CHAPTER 8 – CONTAMINATED LAND

8.1 Introduction and Key Issues

8.1.1 This chapter assesses the likely effects of contaminated land both within the Deephams Site and on adjacent and nearby sites where contaminant migration could impact on the Upgrade or contaminants could migrate within and beyond the site and impact on sensitive receptors.

8.1.2 Land contamination in the context of this assessment is defined as the presence of substances in, on or under the land, that have the potential to cause harm, whether this is to the environment (i.e. groundwater or controlled waters) or to human health. Potential geoenvironmental impacts with respect to development construction, operation and waste management are also considered.

8.1.3 The key issues considered are:
- Location and nature of any potentially contaminated land within the Site, construction area and other areas in close proximity to the Site;
- identification of potential sources of contaminant migration into the Site, including migration of ground gases;
- impacts of potential contamination arising during clearance, demolition, excavation and construction;
- impacts of potential contamination left in-situ;
- management of potentially contaminating materials arising from clearance, demolition and construction; and
- management of potential unexploded ordnance within the study area.

8.1.4 The study area for the contaminated land assessment is the Deephams Sewage Works site itself together with a surrounding area extending 500 m from the site boundary.

8.2 Consultation

8.2.1 LBE and the Environment Agency have agreed with the scope of assessment of contaminated land issues and the methodology used as set out in the Scoping Report. The scope includes the assessment of soil and groundwater contamination within and adjacent to the site and its potential impacts on sensitive receptors within and outside the site boundary, including controlled waters. An assessment of the impacts of the proposed Upgrade on water quality is included in Chapter 18 - Water Resources.

8.2.2 The assessment focuses on the impacts of contaminated land during demolition, excavation and construction as there are not expected to be any contaminated land impacts during the operational phase of the Upgrade. This is because there will be no new sources of contaminants nor any significant changes to the site that would affect the potential impacts of residual contaminants on site, and all mitigation measures will be complete by the end of the construction phase or will have been incorporated into the design of the Upgrade.

8.3 Legislation and Planning Policy

International / European

8.3.1 The only significant European legislation which has been transposed into UK law on contaminated land the European Union Directive (2004/35) in respect of
environmental liability and remediating environmental damage. This introduced obligations to ensure that the polluter pays for damage caused which strengthened the pre-existing ‘Polluter Pays Principle’ in UK Common Law.

National

8.3.2 Land contamination in the UK is regulated under several regimes, including environmental protection, pollution prevention and control, waste management, planning and development control, and health and safety. There are a number of key legislative drivers for dealing with risks to human health and the risk of pollution of the environment from land contamination, including:

- Part 2A of the Environmental Protection Act (EPA) 1990 (the Contaminated Land Regime);
- Contaminated Land (England) Regulations 2006;
- Contaminated Land (England) (Amendment) Regulations, 2012;
- The Water Act 2003;
- The Water Resources Act, 1991 (as amended);
- The Environmental Damage (Prevention and Remediation) Regulations 2009;
- The Town and Country Planning Act, 1990 (as amended); and

8.3.3 Under Part 2A of the EPA 1990 sites are identified as ‘contaminated land’ if they are causing harm or if there is a significant possibility of significant harm or if the site is causing, or could cause, significant pollution of controlled waters. Part 2A mostly applies to the existing use of the site and its enforcement is the responsibility of the Local Planning Authority. As a minimum, newly developed sites should not be able to be classed as contaminated land as defined by Part 2A of the EPA 1990.

8.3.4 The EPA 1990 endorses the principle of a ‘suitable for use’ approach for contaminated land, where remedial action is only required if there is an unacceptable risk to human health or risk of pollution of the environment, taking into account the use of the land and its environmental setting. Statutory Guidance on contaminated land guidance describes a risk-based approach based on a ‘source-pathway-receptor’ model of the site. For the land to be determined as contaminated in a regulatory sense, and thereby require remediation, all three elements (a source of contamination, a receptor and a pathway by which the receptor could be exposed to the contamination) must be present.

8.3.5 The Contaminated Land (England) Regulations 2006 elaborate on various details of the Part 2A regime, such as dealing with ‘special sites’; public registers; remediation notices; and the rules for appeals and are amended by the Contaminated Land (England) (Amendment) Regulations 2012.

8.3.6 The Water Act 2003 amended the Water Resources Act 1991 and makes numerous provisions, including those related to contaminated land. The Water Act 2003 (and various commencement orders) brings into effect changes to the definition of contaminated land in the EPA 1990 so that, in relation to the pollution of controlled waters, for land to be determined as contaminated land it must cause significant pollution or there must be a significant possibility of such pollution of controlled waters.

8.3.7 The Water Resources Act 1991 (as amended) seeks to protect the quality of water by setting out the functions of the Environment Agency and describing offences relating to water and discharges to it.

8.3.8 The Environmental Damage (Prevention and Remediation) Regulations 2009 implement the European Union Directive (2004/35) in respect of environmental
liability and remediing environmental damage. They introduced obligations to ensure that the polluter pays for damage caused, supplementing existing legislation. Various enforcing authorities include the Environment Agency in relation to damage to water, Natural England in relation to biodiversity and LPAs in relation to land damage.

8.3.9 The National Planning Policy Framework (NPPF) states in Section 11, paragraph 120 'Conserving and Enhancing the Natural Environment' that '…where a site is affected by contamination, responsibility for securing a safe development rests with the developer and/or landowner'.

8.3.10 The NPPF states in paragraph 121 that local 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'.

8.3.11 This is consistent with the requirement that a development site granted planning consent should not be able to be classed as contaminated land under Part 2A of the EPA 1990 when the site is occupied and in use (paragraph 121 of the NPPF).

8.3.12 It is also stated in paragraph 17 of the NPPF that within the overarching roles that the planning system ought to play, a set of core land-use planning principles should underpin both plan-making and decision-taking. These include contributing to the conservation and enhancement of the natural environment and to the reduction of pollution.

8.3.13 Section 11, paragraph 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, or water pollution and remediating and mitigating despoiled, degraded, derelict and contaminated land, where appropriate.'

8.3.14 Planning Practice Guidance was published in March 2014 to reflect the requirements of the NPPF in respect of land affected by contamination 1. The guidance deals primarily with matters of concern for local planning authorities and the role of planning in dealing with land contamination. It confirms that a contaminated land risk assessment is required to inform an Environmental Impact Assessment where this is a planning requirement and that the minimum requirement is the report of a desk study and walkover and a conceptual model. The Planning Practice Guidance also indicates that local planning authorities may use planning conditions to secure the submission of remediation schemes for approval and the validation of remedial works when they are complete. Planning conditions may also specify a system for notifying the planning authority of key stages in the process and reporting of unexpected contamination and responses to it.

