14 Land Contamination

14.1 Introduction

14.1.1 This chapter assesses the effects of the Bank Station Capacity Upgrade (BSCU) with respect to land contamination and its impact on sensitive receptors and resources. This is informed by the baseline conditions that currently exist at the Whole Block and Arthur Street Work Sites and in the surrounding area. An assessment has been made of the potential direct and indirect effects of the BSCU arising from construction and operation of the new infrastructure due to potential disturbance of existing ground contamination. Where required, mitigation measures are proposed to avoid, reduce or offset likely impacts and resulting environmental effects.

14.1.2 Chapter 13: Water Resources and Flood Risk considers the potential for and where relevant, provides a more detailed assessment of the impacts on:

- surface water receptors, including surface water drainage;
- water quality; and
- flood risk.

14.1.3 This chapter focuses on the demolition/construction and operational impacts of the BSCU on receptors and resources, with respect to the potential disturbance of historical contamination.

14.2 Legislative and Policy Context

Legislation and National Policy

Environmental Protection Act: Part 2A

14.2.1 *Part 2A* of the *Environmental Protection Act 1990* included the first statutory definition of 'contaminated land' and conferred new responsibilities and powers on local authorities and (what is now) the Environment Agency to identify contaminated land and ensure that it is dealt with. For the purposes of *Part 2A*, contaminated land is defined as:

> *any land which appears to the local authority in whose area it is situated to be in such a condition, by reason of substances in, on, or under the land that:*
>
> *(a) significant harm is being caused or there is a significant possibility of such harm being caused; or*
>
> *(b) significant pollution of controlled waters is being caused, or there is a significant possibility of such pollution being caused.*

National Planning Policy Framework (Department for Communities and Local Government, 2012)

14.2.2 The *National Planning Policy Framework* (*NPPF*) sets out the Government's planning policies for England and how these are expected to be applied.

14.2.3 One of the Core Planning Principles in the framework under *Paragraph 17* seeks to: *Encourage the effective use of land by reusing land that has been previously developed (brownfield land), provided that it is not of high environmental value.*

14.2.4 With respect to pollution and contamination, *Paragraph 109* 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.*

14.2.5 *Paragraph 120* states that *to prevent unacceptable risks from pollution and land instability, planning decisions should ensure that new development is appropriate for its location. The effects (including cumulative effects) of pollution on health, the natural environment or general amenity, and the potential sensitivity of the area or proposed development to adverse effects from pollution, should be taken into account. Where a site is affected by contamination or land stability issues, responsibility for securing a safe development rests with the developer and/or landowner.*

14.2.6 *Paragraph 121* states that planning policies and decisions should ensure that *adequate site investigation information, prepared by a competent person, is presented.*

Planning Practice Guidance (Department for Communities and Local Government, 2014)

14.2.7 The *Planning Practice Guidance* includes guidance on planning for land affected by contamination. The *PPG* includes information on sources of information that can be drawn on to help indicate whether land could be contaminated and recommendations for developers of sites that could be affected by contamination, including early engagement with the local planning and environmental health departments. The guidance notes that planning authorities need to be satisfied that development should not pose an unacceptable risk due to contamination and provides advice on information required for remediation schemes.

Regional Policy

The London Plan (Greater London Authority, 2011)

14.2.8 *Policy 5.21 – Contaminated Land* and supporting *paragraph 5.95* identify the beneficial reuse of brownfield land and state 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.*
- *In a city where space is increasingly at a premium, it is essential that wherever practicable, brownfield sites – including those affected by contamination – should be recycled into new uses. This also provides an opportunity to deal with any threats to health and the environment posed by contamination. Any land that is affected by contamination, whether or not identified under the regulations, may require measures to prevent contamination being activated or spread when building takes place.*

14.2.9 The *Revised Early Minor Alterations to the London Plan* (Greater London Authority, 2013) included a minor addition of a new paragraph (*5.95A*), stating that *where potentially contaminating activities are proposed, development should include appropriate measures to mitigate any potential harmful effects.*

Local Policy

Core Strategy (City of London Corporation, 2011)

14.2.10 *Policy CS15* requires developments to *positively address land contamination, ensuring development does not result in contaminated land.*

14.2.11 The City of London Corporation *Draft Local Plan* was published in 2013 and is due to be adopted in late 2014. Draft *Policy DM 15.8*, states that: *Where development involves ground works or the creation of open spaces, developers will be expected to carry out a detailed site investigation to establish whether the site is contaminated and to determine the potential for pollution of the water environment or harm to human health and non-human receptors. Suitable mitigation must be identified to remediate any contaminated land and prevent potential adverse impacts of the development on human and non-human receptors, land or water quality.*

14.2.12 *Paragraph 3.15.24* of the draft policy states that: *When a site is developed and ground conditions change there is potential for contaminants to be mobilised,*

increasing the risk of harm. Site investigation should establish whether the proposed use is compatible with the land condition.

