to be negligible will not require any mitigation; however the effects from the operational phase that are anticipated to be minor adverse will require mitigation measures to reduce the effects as far as reasonably practicable. Such mitigation measures include potential operational monitoring of groundwater and surface water (post-construction).

Operational Residual Effects and Conclusion - Groundwater

13.243 The abovementioned mitigation measures, if adopted, would reduce all the residual operational effects to **negligible**.

Summary of Effects - Groundwater

13.244 Table 13-15 provides a summary of the identified construction and operational effects, the mitigation measures proposed and the subsequent residual effects.

13.245 Table 13-15 shows that during the construction and operational phase, all of the effects are either minor adverse or negligible. The mitigation measures of piling and diaphragm wall techniques, including risk assessments if contamination were found, would reduce any residual effects to **negligible** during the construction phase. For the operational phase, mitigation measures (including monitoring) would ensure that the residual effects are reduced to **negligible**.

Cumulative Effects Assessment – Groundwater

13.246 A number of development schemes are proposed within approximately 1km of the site, as outlined in *Chapter 2: EIA Methodology* of this ES.

13.247 Of these, there are seven with proposed basements (potential obstruction to groundwater movement in the upper aquifer) which would be under construction during the construction phase of the NLE and therefore a cumulative construction effects assessment has been required. In addition, two of the seven schemes would be under construction during the operational phase of the NLE and therefore a cumulative operational effects assessment has also been required.

13.248 One of the schemes would involve a deep shaft extending down into the lower aquifer and would be under construction during both the construction and operational phases of the NLE.

Cumulative construction effects – Groundwater

13.249 As stated above, the seven cumulative schemes with basements may all create local impacts on groundwater levels in the upper aquifer but given that schemes are all down hydraulic gradient and located at a considerable distance away (>100m), then these impacts are not expected to be significant. Any changes would be detected by monitoring of groundwater levels in the upper aquifer. Therefore the effects on groundwater within the upper aquifer would remain **negligible**.

13.250 One scheme, No.12 Thames Tunnel (Thames Tunnel) Kirtling Street, has been identified which could potentially give rise to cumulative effects during construction relevant to groundwater resource in the lower aquifer through the depressurisation of the Lambeth Group (by pumping from the lower aquifer) required for the NLE. However, the construction of the NLE in the vicinity of the Thames Tunnel scheme would be within the London Clay and would be separated from the lower aquifer by a thick layer of Lambeth Group. Therefore the effects on the groundwater within the lower aquifer would **negligible**.

Cumulative operational effects – Groundwater

13.251 As stated above, two schemes could potentially give rise to cumulative effects during the operation relevant to groundwater in the upper aquifer, through the inclusion of basements. These schemes may create local impacts on groundwater levels in the upper aquifer but given that the schemes are both down hydraulic gradient and located at a considerable distance away (>250m), then these effects are not expected to be significant. Any changes would be detected by monitoring of groundwater levels in the upper aquifer prior to construction. Therefore the effects on groundwater within the upper aquifer would remain **negligible**.

13.252 One scheme, the Thames Tunnel scheme, has been identified which could potentially give rise to cumulative effects during operation relevant to groundwater resource in the lower aquifer, through the depressurisation of the Lambeth Group (by pumping from the lower aquifer) required for the NLE. However, the construction of the NLE in the vicinity of the Thames Tunnel scheme would be within the London Clay and would be separated from the lower aquifer by a thick layer of Lambeth Group. Therefore, no additional effects on the groundwater within the lower aquifer would remain **negligible**.

Table 13-15 Summary of Groundwater Construction and Operational Effects, Proposed Mitigation Measures and Residual Effects