Local

8.3.15 The adopted London Plan 2011 is the overall strategic plan for London and sets out a fully integrated economic, environmental, transport and social framework for the development of the capital to 2031.

8.3.16 Policy 5.21 ‘Contaminated Land’ of the London Plan 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; appropriate measures should be taken to ensure that development on previously contaminated land does not activate or spread contamination; and Local development frameworks (LDF) should encourage the remediation of contaminated sites and set out policy to deal with contamination'.

8.3.17 The Minor Early Alterations to the London Plan 2013 adds a new paragraph (5.95A) to Policy 5.21 described above stating that where potentially contaminating activities are proposed, development should include appropriate measures to mitigate any potential harmful effects.

8.3.18 The London Plan also addresses Geological Conservation. Policy 3D.16 states that 'the Mayor will work with partners to ensure the protection and promotion of geodiversity. Boroughs should:

- accord the highest protection to nationally designated sites (SSSIs) in accordance with Government guidance
- give strong protection in their DPDs (Development Plan Documents) to Regionally Important Geological Sites (RIGS) which, in addition to nationally designated sites, includes sites of strategic importance for geodiversity across London'.

8.3.19 Core Policy 32 of the Enfield Plan Core Strategy 2010 – 2025 states that 'The Council will work with its partners to minimise air, water, noise and light pollution and to address the risks arising from contaminated land and hazardous substances. In particular, new development will be required to address the risks arising from contaminated land through land remediation so that it is suitable for the proposed end use. Proposals on or in the vicinity of potentially contaminated land will be assessed according to criteria set out in the Development Management Document'.

8.3.20 Policy DMD 64 of the Proposed Submission Development Plan Document states that 'Developments will only be permitted if pollution and the risk of pollution is prevented, or minimised and mitigated during all phases of development, including demolition/decommissioning, construction, operations/occupation and maintenance'.

8.3.21 Policy DMD 66 on Land Contamination and Instability states that:

- 'Planning permission will be refused if there are unacceptable risks of contamination and land instability which are not addressed through remediation. Development will only be permitted where appropriate remediation is undertaken to make the development safe.
- All development on land which is or may be affected by contamination and/or instability must be accompanied by assessments to ensure that any risks are identified.
- An initial assessment should be undertaken for all development to assess a. the previous uses of the site; b. the potential for contamination and/or land instability; and c. any risks.
- In circumstances where the initial assessment identifies contamination risks or land instability, the Council will require the developer to provide more detailed investigations/studies to determine the level of contamination, assess the risks and provide details of a remediation and management strategy. On site remediation (treatment in-situ or
ex-situ) of contaminated soils will be encouraged, where appropriate, to reduce waste sent to landfill.

- The Council will impose planning obligations/conditions to ensure that remediation of the site is secured, the level of remediation is suitable for its intended end use, and the development is safe.'

8.4 Assessment Methodology

Impact Evaluation

8.4.1 The principal guidance document on managing contaminated land is Contaminated Land Report 11 (CLR11), published by the Environment Agency. This provides a technical framework for identifying and remediating contaminated land through the application of a risk management process. CLR11 also sets out the approach to remediation of contaminated land.

8.4.2 The question of whether risk is unacceptable in any particular case involves not only scientific and technical assessments, but also appropriate criteria to judge the risk and conclude on exactly what risk would be unacceptable.

8.4.3 The process of risk assessment is summarised as follows:

- Develop a Conceptual Site Model – carry out a desk study review of available documentary information and identify the potential sources, pathways and receptors relevant to the site, and the potential pollutant linkages.
- Gather site-specific information on the Conceptual Site Model – through site investigation, gather information on the nature and extent of contamination, details of pathways for migration of contamination, specific information on the receptors to update the model.
- Risk assessment – apply criteria that will enable a judgement as to whether the concentrations of contaminants in soil represent an unacceptable risk. These criteria must be relevant to each pollutant linkage, and can be generic (conservative) criteria, or can be site-specific (less conservative). Generic assessment criteria are concentrations of a contaminant in soil below which the risk is acceptable. Site-specific assessment criteria are concentrations of a contaminant in soil above which there is likely to be an unacceptable risk.

8.4.4 If a site passes based on the application of generic assessment criteria, then it is likely that no remedial action is required. If a site fails, then there may be a benefit in gathering further information and deriving site specific assessment criteria. If a site also fails on the application of site specific criteria, then remedial action will be required. Alternatively, a decision to remediate can be based on generic criteria as these are likely to be more conservative than site-specific criteria. In general, this is the approach taken in this assessment.

8.4.5 The Environment Agency has published extensive guidance on the technical aspects of risk assessment, which forms the recognised basis of the UK approach to identifying whether land affected by contamination presents an unacceptable risk. Derivation of relevant assessment criteria is done using the Contaminated Land Exposure Assessment model. The Environment Agency has published a number of generic assessment criteria in the form of Soil Guideline Values for a number of contaminants, while a wide range of generic values have been published independently by various agencies using CLEA. The principal sources of generic

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criteria used in the assessment are EIC/AGS/CL:AIRE\(^3\) and the Chartered Institute of Environmental Health\(^4\).

8.4.6 Risks arising from gas in the ground would be assessed and managed in accordance with the guidance in Construction Industry Research and Information Association (CIRIA) report C665\(^5\).

8.4.7 CIRIA defines Gas Screening Values (GSVs) which are calculated by multiplying the maximum concentration of the gas detected in borehole sampling by the measured flow rate to give a value expressed in litres per hour. Threshold values are given for a range of six risk classifications (termed Characteristic Situations) ranging from very low (<0.07 l/h) to very high (>70 l/h).

**Significance of Impacts**

8.4.8 For the purposes of the EIA, the assessment of likely significant effects and likely residual effects will be based on significance criteria derived in line with the good practice provided in the CIRIA Report C552. The criteria consider controlled waters, human health, ecological and property receptors listed in the contaminated land statutory guidance and Environment Agency Model Procedures (CLR11).