14.2.13 *Paragraph 3.15.25* of the draft policy states that: *Pre-application discussions should be used to identify the particular issues related to environmental protection that are relevant to each development site. The City of London's Air Quality, Noise and Contaminated Land Strategies provide details of the issues likely to be encountered in different parts of the City and should be used for reference by developers*.

Other Policy

14.2.14 Relevant guidance is set out in *Contaminated Land Statutory Guidance* (Defra, 2012) *Groundwater Protection: Policy and Practice (GP3).*

14.2.15 *Part 2* of *GP3* summarises the legislation relevant to the management and protection of groundwater and sets out the Environment Agency's associated and complementary policies. *Section 6/J* sets out the land contamination policy and legal framework regarding land contamination and the protection of groundwater.

14.2.16 This assessment has also been prepared in accordance with guidance in *Model Procedures for the Management of Land Contamination*, issued by the Environment Agency (EA), Scottish Environment Protection Agency and Defra in 2004.

14.3 Scope of Assessment

14.3.1 The scope of the assessment is as follows:

- to assess the baseline ground conditions and pre-existing contamination at the BSCU Works Sites, with respect to soil, groundwater and ground-gas from a review of both desktop study information and historical ground (intrusive) investigation data collected in the wider area;
- using the above information, to assess the risks of baseline ground contamination impacting on human health or the environment as a result of construction and operational activities associated with the BSCU; and
- to assess appropriate mitigation measures required to avoid, reduce or offset any likely impacts and resulting significant environmental effects.

Temporal

14.3.2 The potential impacts of the BSCU have been assessed at three points in time:

- current baseline, 2013;
- construction, approximately 2016-2021; and

- operation of the BSCU, 2021.

Spatial

14.3.3 A study area of 250m radius from the boundaries of the main Whole Block and Arthur Street Work Sites has been used. The utilities and potential grout shaft locations are included within this study area.

14.4 Assessment Methodology

Overview

14.4.1 The EA provides guidance on conducting an Environmental Impact Assessment (EIA) with regard to contamination issues (*Scoping Guidelines on the Environmental Impact Assessment of Projects 2002*) (EA, 2002). In addition, a considerable body of guidance has been prepared in order to assist both local authorities and practitioners in assessing the degree to which land is contaminated and deciding whether such land is contaminated within the meaning of *Part 2A* of the *Environmental Protection Act 1990*.

14.4.2 Further guidance on the risk assessment process is given in EA documentation on the basis of the Contaminated Land Exposure Assessment (CLEA) model which is intended to be used as the common basis for contamination assessments in the UK. Guidance on the risk assessment process is given in *Model Procedures for the Management of Land Contamination. Contaminated Land Report 11* (Defra and EA, 2004).

14.4.3 With regard to pollution of controlled waters, the EA has prepared guidance on methods of assessment. These are contained in its *Research and Development Publication No 20 - Methodology for the Derivation of Remedial Targets for Soils and Groundwater to protect Groundwater* and in *GP3 parts 1 to 3*.

Source-Pathway-Receptor Methodology

14.4.4 Underpinning all sets of guidance is a hazard-pathway-receptor methodology which is used to identify significant contaminant linkages. The following definitions apply:

- hazard: source of contamination;
- receptor: the entity which is vulnerable to harm from the hazard; and
- pathway: the means by which the hazardous contamination can come into contact with the receptor.

14.4.5 Without a significant contaminant linkage, the contamination may be a hazard, but does not constitute an unacceptable risk to human health or the environment.

14.4.6 Therefore, in assessing the potential for contamination to cause a significant effect, the extent and nature of the potential source or sources of contamination must be assessed, pathways identified, and sensitive resources or receptors identified and appraised, to determine their value and sensitivity to contamination related impacts.