Phase	Impact	Receptor	Magnitude of Impact	Area	Receptor sensitivity/ value	Significance of Effect	Mitigation Proposed	Significance of Residual Effect
Construction	Lowering of groundwater levels and impacting on flows by depressurisation	Upper aquifer	Low	Ventilation shafts, temporary grouting shafts and step plate junction	Moderate	Negligible	• None required	**Negligible**
		River Thames			High	Minor adverse	• Install piling or diaphragm walls to seal out the upper aquifer during construction	**Negligible**
		London Tertiaries	Low		Moderate	Negligible	• None required	**Negligible**
		Chalk Formation	Negligible		High	Negligible		**Negligible**
		Licensed groundwater abstraction (28/39/42/0033)			High	Negligible		**Negligible**
	Mobilisation of poor quality groundwater	Upper aquifer	Low		Moderate	Negligible		**Negligible**
		London Tertiaries	Low		Moderate	Negligible		**Negligible**
		Chalk Formation	Negligible		High	Negligible		**Negligible**
	Introduction of contamination	Upper aquifer	Low	All areas of subsurface construction	Moderate	Negligible		**Negligible**
		River Thames			High	Minor adverse	• Install piling or diaphragm walls to seal out the upper aquifer during construction, Carry out a risk assess-ment of piling activities if necessary	**Negligible**
		Upnor Formation	Negligible		Moderate	Negligible	•None required	**Negligible**
	Creation or altering of contaminant pathways during construction	Upper aquifer	Low		Moderate	Negligible		**Negligible**
		River Thames			High	Minor adverse	• Install piling or diaphragm walls to seal out the upper	**Negligible**

Phase	Impact	Receptor	Magnitude of Impact	Area	Receptor sensitivity/ value	Significance of Effect	Mitigation Proposed	Significance of Residual Effect
							aquifer during construction. Carry out a risk assess-ment of piling activities, if necessary	
		London Tertiaries	Negligible		Moderate	Negligible	•None required	**Negligible**
		Chalk Formation	Negligible		High	Negligible		**Negligible**
	Deterioration of groundwater quality	London Tertiaries	Negligible	Ventilation shafts, temporary grouting shafts and step plate junction	Moderate	Negligible		**Negligible**
Operational	Creation of contaminant pathways by permanent subsurface structures	Upper aquifer	Low	All permanent subsurface structures	Moderate	Negligible		**Negligible**
		River Thames			High	Minor adverse	• Operational monitoring of groundwater and surface water monitoring)	**Negligible**
		London Tertiaries	Negligible		Moderate	Negligible	•None required	**Negligible**
		Chalk Formation	Negligible		High	Negligible		**Negligible**
	Physical obstruction to groundwater flow	Upper aquifer	Negligible	All permanent subsurface structures	Moderate	Negligible		**Negligible**
	Seepage into tunnels and shafts	Upper aquifer	Negligible		Moderate	Negligible		**Negligible**
		London Tertiaries	Negligible		Moderate	Negligible		**Negligible**

13 Land Quality and Groundwater

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Location Plan

Key:

- Track Alignment
- Borough Boundary
- Borehole

Client:

Transport for London

URS

Project:

NORTHERN LINE EXTENSION
TO BATTERSEA
TWAO FOR TfL

Drawing:

LOCATION OF CONCEPT
CONSULTANT BOREHOLES

Suitability: S4	FORMAL ISSUE TO CLIENT		
Drawn by:	DT	Date:	04/03/2013
Checked by:	TW	Date:	04/03/2013
Approved by:	HW	Date:	04/03/2013
Drawing Scale:	1:15,000 @ A3		
Drawing No:	Figure 13-3	Revision:	01