8.4.9 The significance criteria are shown in Table 8.1.

**Table 8.1 Significance Criteria for Contaminated Land**

<table>
<thead>
<tr>
<th>Effect</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Major adverse</td>
<td>Severe or irreversible detrimental effect to human health. Severe temporary or irreversible reduction in the quality of a potable groundwater or surface water resource of local, regional or national importance. Irreversible or severe temporary detrimental effect on animal or plant populations. Irreversible detrimental effect to nationally important geological feature. Irreversible detrimental effect to building structure resulting in collapse or demolition.</td>
</tr>
<tr>
<td>Moderate adverse</td>
<td>Long-term minor or short-term moderate detrimental effect to human health. A minor or moderate, local-scale reduction in the quality of potable groundwater or surface water resources of local, regional or national importance, reversible with time. Reversible widespread reduction in the quality of groundwater or surface water resources used for commercial or industrial abstractions. Medium-term, reversible detrimental effect on animal or plant populations. Medium-term, reversible detrimental effect to nationally important geological feature. Detrimental effect to building structure requiring remedial engineering works.</td>
</tr>
<tr>
<td>Minor adverse</td>
<td>Short-term minor detrimental effect to human health. A minor or moderate temporary detrimental effect in the quality of groundwater or surface water resources that are used for, or have the potential to be used for, commercial or industrial abstractions. Short-term reversible detrimental effect on animal or plant populations. Short-term reversible detrimental effect to nationally important geological feature. Detrimental effect to building structures not requiring remedial engineering works.</td>
</tr>
<tr>
<td>Negligible</td>
<td>No appreciable effect on human, animal or plant health, potable groundwater or surface water resources or geological features of importance.</td>
</tr>
</tbody>
</table>

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### 8.5 Baseline

#### Introduction

8.5.1 The study area covers both the site of the Deephams Sewage Works itself and a surrounding area of search for baseline data up to 500m from the site boundary of the sewage works. A buffer zone of 500m is considered sufficient to identify any potential sources of contamination outside the site boundary which could result in the migration of contaminants into the Site.

8.5.2 The following description of the existing environment on and in the vicinity of the Site is based on a Geotechnical and Geoenvironmental Constraints Report prepared by Hyder Consulting Ltd for the Deephams Sewage Works Upgrade (dated August 2011) and an updated historical mapping and data report in the form of a Landmark Envirocheck report dated October 2013. The Hyder report is included as Appendix 8.1 and the historical mapping and data report is included as Appendix 8.2.

8.5.3 Additional information that has informed the establishment of baseline conditions appears in a series of reports referenced and summarised in the Geotechnical and Geoenvironmental Constraints report:

- Thames Water Utilities Limited, Deephams Sewage Works Inlet Works Improvement – Interpretative Report on Ground Investigation (R02, May 2009);
- Faber Maunsell Limited, Deephams Sewage Treatment Works – Geotechnical and Geo-environmental Desk Study Report (Final Issue, January 2009); and,

8.5.4 Relevant information from these reports is included in the following description of baseline conditions.

8.5.5 The Site is an operational sewage treatment works, occupied by primary settlement tanks, aeration tanks, final settlement tanks, and other related buildings, plant and equipment. The western third of the Site comprises an area of cleared and levelled ground previously occupied by 12 disused sludge digesters in the north, and an inlet works area comprising various chambers, pumping stations, screening and grit plants, storm tanks and ancillary structures in the central and southern part. The southern portion of the Site is occupied by the sludge treatment plant.
8.5.6 Ground level across the Site varies typically between about 9.5m above ordnance datum (AOD) and 15.0 m AOD. The maximum height of bunds on the Site is 17.3m AOD.

8.5.7 A review of historical Ordnance Survey mapping dating back to the mid-19th century (see Appendix 8.2) indicates that the Site has been used as a sewage works since the late 1800s. Prior to this the Site comprised farmland. Initially, only the southern and eastern section of the Site was occupied by plant, but by 1960 the sewage works was developed to its current layout.

8.5.8 Off site, the Great Eastern Railway, across Meridian Way to the west of the site, was present in its current location by 1879. The William Girling Reservoir to the east of the Site was under construction by 1936. Two gravel pits were in existence to the north of the Site in 1935 but were decommissioned and replaced by works by 1965. Two artificial ponds were located south of the Site in 1960 but were infilled by 1991. Two sludge lagoons were located to the south of the Site until at least 1991.

8.5.9 The area to the south of the sewage works is occupied by commercial/light industrial land uses including warehouses, repair centres, scrap yards and the London Waste EcoPark which incorporates a waste incineration plant and green waste composting plant (approximately 700m to the south). Historical land uses in this area included a leather cloth works, lead shot works, flooring preservatives manufacturers, chemical manufacturers, metal manufacturers, paper manufacturers, gas manufacturers and precast concrete manufacturers.

8.5.10 One area of historical landfilling is recorded on site at the present location of the secondary digesters, dewatering plant and sludge cake storage in the south-east corner of the Site (waste deposited until 1971 included ‘refuse and controlled waste’). Three other areas of historical landfilling are recorded within 500m of the Site. These include the area of Lee Valley Leisure Complex to the north of the Site (waste deposited from 1979 to 1985 included inert and household waste, liquid/sewage sludge, pulverised refuse and ashes), part of the area currently occupied by commercial warehouses to the south of the Site (waste deposited from 1952 and 1971 included household waste) and the area bounded by Montagu Road and Meridian Way to the west of the Site (waste deposited from 1958 to 1965 included inert and industrial waste and liquid/sewage sludge).

8.5.11 The Site itself is overlain with made ground of variable thickness up to 5.8m below ground level.

8.5.12 A desk study reported by Hyder Consulting Ltd in the Geotechnical and Geo-Environmental Constraints report (Appendix 8.1) indicated that there is a moderate risk from unexploded ordnance. Although no unexploded ordnance has ever been found on site and it is considered a remote possibility that there is any present, the potential consequences of detonating unexploded ordnance were considered so significant that a moderate risk rating was justified. This conclusion was based on the findings of an earlier report by RPS. However, the scope of works considered by the assessment was different from the current proposals and the method of assessment was not in accordance with current good practice. Therefore, the conclusions lacked validity and a new assessment was required. An updated unexploded ordnance risk assessment is included within the Construction Environmental Management Plan attached as Appendix 5.3.

8.5.13 Baseline conditions are not expected to change significantly between those described in previous reports (paragraph 8.5.2) and the commencement of the operation of the Upgrade because:

- The Site will continue in operation during the Upgrade works;
• the geology and ground conditions are stable;
• most of the contamination present is as a result of historical incidents; and
• there are no significant continuing sources of soil contamination at the Site or on
  nearby sites with a significant potential to cause future migration of contaminants
  into the Site.

8.5.14 AMP5 works on the Site are either to take place in areas which are not
contaminated according to the criteria set out in this chapter of the E S, or will
involve excavation of soil or fill with low levels of contaminants which will be
removed from site prior to the Upgrade commencing. The baseline therefore
assumes that the AMP5 works are in place.

8.5.15 The only exception to this is the possibility that levels of carbon dioxide and
methane in the ground the will change over time. Areas outside the site boundary
that were formerly landfilled with putrescible waste may continue to produce gas.
However, the rate of gas production falls exponentially with time so that gas levels
in the Site influenced by these waste deposits are likely to fall over time. There are
no new sources of ground gases that could cause gas levels to increase within the
Site. Therefore any measures designed to mitigate impacts of current levels of gas
are expected to be more than sufficient to mitigate the effects of gas level in the
future.

**Sensitive Receptors**

8.5.16 The sensitive receptors potentially at risk of exposure to contaminated land are
listed in Section 8.6, below, as part of the initial conceptual model of the Site.