Sources of Contamination

14.4.7 In order to assess the magnitude of the sources of contamination at the Whole Block and Arthur Street Work Sites, consideration has been made of previous land use, including the study of historic site maps and regulatory data, covering the two sites and within a surrounding area radius of 250m.

14.4.8 The magnitude of sources of land contamination can be described qualitatively according to the categories shown in Table 14.1.

Magnitude of Impact

Table 14.1: Scale for Magnitude of Extent and Potential Sources of Land Contamination

Magnitude	Previous Land Uses
High	Previous or ongoing activity on or near to the sites with high potential to cause land contamination (e.g. gasworks, chemical works, landfill).
Medium	Previous or ongoing activities on or near to the sites with some potential to cause moderate contamination (e.g. railways, collieries, scrapyards).
Low	Previous or ongoing activities on or near to the sites with low potential to cause contamination (e.g. residential, retail or offices).
Very Low	Greenfield site.

Receptor Sensitivity

14.4.9 The sensitivity of potential receptors and resources can be described qualitatively according to the categories shown in Table 14.2.

Table 14.2: Sensitivity Criteria and Indicative Descriptive Scale for Sensitivity / Importance of Receptors and Resources

Sensitivity	Definition	Future Site Users and Surrounding Land Users	Construction / and Maintenance Workers	Groundwater	Built Environment
Very High	Resource/receptor responds to major change(s) e.g. agricultural land use for food production, allotments.	Residential with plant uptake, and allotments	Extensive earthworks and demolition of buildings	Principal Aquifers	Buildings, including services and foundations of historic significance
High	Resource/receptor clearly responds to effect(s) in quantifiable and / or qualifiable manner e.g. low grade agricultural land, recreational ground.	Residential without plant uptake	Limited earthworks	Secondary A Aquifers	Buildings, including services and foundations
Medium	Resource/receptor responds in a minimal way such that only minor changes are detectable e.g. landscaped areas.	Commercial landscaping or open space areas	Minimal disturbance of ground	Secondary B Aquifers	Infrastructure (roads, bridges, railways)
Low	Resource/receptor is insensitive to impact, no discernible changes e.g. soils are not in use, the land has an industrial / commercial land use and / or mainly covered by hard standing.	Industrial land covered by hard standing	No disturbance to ground	Unproductive Strata (Non-Aquifers)	Minor industrial development without subsurface services

Prediction of Effects

14.4.10 If a hazard and potential sensitive receptors have been identified then the potential impacts can be determined by considering the pathways. The strength of pathway between a source and receptor is a function of the distance between the two and the ease or otherwise of the migration pathway. For example, on sites underlain by impermeable clays, the migration pathway via groundwater would be weak even over short distances, whereas within sands or gravels, the migration pathway would be strong for receptors in close proximity to a source and weak for receptors at some distance from the source.

14.4.11 For construction workers on contaminated sites, the pathway is invariably strong because they are likely to be in close proximity to the soils, particularly during ground works.

14.4.12 For industrial and commercial developments, where much of the ground may be covered in hard surfacing, the migration pathways for soil or water contamination to impact upon future site users are generally moderate or weak.

Assessment of Effects

14.4.13 The effects (before any mitigation) can be assessed on the basis of the matrix as shown in Table 14.3 in conjunction with professional judgement of the site specific geological, hydrogeological and contamination ground conditions. These include contamination types, concentrations and distribution, groundwater flow direction and presence and thickness of any impermeable geological strata.

Table 14.3: Classification of Effects

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

14.4.14 Generally, major and moderate effects are considered to be significant and in need of mitigation. Minor and negligible effects are considered not significant and not requiring mitigation. Determination of whether an effect is considered to be significant is also based on professional judgement, taking account of whether effects are considered to be positive or negative, permanent or temporary, direct or indirect, the duration and frequency of the effect and whether any secondary effects are caused.

Risk Assessment

14.4.15 The classification of potential effects determined using the above matrix, and consideration of likelihood of an event occurring, can then be incorporated into a final risk based assessment. Likelihood will take into account both the presence and distribution of a particular hazard at the Whole Block and Arthur Street Work Sites as well as the integrity (strength) of the pathway between the hazard and receptor. This approach is adopted from guidance within *Section 6.3* of *CIRIA C552: Contaminated Land Risk Assessment - A guide to Good Practice, 2001*.