SCALES
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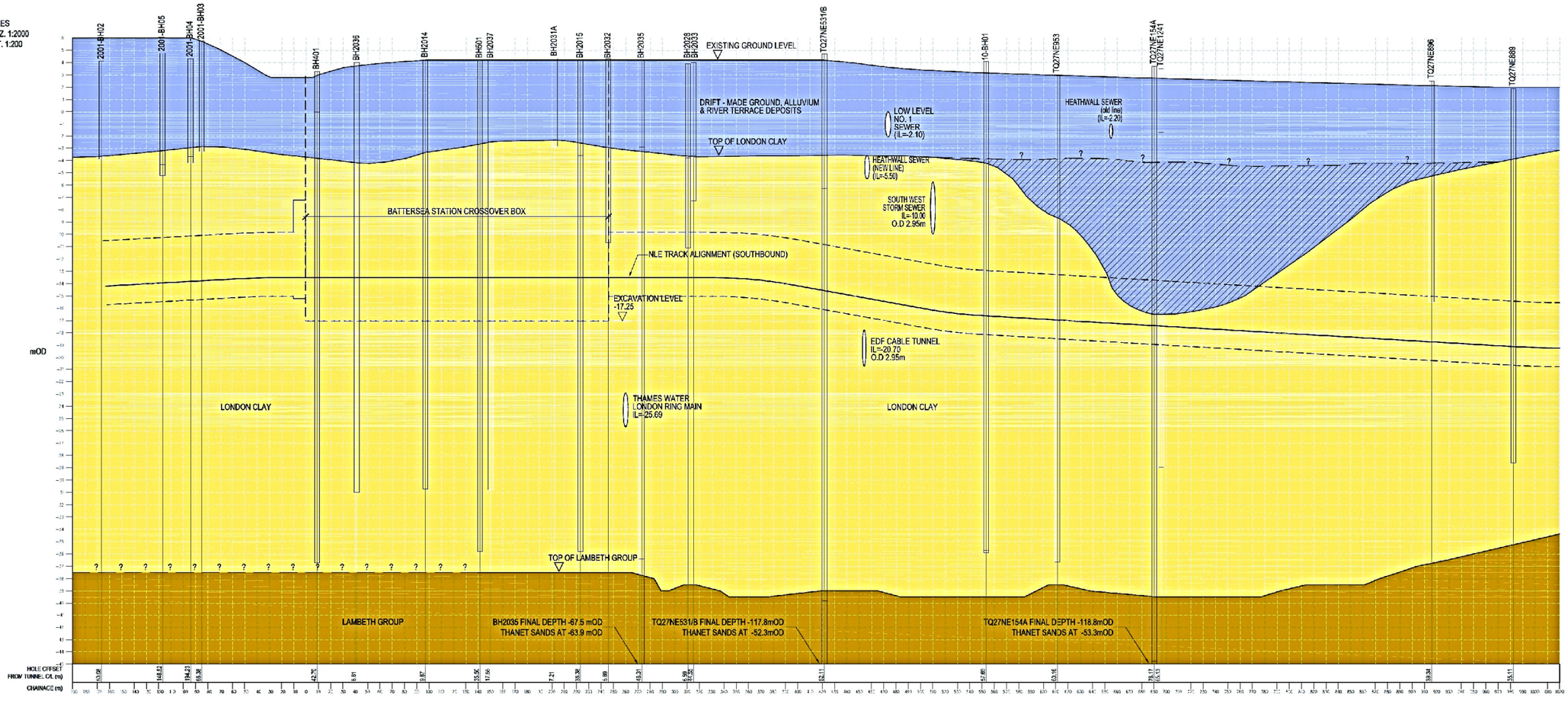
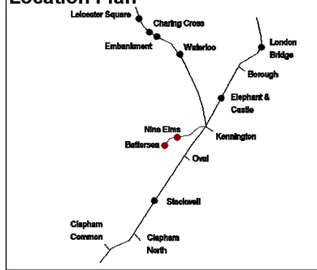
VERT. 1:200



Location Plan



Key:

Geological profile developed, based on the ground investigation undertaken by Concept Consultants LTD *(ES Volume II: Appendix I3)* and other data held by Buro Happold

__?__?__ Insufficient Data to Define Interface

Client:

Transport for London

URS

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Project:

NORTHERN LINE EXTENSION
TO BATTERSEA
TWAO FOR TfL

Drawing:

GEOLOGICAL STRATA SHOWING LOCATION OF NLE RUNNING TUNNELS AND OTHER THIRD PARTY STRUCTURES

Suitability: S4 FORMAL ISSUE TO CLIENT

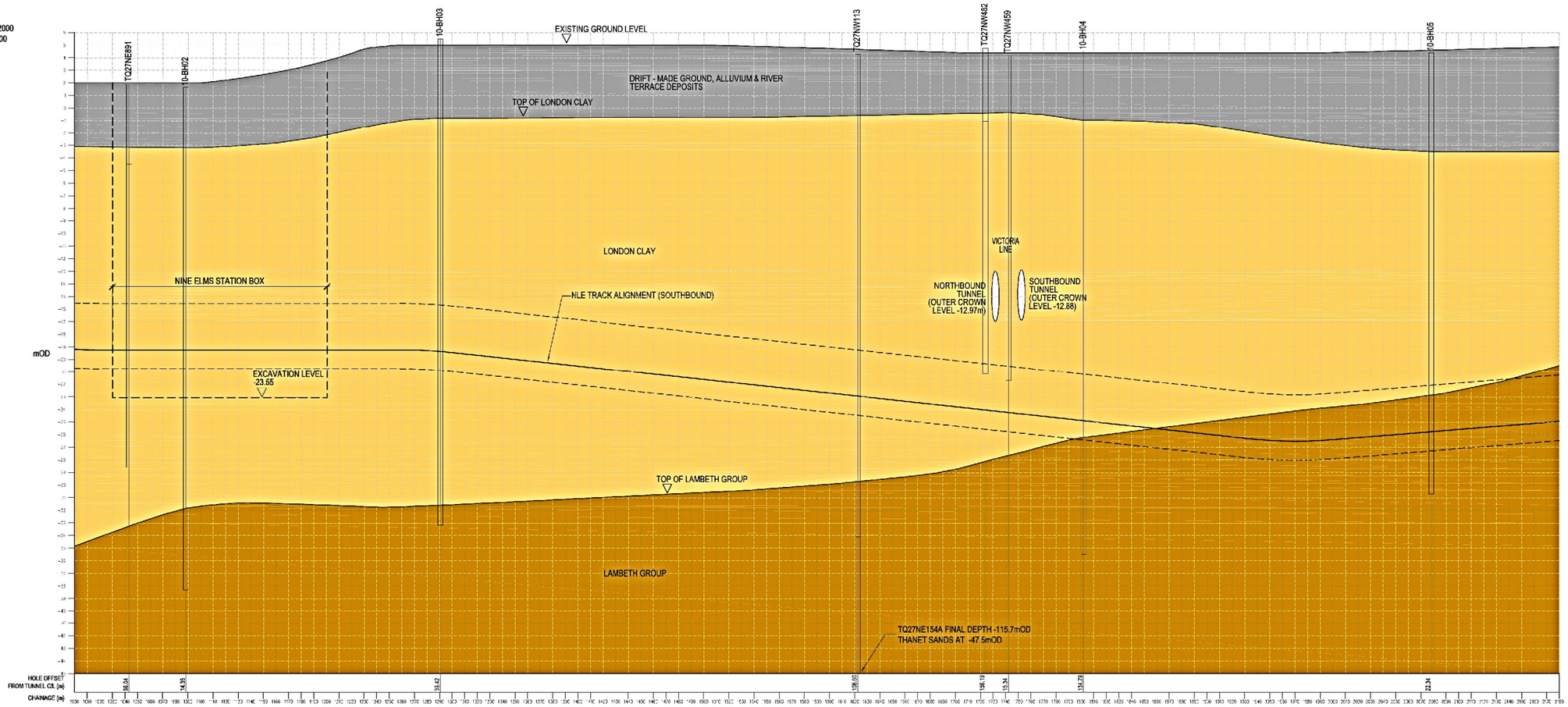
Drawn by:	DT	Date:	04/03/2013
Checked by:	TW	Date:	04/03/2013
Approved by:	HW	Date:	04/03/2013

Drawing Scale: Not to scale

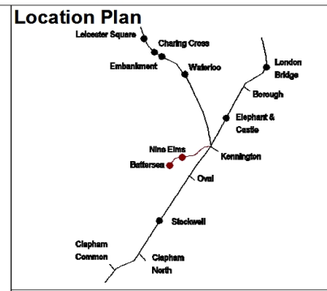
Drawing No: Figure 13-4a

Revision: 01

SCALES
HORIZ. 1:2000
VERT. 1:200



Location Plan



Key:

Geological profile developed, based on the ground investigation undertaken by Concept Consultants LTD *(ES Volume II: Appendix I3)* and other data held by Buro Happold

__?__?__ Insufficient Data to Define Interface

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TO BATTERSEA
TWAO FOR TfL

Drawing:

GEOLOGICAL STRATA SHOWING LOCATION OF NLE RUNNING TUNNELS AND OTHER THIRD PARTY STRUCTURES

Suitability: S4 FORMAL ISSUE TO CLIENT

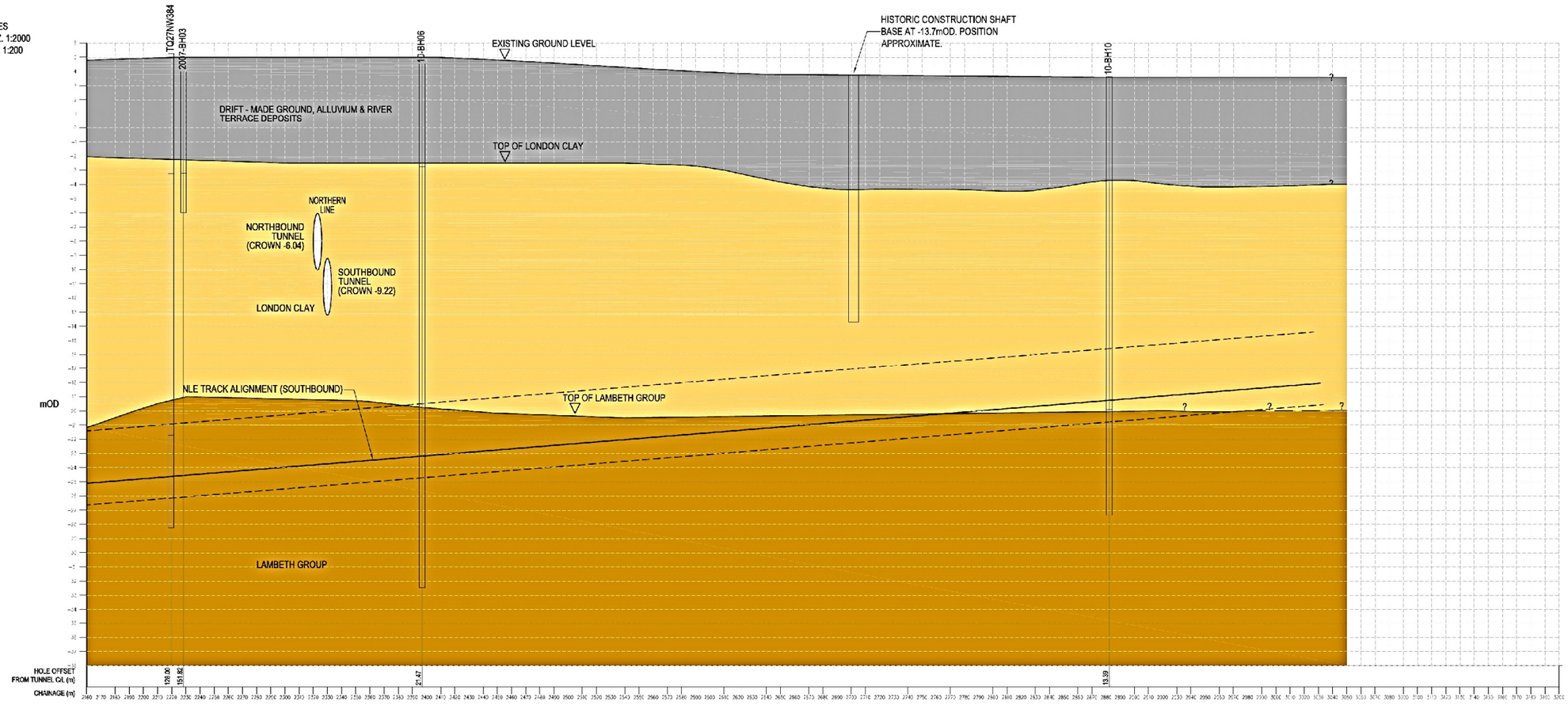
Drawn by:	DT	Date:	04/03/2013
Checked by:	TW	Date:	04/03/2013
Approved by:	HW	Date:	04/03/2013

Drawing Scale: Not to scale

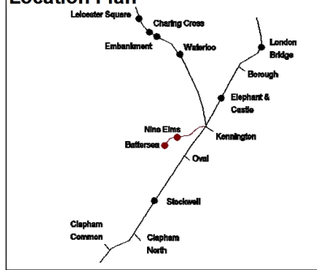
Drawing No: Figure 13-4b

Revision: 01

SCALES
HORIZ. 1:2000
VERT. 1:200



Location Plan



Key:

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Suitability: S4 FORMAL ISSUE TO CLIENT

Drawn by:	DT	Date:	04/03/2013
Checked by:	TW	Date:	04/03/2013
Approved by:	HW	Date:	04/03/2013
Drawing Scale:	Not to scale		
Drawing No:	Figure 13-4c	Revision:	01