8.5.17 According to the criteria in **Table 8.1**, geological features of importance are
potential receptors for contaminated land impacts. Sites of Geological
Conservation Value (a term which has no statutory meaning) are locally designated
sites. According to Natural England⁶:

‘The term Local Geological Site (previously Regionally Important
Geological/geological Site (RIGS)), as recommended in the Defra Local Sites
Guidance below, is now widely adopted. Local Geological Sites are selected
by voluntary geoconservation groups, such as RIGS Groups⁷ and Geology
Trusts, which are generally formed by county or unitary authority area in
England. The sites are selected on a local basis according to nationally
agreed criteria’.

8.5.18 The local RIGS group is the London Geodiversity Partnership. This covers all
London boroughs including Enfield. The London Geodiversity Partnership published
their Geodiversity Action Plan in 2012⁸ and this listed candidate RIGS and Local
Geological Sites as at 2009. However, there are none in Enfield. LBE’s
Development Planning Document and its related policies map do not mention
RIGS or Local Geological Sites and there are no policies for the Site itself which
relate to such designations. Therefore, potential impacts on geological features are
not considered further.

**Baseline Limitations**

8.5.19 As with any assessment based on a finite number of samples taken from different

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locations across the Site there is a risk that unidentified contamination could be present. This possibility, together with appropriate management responses, is addressed in the section on mitigation, below.

8.6 Impact Assessment

Site Enabling, Demolition and Construction

Initial Conceptual Model

8.6.1 The potential impacts of contaminated land will be assessed based on a conceptual model of the Site. This is based on the source - pathway - receptor concept described in Section 8.3.4.

8.6.2 The following sources of contamination, potential receptors of this contamination and the potential pathways linking the two have been identified based on work undertaken to date:

8.6.3 On site sources

- Underground fuel storage tanks;
- above ground fuel storage tanks – including fuel oil (connected to generators with underground pipes); waste oil; lubricating oil;
- skips – used for storage of waste;
- electrical sub-station (possible use of polychlorinated biphenyls as dielectric fluids);
- transformers - with cables extending into ground;
- sewage - overflow or leakage of pipes (some evidence on site);
- historical landfilling of former sand and gravel quarry (recorded as ‘refuse and controlled waste’);
- storage of construction materials and machinery;
- Category 2 pollution incident relating to sewage discharge from Sewage Works;
- storage of hazardous substances at Sewage Works; and
- sludge lagoons.

Off site sources

- Historic landfills to north, south and west;
- waste transfer station and treatment plant to south;
- modern commercial/ light industrial land uses to south e.g. warehouses and repair centres; scrap metal yards, waste incineration plant;
- historical commercial/ light industrial land uses to south e.g. leather cloth works, lead shot works, flooring preservatives, battery manufacturers, chemical manufacturers, metal manufacturers, paper manufacturers, gas manufacturers, precast concrete manufacturers; and
- railway to west.

8.6.4 Contaminants associated with these sources were identified to include:
Hydrocarbons (diesel, fuel oil, lubricating oils, paraffin, waste oils); polycyclic aromatic hydrocarbons (PAHs); polychlorinated biphenyl (PCBs); solvents; alum (aluminium sulphate being major component); ash and fill (metals, phenols, sulphates, PAHs); sulphates; nutrients (nitrates and phosphate); pathogens; and flocculants.

Potential Pathways

- Surface water run-off into surface water features;
• migration of leachable contaminants from Made Ground into shallow aquifer;
• migration of contaminants within groundwater in shallow aquifer into surface water features;
• creation of preferential pathway between shallow aquifer and deep aquifer if London Clay Formation penetrated;
• dermal contact / ingestion / inhalation of dust, soil or liquids;
• inhalation of ground gases, vapours and dust;
• migration of ground gases and vapours;
• dissolution of ground gases into groundwater; and
• direct contact of aggressive contaminants with concrete or pipes.

Potential Receptors

**Controlled waters:**
- Shallow Secondary A Aquifer underlying site (River Terrace Deposits);
- Deep Secondary A Aquifer underlying the Site (Lambeth Group and Thanet Sands);
- Deep Principal Aquifer underlying the site (Seaford Chalk) with associated potable water supply extractions within 1km/SPZ II;
- sludge lagoon next to treatment tanks in south of the Site;
- concrete lined drain leading from the Site to Salmons Brook (from surface water run-off);
- Salmons Brook to south of site;
- River Lee Navigation Canal to east;
- Brimsdown Ditch and Enfield Ditch.

**Human health:**
- construction workers;
- future site operators; and
- adjacent site users and residents.

**Construction materials and structures:**
- concrete; and
- pipes.

**Ecological Receptors:**
- Terrestrial ecology (particularly the Lea Valley Site of Metropolitan Importance for Nature Conservation adjacent to the eastern boundary of the site); and
- Aquatic ecology (see Controlled Waters, above).

**Soil Chemical Contamination**

8.6.5 A comprehensive Ground Investigation was undertaken for Thames Water by Structural Soils Ltd, under instruction from Hyder Consulting Ltd. during August 2012. The factual report, which sets out details of the sampling and analysis undertaken, is provided in Appendix 8.3. Not all of the appendices to the factual report are included. However, the sampling positions are shown on a plan of the Site in Appendix 8.4 and the results of chemical testing of soil and groundwater samples are provided in Appendix 8.5. Ground conditions are not expected to have changed since 2012 for the reasons set out in paragraph 8.5.13 above.

8.6.6 Where contaminants in soil samples have been detected at levels above the analytical detection limit of the methods used for testing, their concentrations have been screened against relevant assessment criteria. The criteria used were Environment Agency Soil Guideline Values, Generic Assessment Criteria published by CL:AIRE/EIC/AGS and LQM/CIEH and Site Specific Values referenced in the Hyder report. These criteria were all derived using the latest version of the Contaminated Land Exposure Assessment software. For each contaminant there
are a range of published criteria which relate to different end uses of the land. The criteria used in this assessment are those which correspond to a commercial end use for the development. Where the relevant criterion for a particular contaminant varies according to the soil organic matter concentration, initial screening has been against the most stringent value (generally a soil organic matter concentration of 1%).

8.6.7 The analytical detection limits reported by the testing laboratory are generally lower than the relevant Soil Guideline Values or Generic Assessment Criteria so that where contaminant concentrations in soil fall below the analytical detection limit they would also fall below the relevant criteria.

8.6.8 The relevant guideline values or assessment criteria are used both for the assessment of risks to construction workers and future site users in the longer term, i.e. they apply for both construction and operational phases of the proposed development.

8.6.9 Only one sample, taken at a depth of 2.5 m below ground level in borehole 18, contained levels of contaminants above the relevant guideline value. In this sample, the concentration of benzo[a]pyrene was elevated above the guideline value by a factor of about 2.4.