14.4.16 Table 14.4 demonstrates the perceived likelihood of an event occurring and Table 14.5 provides details of the level of risk based on the combination of the likelihood of an event occurring and significance of effects. Table 14.6 interprets the risk.

Table 14.4: Likelihood Matrix

Magnitude of Impact	**Strength of Pathway**		
	Weak	**Moderate**	**Strong**
Very Low	Unlikely	Unlikely	Low
Low	Unlikely	Low	Low
Medium	Low	Medium	Medium
High	Low	Medium	High

Table 14.5: Risk Assessment

Likelihood	**Significance of Effect**			
	Negligible	**Minor**	**Moderate**	**Major**
Unlikely	Very low risk	Very low risk	Low risk	Moderate / low risk
Low	Very low risk	Low risk	Moderate / low risk	Moderate risk
Medium	Low risk	Moderate / low risk	Moderate risk	High risk
High	Moderate / low risk	Moderate risk	High risk	Very high risk

Table 14.6: Risk Criteria

Risk Assessment	**Description**
Very low risk	The presence of an identified hazard does not give rise to the potential to cause significant harm to a designated receptor.
Low risk	It is possible that harm could arise to a designated receptor from an identified hazard but it is likely that, at worst, this harm, if realised, would normally be minor.
Moderate risk	It is possible that, without appropriate remedial action, harm could arise to a designated receptor. It is relatively unlikely that any harm would be high, and if any harm were to occur it is more likely that such harm would be relatively minor.
High risk	Harm is likely to arise to a designated receptor from an identified hazard at the site without appropriate remedial action.
Very high risk	There is a high likelihood that severe harm could arise to a designated receptor from an identified hazard at the site without appropriate remedial action.

14.5 Baseline Conditions

Existing Baseline (2013)

14.5.1 Unless otherwise noted, an assumption has been made that the current baseline conditions presented in this assessment will remain unchanged until the start of the construction works.

14.5.2 Baseline information pertaining to the BSCU Work Sites and their surroundings has been derived from the following sources (provided in Appendix A14):

- Geotechnical Baseline Report (0011-UA04557-UP31R-02) (October 2012) by Hyder (A14.1);
- Geotechnical Desk Study (N133-BCR-MMD-00-Z—DC-Z-0047-S0-1.0) (March 2012) by Mott MacDonald (A14.2);
- Unexploded Ordnance Desk Study (November 2011) by MACC International (A14.3);
- Redevelopment of 81 King William Street (1982); by Wembley Laboratories Ltd (A14.4);
- Redevelopment of 10 King William Street (1974); by Wimpey Laboratories Ltd (A14.5);
- The Walbrook Development (2006) by Fugro Engineering Services Ltd (A14.6);
- NM Rothschild Bank (2007) by Norwest Holst Soil Engineering Ltd (A14.7);
- The Walbrook Square Development (2007) by Soiltechnics (borehole data only without absolute levels available) (A14.8);
- Bank Station Capacity Upgrade – Abstraction and Historic Wells Current Status (April 2012) by London Underground (A14.9); and
- Landmark Information Group Envirocheck Report, Ref. 49557448_1_1 (Landmark, 2013) (A14.10).

Environmental Setting

14.5.3 An *Envirocheck Report* was obtained focussed on a rectangular area of approximately 100m x 250m, which includes both the Whole Block and Arthur Street Work Sites and is attached in Appendix A14.10. The *Envirocheck Report* also includes information from a wider area, which was reviewed to account for and consider utilities and potential grout shaft works within 250m of the main Envirocheck study area.

Geology of the BSCU Main Work Sites

14.5.4 *The British Geological Survey (BGS) 1:10,000 Solid and Drift Geology Maps* included in the *Envirocheck Report* indicate that the underlying geology comprises Alluvium (only north of River Thames as far north as Arthur Street) and River Terrace Deposits (Taplow Gravel), overlying the London Clay Formation.

14.5.5 Historical site investigations identified the presence of shallow Made Ground in the region, of varying thicknesses and variable composition. Therefore Made Ground may be absent beneath the Whole Block Site in areas where basements currently exist.

14.5.6 The underlying solid geology at the Whole Block and Arthur Street Work Sites comprises London Clay, which has been shown to be at least 35m thick, and extend beyond the depth of the project. The London Clay is underlain by the Lambeth Group, Thanet Sands and Chalk.

14.5.7 Summarised geology from available ground investigations and BGS borehole logs is shown in Table 14.7.

Hydrogeology and Hydrology

14.5.8 The River Thames (a Water Framework Directive water body) is located 300m south of the Whole Block Site and 120m south of the Arthur Street Work Site. There are no entries within the *Envirocheck Report* (See Appendix A14.10) for water quality for the River Thames in this area. The BSCU is also in the near vicinity of the buried River Walbrook, which is part of Thames Water's combined sewer system.

14.5.9 The hydrogeology of the Whole Block and Arthur Street Work Sites comprises a shallow aquifer (Alluvium/River Terrace Gravels) and a deep aquifer (Chalk/Thanet Sands). The aquifers are hydraulically separated by a non-aquifer comprising the London Clay Formation/Lambeth Group. There are seven licensed groundwater abstractions from the deep aquifer in the vicinity of the Whole Block and Arthur Street Work Sites. According to the *Geotechnical Desk Study* (Mott MacDonald, 2012), groundwater has been encountered approximately 10m below existing ground level (m bgl) within a borehole located in Swan Lane which corresponds with the River Terrace Deposits.

Table 14.7: Whole Block and Arthur Street Work Sites Summarised Geology from Ground Investigations and BGS Borehole Logs

Strata	Thickness (m)	Strata Description
Made Ground	From 0.0m up to 5.0m	Extremely variable thickness and material across the Whole Block Site and Arthur Street Work Site. Comprising either demolition rubble, to reworked natural soils from Alluvium, River Terrace Deposits and London Clay Formation.
Alluvium	From 0.0m to 2.5m	Typically described as soft to firm grey to dark grey organic silt or clay. Generally absent in the Whole Block Site area.
Flood Plain Gravel (River Terrace Deposits)	From 2.0m to 10.0m	Typically described as very dense brown, grey and black sandy fine to coarse gravel.
London Clay Formation	From 35m to 45m	Typically described as firm becoming stiff to very stiff/hard fissured brown/grey silty/sandy clay. The sand is generally fine grained and often present as partings or laminations.
Lambeth Group	Up to 1.5m (base not proven)	Typically described as a matrix of hard friable mottled grey-green brown silty clay with fragments of grey-green-brown silty clay with frequent polished and striated surfaces. Becoming stiff to hard mottled brown-blue silty clay with depth.

14.5.10 The *Envirocheck Report* indicates the superficial deposits at the Whole Block and Arthur Street Work Sites (River Terrace Deposits and Alluvium) are classified as a Secondary A Aquifer and a Secondary Undifferentiated Aquifer respectively. Secondary A Aquifers are 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. A Secondary Undifferentiated category is assigned in cases where it has not been possible to attribute either category A or B, likely due to the variable characteristics of the rock type.

14.5.11 These strata are underlain by the London Clay Formation which is classified as Unproductive Strata. Unproductive Strata are defined as rock layers or drift deposits with low permeability that have negligible significance for water supply or river base flow. The London Clay Formation also acts as an impermeable barrier to the vertical migration of shallow contamination to the underlying Thanet Sands and Chalk aquifers.

14.5.12 The *Geotechnical Desk Study* (Mott MacDonald, 2012) noted the potential for pathways between the shallow aquifer and deeper aquifers of the Lambeth Group, Thanet Sands and Chalk, where local, deep drift filled hollows may

exist, although hollows are not known to be present beneath the Whole Block and Arthur Street Work Sites.

14.5.13 The Whole Block and Arthur Street Work Sites are not located within any groundwater Source Protection Zones (SPZs) designated by the Environment Agency for the protection of potable water supply and there are no potable groundwater abstractions within 1km.

Site Sensitivity

14.5.14 The *Envirocheck Report* indicates that the application site is not located within or in the vicinity of any regulated sensitive sites (e.g. areas of Green Belt, National Parks, Sites of Special Scientific Interest etc).

Regulatory Data

14.5.15 There is one Local Authority Pollution Prevention Controls (LAPPCs) activity within approximately 500m of the Whole Block Site, related to a dry cleaner located 300m northeast.