8.6.10 A summary of the principal guideline values used and the maximum concentrations of contaminants found in the soil samples, noting any exceedances, is shown in Table 8.2.

8.6.11 Figure 8.1 shows the locations of boreholes excavated during the 2012 ground investigation (Appendices 8.3 - 8.5) in which concentrations of contaminants exceeded the relevant criteria. Figure 8.1 also shows locations where asbestos was found (see paragraph 8.6.15, below) and where PAH contamination of groundwater was found (see paragraph 8.6.24 and Table 8.3). Marginal exceedances of the adopted criteria for groundwater are not shown for the reasons set out in paragraph 8.6.28, below.

Table 8.2: Summary of Soil Testing Data and Comparison with Risk Assessment Criteria

<table>
<thead>
<tr>
<th>Determinand</th>
<th>Maximum value (mg/kg)</th>
<th>Guideline Value (mg/kg) for commercial end use</th>
<th>Source</th>
<th>Exceedances</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asbestos</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>pH (min/max)</td>
<td>7.4 - 7.71</td>
<td>N/A</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>Total cyanide</td>
<td>12</td>
<td>34</td>
<td>SSV, 1% SOM</td>
<td></td>
</tr>
<tr>
<td>As</td>
<td>26</td>
<td>640</td>
<td>Environment Agency SGV</td>
<td></td>
</tr>
<tr>
<td>Cd</td>
<td>16.6</td>
<td>230</td>
<td>Environment Agency SGV</td>
<td></td>
</tr>
<tr>
<td>Cu</td>
<td>937</td>
<td>N/A</td>
<td>No limit (phytotoxicity only)</td>
<td></td>
</tr>
<tr>
<td>Cr</td>
<td>116</td>
<td>330</td>
<td>SSV assuming 100% Cr (VI)</td>
<td></td>
</tr>
<tr>
<td>Pb</td>
<td>930</td>
<td>6,490</td>
<td>SSV, 1% SOM</td>
<td></td>
</tr>
<tr>
<td>Hg</td>
<td>2.54</td>
<td>4.3</td>
<td>SGV, assuming worst case</td>
<td></td>
</tr>
<tr>
<td>Determinand</td>
<td>Maximum value (mg/kg)</td>
<td>Guideline Value (mg/kg) for commercial end use</td>
<td>Source</td>
<td>Exceedances</td>
</tr>
<tr>
<td>----------------------</td>
<td>-----------------------</td>
<td>-----------------------------------------------</td>
<td>-------------------------------------------------</td>
<td>-----------------</td>
</tr>
<tr>
<td>Ni</td>
<td>103</td>
<td>1,800</td>
<td>CIEH/LQM GAC</td>
<td></td>
</tr>
<tr>
<td>Se</td>
<td>5</td>
<td>13,000</td>
<td>Environment Agency SGV</td>
<td></td>
</tr>
<tr>
<td>Zn</td>
<td>1,730</td>
<td>N/A</td>
<td>No limit (phytotoxicity only)</td>
<td></td>
</tr>
<tr>
<td>TPH</td>
<td>845</td>
<td>8,300</td>
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<td></td>
</tr>
<tr>
<td>Ethylbenzene</td>
<td>4</td>
<td>17,000</td>
<td>CL:AIRE/EIC/AGS GAC</td>
<td></td>
</tr>
<tr>
<td>m- &amp; p-xylene</td>
<td>11</td>
<td>576</td>
<td>CL:AIRE/EIC/AGS GAC</td>
<td></td>
</tr>
<tr>
<td>o-xylene</td>
<td>1</td>
<td>478</td>
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<tr>
<td>Acenaphthene</td>
<td>2.47</td>
<td>57</td>
<td>CL:AIRE/EIC/AGS GAC</td>
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</tr>
<tr>
<td>Acenaphylene</td>
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<td>86</td>
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<tr>
<td>Anthracene</td>
<td>3.77</td>
<td>530,000</td>
<td>CL:AIRE/EIC/AGS GAC</td>
<td></td>
</tr>
<tr>
<td>Benzo[a]anthracene</td>
<td>33.5</td>
<td>90</td>
<td>CL:AIRE/EIC/AGS GAC</td>
<td></td>
</tr>
<tr>
<td>Benzo[a]pyrene</td>
<td>33</td>
<td>14</td>
<td>CIEH/LQM GAC</td>
<td>BH18, 2.5m</td>
</tr>
<tr>
<td>Benzo[bj]fluoranthene</td>
<td>38</td>
<td>100</td>
<td>CL:AIRE/EIC/AGS GAC</td>
<td></td>
</tr>
<tr>
<td>Benzo[ghil]perylene</td>
<td>25.5</td>
<td>650</td>
<td>CL:AIRE/EIC/AGS GAC</td>
<td></td>
</tr>
<tr>
<td>Benzo[kj]fluoranthene</td>
<td>7.54</td>
<td>140</td>
<td>CL:AIRE/EIC/AGS GAC</td>
<td></td>
</tr>
<tr>
<td>Chrysene</td>
<td>31.5</td>
<td>140</td>
<td>CL:AIRE/EIC/AGS GAC</td>
<td></td>
</tr>
<tr>
<td>Dibenzo[a,h]anthracene</td>
<td>3.22</td>
<td>13</td>
<td>CL:AIRE/EIC/AGS GAC</td>
<td></td>
</tr>
<tr>
<td>Fluoranthene</td>
<td>103</td>
<td>23,000</td>
<td>CL:AIRE/EIC/AGS GAC</td>
<td></td>
</tr>
<tr>
<td>Fluorene</td>
<td>2.81</td>
<td>31</td>
<td>CL:AIRE/EIC/AGS GAC</td>
<td></td>
</tr>
<tr>
<td>Indeno[1,2,3-cd]pyrene</td>
<td>21.8</td>
<td>60</td>
<td>CL:AIRE/EIC/AGS GAC</td>
<td></td>
</tr>
<tr>
<td>Naphthalene</td>
<td>0.37</td>
<td>200</td>
<td>CL:AIRE/EIC/AGS GAC</td>
<td></td>
</tr>
<tr>
<td>Phenanthrene</td>
<td>27.9</td>
<td>22,000</td>
<td>CL:AIRE/EIC/AGS GAC</td>
<td></td>
</tr>
<tr>
<td>Pyrene</td>
<td>85.2</td>
<td>54,000</td>
<td>CL:AIRE/EIC/AGS GAC</td>
<td></td>
</tr>
<tr>
<td>n-dibutyl phthalate</td>
<td>0.37</td>
<td>15,400</td>
<td>SSV, 1% SOM</td>
<td></td>
</tr>
<tr>
<td>4-methylphenol</td>
<td>0.13</td>
<td>185,000</td>
<td>SSV, 1% SOM</td>
<td></td>
</tr>
<tr>
<td>Dichloromethane</td>
<td>0.13</td>
<td>116</td>
<td>SSV, 1% SOM</td>
<td></td>
</tr>
</tbody>
</table>
Legend
- Borehole location
- Dynamic probe location
- A Asbestos fibres found
- G Groundwater contaminated by elevated PAH
- S Soil contaminated by PAH