14.5.16 The *Envirocheck Report* lists three recorded pollution incidents to controlled waters within approximately 250m of the Whole Block and Arthur Street Work Sites. They are all registered as minor incidents, and the closest relates to the spillage of unknown oils at 30 Monument Street.

14.5.17 Nine registered abstraction wells have been identified within 250m of the Whole Block and Arthur Street Work Sites. These are all for commercial/industrial/ public use including potable use. The majority are indicated as being drilled into the Chalk Aquifer below the London Clay, although wells with abstraction rates below $20m^3$/day do not require Abstraction Licence applications, and hence it is possible that other wells in the area may be in use that have not been identified.

14.5.18 There is one Control of Major Accident Hazards site (COMAH) located approximately 100m northeast of the Whole Block and Arthur Street Work Sites, related to 'Saltend Cogeneration Co Ltd' (classified as 'lower tier facility').

Waste

14.5.19 The *Envirocheck Report* indicates that no licensed waste management facilities or registered waste transfer sites are located within 250m of the Whole Block and Arthur Street Work Sites.

History of the Site

14.5.20 The following history of the Whole Block and Arthur Street Work Sites and surrounding area has been determined from the *Geotechnical Desk Study*

(Mott MacDonald, 2012) and the historical mapping data within the *2013 Envirocheck Report*.

14.5.21 Following the Great Fire of London (1666) the Whole Block and Arthur Street Work Sites and surrounding area were rebuilt at the beginning of the 18th century and remained relatively unaltered until the early 19th century when King William Street was constructed as part of the Metropolitan Improvements scheme.

14.5.22 The Whole Block and Arthur Street Work Sites altered little once this streetscape had been established and has included several financial institutions and banks, with no industrial land uses recorded in available maps.

14.5.23 The *Historical Data Report* included in the *Envirocheck Report* identified the presence of two historical above ground fuel tanks on the Whole Block Site and a further two near the Arthur Street Work Site. Additional historical entries indicate electricity sub-stations, asbestos and oil and gas use within 100m of the Whole Block and Arthur Street Work Sites.

Unexploded Ordnance (UXO)

14.5.24 According to the *Geotechnical Desk Study* (Mott MacDonald, 2012), there are records of a bomb strike at St Mary's Abchurch in September 1940 and Bank Underground Station sustained a direct strike by a High Explosive bomb on 10th January 1941. The crater, measuring 37m x 30m, was covered with a bailey bridge to enable traffic to pass over.

14.5.25 In addition, the *Historical Data Report* included in the *Envirocheck Report* identified three *Areas Cleared due to Enemy Action* located near Arthur Street.

14.5.26 A UXO desk study and detailed risk assessment, in accordance with CIRIA *C681 Unexploded Ordnance (UXO): A guide for the construction industry*, was commissioned as part of the *Geotechnical Desk Study* (Mott MacDonald, 2012), and undertaken by MACC International. The findings of the desk study and threat assessment identified the UXO risk level to be *Medium to High* with regards to the ground investigations proposed by Mott Macdonald at the time of report issue within the identified bomb penetration depth (8.0mbgl).

Potential Sources of Contamination

14.5.27 As the region has long been developed primarily for commercial purposes (office uses), the likelihood of significant contamination in soils and groundwater beneath the Whole Block and Arthur Street Work Sites is considered to be low. The most likely source of contamination arises from Made Ground in shallow soils likely to be present beneath the Arthur Street Work Site, and potentially beneath the Whole Block Site. The historical presence of above ground fuel tanks, electricity sub-stations, potential

asbestos, and oil and gas use may have resulted in localised contamination of the Made Ground.

14.5.28 The potential presence of layers of organic alluvial deposits may result in the generation of methane and carbon dioxide, and spills and leaks from on-site fuel storage tanks may result in the presence of volatile organic vapours – thereby potentially posing an inhalation risk. These risks are further considered in the following sections.

14.5.29 It is likely that basement construction at the Whole Block Site would have removed much of the contamination associated with the imported Made Ground. However, the possibility of more recent spillages or leaks of contaminants within the basement cannot be discounted.

Site Investigations

14.5.30 No soil or groundwater chemical test results or waste classification test results are currently available for the BSCU Work Sites. Ground Investigation works will be undertaken in support of the final detailed design of the BSCU. The ground investigations will be used to evaluate whether further Contaminated Land assessment and remediation works are necessary.

14.5.31 The Mott MacDonald desk study reported on a review of an ES for the nearby Crossrail project which stated that *water is very rarely of a quality suitable for potable supply and is therefore seldom abstracted*. The desk study further notes that anecdotal information from CIRIA (1993) indicated that the majority of seven samples collected in the nearby area showed high lead concentrations and electrical conductivities over 2000µS/cm, and that the status of the shallow aquifer within the area surrounding the BSCU at Bank was expected to be similarly affected and non-potable as a result of urbanisation.

14.5.32 The Environment Agency has reported on the qualitative status of groundwater in London, where the principal (chalk) aquifer is confined. The recorded site reference, PGWU1416, is close to Bank Station and is reported as being of type sodium sulphate bicarbonate ($Na\text{-}SO_4\text{-}HCO_3$). This suggests a degree of sodium and sulphate enrichment when compared to the quality generally reported in potable water wells in the Chalk aquifer. The accompanying maps suggest the fluoride concentration is between 1.4 and 2mg/l which is possibly too high for a potable water supply (in accordance with the published maximum acceptance criteria value of 1.5mg/l).

Future Baseline

14.5.33 It is considered that the existing (2013) baseline conditions presented in this assessment will remain broadly unchanged in future baselines in terms of land contamination. No additional contaminants would be expected to be added to the Whole Block and Arthur Street Work Sites taking into account the BSCU

and surrounding land uses, and no increased mobilisation of any existing contaminants as a result of extensive hardstanding on the site and surrounds.

14.6 Incorporated Mitigation

14.6.1 The Draft Code of Construction Practice (CoCP) document includes details of environmental controls and monitoring that will be applied by the contractor in order to avoid or reduce impacts. These controls have been accounted for in the assessment of land contamination risks in this chapter.

Proposed Buildings and Below Ground Services

14.6.2 Future ground investigation and laboratory analysis will highlight if any risks to construction materials are present (such as elevated sulphate levels in soil or groundwater) which will potentially require mitigation. Construction material risks to the application site will be adequately mitigated through adherence to the following guidance:

- with regard 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
- appropriate design of concrete class in accordance with *BRE Special Digest 1:2005.*

Unexploded Ordnance (UXO)

14.6.3 The *UXO threat review* (Mott MacDonald, 2011) concluded that a specialist engineer would be required to supervise ground investigation works undertaken, particularly up to 8m depth; adherence to this recommendation will be maintained.

14.6.4 Testing and clearance certification of the intended boring/drilling locations could be achieved by progressively introducing a specialist magnetometer into the borehole to ensure it is safe to continue drilling.

14.6.5 Any suspect devices encountered must be notified to the City of London Corporation Police and/or Metropolitan Police. All site work would be stopped and the site evacuated until such time as the matter has been appropriately dealt with and the site declared safe.

Contamination

14.6.6 Due to the nature of the BSCU and the historically urban/commercial environment, the likelihood of soil contamination is low, and any potentially contaminated soil would be expected to be restricted to shallow depths and removed during excavation and tunnelling works. Potentially contaminated soil

encountered during construction works will be segregated, treated and reused off-site or alternatively disposed of to landfill and no mitigation beyond this is expected to be required.

14.6.7 During construction contaminated soils and groundwater have the potential to pose a moderate to low risk to construction workers via inhalation, ingestion and dermal contact although this can be adequately mitigated with the appropriate use of Personal Protective Equipment (PPE) and site controls. The available PPE should include chemical-resistant gloves when handling soils and wearing dust masks during dry, windy conditions. If ground-gas or vapours are shown to be present at concentrations requiring mitigation, appropriate PPE and other health and safety measures will be adopted.

14.6.8 In addition to PPE, site controls will be put in place, such as designated areas for drinking and eating on the BSCU Work Sites. All excavations will be kept well ventilated and dust suppression will be implemented during periods of dry, windy weather in order to mitigate exposure to adjacent site users. Stockpiles of site-derived material will be covered over. Dust emissions will be monitored by the contractor. A more detailed summary of dust controls and monitoring requirements is provided in the draft CoCP.