Figure 8.1

Site boundary

Not all locations are approximate

Note: All locations are approximate

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Project Title:
Deephams Sewage Works Upgrade

For Information Only

Figure Title:
Borehole locations

Figure 8.1  June 2014
8.6.12 These findings are broadly consistent with the conclusions of the Hyder report in Appendix 8.1, which found that almost all concentrations of contaminants were below the relevant criteria for commercial/industrial use. They noted that there was an elevated lead concentration at one location within the Site near the inlet works and at several locations outside the site boundary and elevated PAH concentrations immediately to the south of the Site (although the PAH data were not in a suitable form to make a direct comparison with the Generic Assessment Criteria). It should be noted that criterion used by Hyder for comparison with the elevated lead level was a former Environment Agency Soil Guideline Value which had been formally withdrawn but not replaced or updated. Since then, a new Generic Assessment Criterion for lead has been published and this is higher than the reported elevated lead level. The Site would therefore not be considered to be contaminated by lead when judged against this new criterion.

8.6.13 Where contaminants are present at levels above the relevant criteria or guideline values they may be considered to pose a potential risk to human health should people come into contact with the soils for prolonged periods of time. However this is considered unlikely given that the Site is accessible to construction workers and Thames Water staff only during the construction phase of the project and only the latter during the operational phase. There is no public access or right of way over the Site.

8.6.14 The levels of contaminants in soil samples from boreholes close to the Site of Metropolitan Importance for Nature Conservation do not exceed relevant criteria or guideline values and therefore potential effects on the ecology of this site are expected to be negligible.

8.6.15 Contaminant levels above the relevant criteria or guideline values are not noted for their potential adverse effects on construction materials, such as corrosion.

8.6.16 Prior to mitigation of impacts, the significance of potential effects of soil contamination are considered to be minor adverse in accordance with the criteria in Table 8.1.

Asbestos

8.6.17 Seven samples taken from the Made Ground within the inlet works area of the Site were screened for asbestos (May 2009). No asbestos was identified. During the 2012 ground investigation asbestos was identified in four locations in boreholes 3, 6, 13 and 17.

8.6.18 Assessment of risks from asbestos is based on simple presence or absence criteria. Prior to mitigation of impacts, the significance of effects of soil contamination are considered minor adverse in accordance with the criteria in Table 8.1.

Ground Gases

8.6.19 Monitoring of gas in the ground was undertaken during the 2009 investigations. Concentrations of carbon dioxide above the short term (1.5%v/v) and long term (0.5%v/v) Occupational Exposure Limits specified by the Health and Safety Executive (HSE EH40) were detected within the ground at both areas where ground gas monitoring was completed the (inlet works area of site and the area to the south of the Site).

8.6.20 Depleted oxygen concentrations were also recorded within both areas and concentrations of methane above the lower explosive limit of 5%v/v were detected within the ground to the south of the Site.

8.6.21 During the intrusive investigations, sources of ground gas such as organic material
within the Alluvium, peat, and black oily domestic and industrial waste were also noted, which could give rise to elevated concentrations of ground gas. Organic and ‘pungent’ odours were also noted. Not all of the monitoring standpipes were installed to record gas levels from the Made Ground, so there is a risk that the Made Ground could also be a source of ground gases.

8.6.22 Based on the available ground gas monitoring results, a risk to the health of construction workers is considered to exist at the Site, which would require the adoption of appropriate mitigation measures during the construction phase of the proposed development.

8.6.23 Flow rates recorded on site were relatively low, the maximum recorded being 0.2 l/hr, but flow rates were not available for the area to the south of the Site where the highest concentrations of ground gas were recorded.

8.6.24 Nevertheless, carbon dioxide concentrations greater than 5%v/v and methane concentrations greater than 1%v/v were recorded in the south of the Site, therefore, according to the CIRIA C665 guidance, the risks posed by gas in the ground would be equivalent to ‘Characteristic Situation 2’, which carries a risk classification of ‘low risk’.

8.6.25 Prior to any mitigation, the impacts of ground gases are rated minor adverse.

**Groundwater**

8.6.26 Concentrations of contaminants in groundwater samples taken from the Site investigation boreholes are provided in Appendix 8.5. Maximum contaminant concentrations where these exceeded the analytical detection limit are summarised in Table 8.3.

8.6.27 There are no directly relevant standards for perched groundwater on potentially contaminated sites where the groundwater itself is not abstracted for sensitive uses, such as for potable supply or crop irrigation. The shallow or perched groundwater in and around the Site is not abstracted locally for any uses within 1 km of the Site. Therefore the only waters potentially at risk from contaminants dissolved in perched groundwater at the Site is the drainage ditch that runs along the northern boundary of the Site (Enfield Ditch Tributary) and the deep chalk aquifer beneath the Site.

8.6.28 In order to provide context for the levels of contaminants recorded in groundwater samples, the Environment Agency Environmental Quality Standards for Inland Surface Waters are shown for comparison.

8.6.29 For the most part, the groundwater on the Site is relatively uncontaminated. Cadmium, mercury, petroleum hydrocarbons and a wide range of volatile and semi-volatile organic compounds, including halogenated species, phenols and benzene, toluene, ethylbenzene and xylenes are all below the detection limit.

8.6.30 Where the Environmental Quality Standards are exceeded, this is marginal in most cases (cyanide, sulphate and heavy metals). Since the Environmental Quality Standards are receiving water quality criteria, not discharge standards, and could be met in the cases of these exceedances if a dilution factor of only two were to be applied, it is very unlikely that a sensitive surface or groundwater receptor could be adversely affected by these contaminants in groundwater at the Site.

8.6.31 Exceedances of the Environmental Quality Standards for PAHs, including benzo[a]pyrene, were found in groundwater from only one borehole (BH8). The

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margin of exceedance was only a factor of 0.2 in the case of benzo[a]pyrene. However, for benzo[ghi]perylene and indeno[123-cd]pyrene the total concentration exceeded the EQS by a factor of forty in one borehole which is located in the centre of the Site. Groundwater in boreholes closer to the Enfield Ditch Tributary at the northern boundary of the Site is relatively uncontaminated.

8.6.32 The Hyder geotechnical and geoenvironmental constraints report concluded that the risk posed by contaminated groundwater to the Principal Aquifer underlying the Site and associated abstraction points is low, due to the considerable thickness of London Clay present continuously across the Site. However, the piling design for the upgrade works could involve piling to depths of up to 20 m. In parts of the Site piles could penetrate the base of the London Clay and extend into the Lambeth beds, although they will not extend to the depth of the Thanet Sands and Gravel, which may be in hydraulic continuity with the underlying chalk aquifer. Although contamination of the shallow groundwater on the Site is highly localised, piling in the general area of contaminated groundwater could create a migration pathway to the major aquifer.

8.6.33 Based on the above assessment, the potential environmental effects of the contaminated groundwater are rated moderate adverse without mitigation.

Table 8.3 Summary of Groundwater Testing Data and Comparison with Risk Assessment Criteria

<table>
<thead>
<tr>
<th>Determinand</th>
<th>Maximum value (mg/kg)</th>
<th>Environmental Quality Standard for Inland Surface Watersa</th>
<th>Exceedances</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total cyanide</td>
<td>9</td>
<td>5 (95% ile)</td>
<td>BH2A, 4, 9, 10</td>
</tr>
<tr>
<td>Sulphate</td>
<td>555,000</td>
<td>400,000</td>
<td>BH2A, 10</td>
</tr>
<tr>
<td>As</td>
<td>9</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>Cu</td>
<td>44</td>
<td>28b</td>
<td>BH13</td>
</tr>
<tr>
<td>Cr</td>
<td>20</td>
<td>32 (95% ile)c</td>
<td></td>
</tr>
<tr>
<td>Pb</td>
<td>21</td>
<td>7.2</td>
<td>BH13</td>
</tr>
<tr>
<td>Ni</td>
<td>55</td>
<td>20</td>
<td>BH13</td>
</tr>
<tr>
<td>Zn</td>
<td>413</td>
<td>125d</td>
<td>BH12, 13, 14, 15, 17, 18,</td>
</tr>
<tr>
<td>Naphthalene</td>
<td>0.03</td>
<td>2.4</td>
<td></td>
</tr>
<tr>
<td>Benzo[b]fluoranthene</td>
<td>0.20</td>
<td>0.03 (sum)</td>
<td>BH8</td>
</tr>
<tr>
<td>Benzo[k]fluoranthene</td>
<td>0.07</td>
<td></td>
<td>BH8</td>
</tr>
<tr>
<td>Benzo[a]pyrene</td>
<td>0.12</td>
<td>0.1 (MAC)d</td>
<td>BH8</td>
</tr>
<tr>
<td>Benzo[ghi]perylene</td>
<td>0.03</td>
<td>0.002 (sum)</td>
<td>BH8</td>
</tr>
<tr>
<td>Indeno[123-cd]pyrene</td>
<td>0.05</td>
<td></td>
<td>BH8</td>
</tr>
<tr>
<td>Fluoranthene</td>
<td>4.47</td>
<td>1 (MAC)d</td>
<td>BH8</td>
</tr>
<tr>
<td>n-Dibutyl phthalate</td>
<td>2</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Diethyl phthalate</td>
<td>1</td>
<td>200</td>
<td></td>
</tr>
</tbody>
</table>

a Annual average except where stated
b At maximum water hardness
c Transitional and coastal waters
d Maximum allowable concentration

Mitigation Measures

8.6.34 Further site investigation work involving the excavation of trial pits will be undertaken in advance of the Upgrade. Soil samples will be taken from trial pits in the vicinity of areas identified to be at risk from soil contamination in order to further characterise the level and extent of soil and fill requiring remediation. Further details of the planned works are contained in the Remediation Strategy in Appendix 8.6.
8.6.35 Mitigation of health impacts of contaminants in soil on construction workers will be through a safe system of work and if required, the use of appropriate protection (Personal Protective Equipment). The principal risk from Poly Aromatic Hydrocarbons (PAHs) arises from direct skin contact, although there is also a risk of exposure to both PAHs and asbestos via inhalation. Therefore protection will include face masks and gloves for any personnel coming into direct contact with the material. In addition, where groundworks are to take place in areas identified to be at risk of contamination there will be restrictions on access and measures will be taken to control dust during the works, thereby mitigating the inhalation risks.

8.6.36 The preferred mitigation measure for excavated contaminated material is treatment off site prior to the return of the recovered material for reuse on site. Contaminated material is defined as that which contains contaminants at levels above the appropriate assessment criteria. Such material is classified as waste by virtue of its contamination. It therefore cannot be re-deposited on site, nor used in construction on site or elsewhere (except under the provisions of the Environmental Permitting (England and Wales) Regulations 2010). The suitability of landfills to accept such material will be based on its classification according to the Landfill Regulations and the Environment Agency Waste Acceptance Criteria. Preliminary analysis indicates that while some contaminated excavated material could be disposed of at landfill permitted to accept inert waste, some may require disposal at non-hazardous and hazardous waste sites. Further Waste Acceptance Criteria testing of materials designated for disposal off site will be undertaken once works commence on the Site.

8.6.37 Wherever possible, contaminated soil that must be removed from site will be sent to an off site treatment centre rather than to landfill. The quantities of such material likely to arise on the Site are so small that on site treatment is not a practical or economic possibility. Furthermore, there is a lack of space for commissioning of such treatment. The works is to remain operational during the Upgrade works so that roads and hard standings will be required for access and other spaces will be used by the Upgrade contractors or for stockpiling of non-contaminated excavated materials and secondary aggregate.

8.6.38 The above mitigation is required only where there is an ongoing risk of exposure to contaminants. Where contaminated material is to remain undisturbed on site potential health impacts will be mitigated where required by containment beneath a capping layer.

8.6.39 Some potential risks associated with site contamination have been avoided through design. The major structures to be upgraded, including the primary settlement tanks and activated sludge aeration lanes, will be constructed on the existing concrete tank bases. This avoids the need for breaking out of the concrete and excavation of soil and fill, and therefore avoids potential mobilisation of contaminants.

8.6.40 According to the CIRIA guidance in CIRIA report C665, the appropriate mitigation for office/commercial/industrial development in areas affected by gas levels equivalent to Characteristic Situation 2 would be provision of either a 1,200 g damp proof membrane with a cast in situ reinforced concrete slab or a 2,000 g membrane with a beam and block or pre-cast concrete slab, with possible additional venting. All joints and penetrations should also be sealed against ingress of gas. This avoids the need to excavate and dispose of materials with the potential to generate gas.

8.6.41 These gas protection measures would only apply to enclosed buildings constructed as part of the development and are not required for the new treatment process tanks or for buildings that are not fully enclosed and therefore freely ventilated, for
example through louvred walls. Each such enclosed building will be subject to an individual risk assessment to establish whether mitigation is required and the precise form it will take. These details will be incorporated into a Remediation Strategy document to be approved by LBE (Appendix 8.6).

8.6.42 With mitigation measures in place the likely effects of ground gases in enclosed buildings would be negligible.

8.6.43 Potential impacts of contaminants in soil on groundwater and surface waters during construction will be mitigated by use of containment and prevention of run-off from stockpiled excavated contaminated materials entering controlled waters. Generally, the works will take place in areas which are below the invert level of the surrounding surface water courses, so there is no significant risk of contaminants entering these waters. Any runoff which collects in these low lying areas will be diverted to the head of the works. There will be no direct discharge into surface waters. Specific details of the water management measures to be adopted are set out in the Construction Environmental Management Plan.

8.6.44 Mitigation of the potential effects of contaminants within the perched groundwater and shallow sand and gravel aquifer on the deep Principal Aquifer is required. The piling works could pose a risk of penetration of the base of the London Clay, which overlies the Principal Aquifer. Therefore, a piling risk assessment has been undertaken in accordance with Environment Agency guidance. The risk assessment is provided in Appendix 8.7.

8.6.45 The piling or foundation works risk assessment can be summarised as follows.

8.6.46 The site is generally made ground over terrace gravels over London Clay over Lambeth Beds over Thanet Sands over Chalk. The Chalk is classified as a principal aquifer. The Site is located in Source Protection zone 2. London Clay is considered to be an aquiclude which prevents the flow of groundwater, while the Lambeth Beds are considered to be largely impermeable or of low permeability and may be considered as an aquitard.

8.6.47 Due to the variation in ground conditions, the foundation loads, and the depth to bearing strata the only practicable long term foundation solution for new structures is to use piling. The existing final settlement tanks at the Site have suffered from differential settlement, which affects their operating efficiency and this can only be avoided for the new structures by adopting a piled foundation. Piles will be founded within either the London Clay or the Lambeth Beds. Piling is not be carried out in the southern section of the site where the site investigation found an absence of London Clay.

8.6.48 The piling technique used will be continuous flight auger (CFA) which is has generally been accepted by the Environment Agency as the most suitable piling technique in order to reduce the possibility of transporting contaminated soil from the upper layers into the aquifer and because it will not provide an easy contamination path for surface water to reach the lower strata. It is recognised that well-constructed piles should seal adequately in clay layers with a thickness of at least two pile diameters. This sealing ability will preserve the integrity of the London Clay acting as an aquiclude. The maximum expected pile diameter would be 900mm, although typically it would be about 600mm. The London Clay layer, where present, is more than twice as thick as this and therefore the risk of creating a

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migration pathway is considered to be insignificant. Adoption of CFA piling would therefore result in negligible impacts of contamination on the Principal Aquifer.

8.6.49 An updated assessment of the potential risks of unexploded ordnance has been undertaken by the contractor and is provided in the Construction Environmental Management Plan in Appendix 5.3. The assessment concludes that the risks are extremely small.

8.6.50 A watching brief on contaminated land will be undertaken by members of the contractor’s site team during site preparation and excavation in order to identify any unforeseen contamination that may arise during the works which was not identified as part of the site investigation work done to date. The CEMP sets out the arrangements for this in more detail.

8.6.51 Further details of mitigation proposed are set out in a Remediation Strategy document (Appendix 8.6). Subsequently, a Remediation Validation Report will be submitted to LBE for approval.

**Residual impacts**

8.6.52 After completion of mitigation, the impacts of contaminants in the soil are rated minor to moderate beneficial since the development itself will result in the permanent mitigation or removal of contamination which would otherwise have remained on site.

8.6.53 After mitigating the risk of contamination of the Principal Aquifer due to piling in accordance with the piling risk assessment, the impacts of contaminants in the shallow groundwater are rated negligible since there will be no preferential contaminant migration pathways to the Principal Aquifer.

**Monitoring**

8.6.54 No short term monitoring of contamination (apart from the watching brief) is proposed during the construction stage as there are not expected to be any changes to existing levels of contaminants. However, some additional testing of potentially contaminated material may be required against Waste Acceptance Criteria where it is intended to export the material for disposal at a permitted or licensed waste disposal facility. Further details of this are provided in the Waste Management Plan for the construction phase of the upgrade which is an Appendix to Chapter 17 – Waste Management of this ES (see Appendix 17.1).

8.6.55 A watching brief covering the identification of and response to unexpected contamination will also be implemented.

**Operation**

8.6.56 There are not expected to be any contaminated land impacts during the operational phase of the Upgrade. This is because there will be no new sources of contaminants nor any significant changes to the Site that would affect the potential impacts of residual contaminants on site, and all mitigation measures will be complete by the end of the construction phase or will have been incorporated into the design of the Upgrade.

8.7 **Cumulative Effects Assessment**

8.7.1 There are no additional plans or projects which are likely to have cumulative effects with the contaminated land aspects of the Upgrade. The contaminated land desk study and geo-environmental constraints reports searched for contaminated land data in a buffer zone of 500m from the Site and found nothing of significance that would have any cumulative effects.
8.8 Summary and Conclusion

8.8.1 A contaminated land risk assessment based on site investigation data from 2009 and 2012 has concluded that the majority of the Site contains soil contaminants below screening criteria for commercial/industrial use of the Site. However, there is one exceedance of the relevant criterion for benzo[a]pyrene (a polyaromatic hydrocarbon). This could pose a risk to human health and will require mitigation if this area is to be excavated as part of the Upgrade works. Additionally, a few isolated incidences of asbestos contamination have also been identified. These will also require mitigation.

8.8.2 Mitigation will take the form of further site investigation and soil testing to characterise the nature and extent of contamination followed by excavation and removal of contaminated soil for treatment prior to reuse. However, where there are contaminants in areas where there is to be no excavation for construction purposes, these would be left in situ. The design of mitigation measures is set out in a Remediation Strategy document (Appendix 8.6).

8.8.3 The potential impacts of soil contamination prior to any mitigation are rated minor to moderate adverse, but with mitigation in place the residual effects would be negligible. When construction is completed and the Upgrade is operational, minor to moderate beneficial effects will ensue because levels of contaminants or exposure to them will have been reduced as a result of the works.

8.8.4 The potential effects of ground gases (methane and carbon dioxide) are rated minor adverse. However, after mitigation, which would involve incorporation of gas barriers into the floor slabs of any sensitive structures, the residual effects would be negligible.

8.8.5 The potential effects of contaminants in the perched groundwater and shallow aquifer on surface waters and the deep Principal Aquifer during construction are rated moderate adverse because of the risk of penetration of the base of the London Clay by piling and the creation of a pathway for contamination to migrate into the aquifer. Therefore a piling risk assessment meeting Environment Agency requirements has been completed (Appendix 8.7). The chosen piling method will mitigate these risks so that the residual effects on groundwater would be negligible.

8.8.6 An updated risk assessment for unexploded ordnance has been undertaken and is provided within the Construction Environmental Management Plan (Appendix 5.2). The assessment concludes that the risks are extremely small.