14.6.9 Any stockpiling of excavated soils on site will likely be limited and for a short time only, due to the limited space for stockpiling on the BSCU Work Sites.

14.6.10 In areas where there is a risk of chemical spillage and hazardous substance stores, precautions will be taken including bunding, as outlined within the draft CoCP. The Contractor will manage and dispose of foul water effluents from work site facilities as follows:

- by preference, connection to the local foul water sewer (to be agreed with Thames Water and in a manner adhering to the conditions of the permit obtained); and/or
- containment by temporary foul drainage facilities and disposal off-site by a licensed contractor.

14.6.11 At this stage, the exact phasing of the construction of the OSD is uncertain. There is potential that the OSD Substructure, Superstructure and fit out will overlap with the final stages of the BSCU. However there could be a gap and the ES considers a realistic worst case of a one year overlap in construction programme between these two aspects. In either scenario, normal construction site management practices as outlined in the draft CoCP will be followed to mitigate contamination risks to the underlying aquifers during ground construction works.

Monitoring

14.6.12 Should unexpected evidence of contamination be identified during construction of the BSCU, development within the affected area will temporarily cease and the opinion of an appropriately qualified contamination consultant obtained.

Mitigation Measures during Operation

14.6.13 Upon completion of the BSCU and once the OSD in in place, sites will effectively be covered with structures or hardstanding. As such no contamination specific mitigation measures are considered necessary during the operational phase of the BSCU 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.

14.7 Assessment of Effects

14.7.1 Effects have been assessed during the construction and operational phases based on an assessment of the magnitude of contamination sources as obtained from the *Geotechnical Desk Study* (Mott MacDonald, 2012) and *Envirocheck Report*. The receptors potentially at risk from land contamination that could be present and their sensitivity are shown in Table 14.8.

14.7.2 In addition to contamination risks, an assessment of risks arising from UXO has also been undertaken in the sub-sections that follow.

Table 14.8: Potential Construction and Operational Phase Receptors

Receptor/Resource	Sensitivity	Comments
Construction workers	Very High	Construction/demolition workers involved in below ground construction will have a very high sensitivity, those involved with minimal intrusion or above ground works much less.
Maintenance workers	Low	Maintenance workers will not be in direct contact with soils or waters once the BSCU is completed.
Adjacent site users and the general public	High (residential)	Passers-by, visitors, nearby occupants of offices and residences. There are some residential properties located amongst the predominantly commercial space, including flats situated off Abchurch Yard, Cheapside, Cannon Street, , Martin Lane and Upper and Lower Thames Street.
	Low (offices and general public)	
Future site users	Low	All with minimal exposure opportunity to contamination sources.
Existing built environment	High	Existing substructures and services in contact with potential contamination in soil and groundwater.
New built environment	High	Includes the BSCU buildings and services.
Surface water	High	The River Thames is located 300m south of the Whole Block Site (high) and 120m south of the Arthur Street Work Site (high).
Groundwater	High	The *Envirocheck Report* indicates there are no potable abstractions listed from the Secondary Aquifer or Principal Aquifer within 1km of the Whole Block and Arthur Street Work Sites and the BSCU Work Sites are not within a SPZ. In addition, the presence of London Clay is expected to act as a barrier to migration of contaminants to the Chalk Aquifer
Ecology / Sensitive Land Uses	Not Applicable	No receptors found.

Potential Contamination Sources

14.7.4 Sources of potential contamination have been identified from historic maps in the *Envirocheck Report*. No chemical data from soil or groundwater samples was present within the available ground investigation reports and therefore a conservative approach to the land contamination assessment, based on professional judgement and experience has been adopted.

14.7.5 From the baseline data, the potential for soil, groundwater and ground-gas contamination to be present at the Whole Block and Arthur Street Work Sites is considered to be low. Potential contamination sources and associated chemicals of concern are restricted to the following:

- Made Ground imported to the Whole Block and Arthur Street Work Sites as part of their historic development – Polycyclic Aromatic Hydrocarbons (PAHs), Total Petroleum Hydrocarbon (TPH), metals, ground-gases, asbestos;
- reworked natural soil – ground-gas, metals, PAHs, TPH and asbestos;
- leaking fuel tanks potentially present in existing buildings within the Whole Block Site, or close-by – PAHs, TPH, metals;
- historic use of underground railway at Bank Station – TPH, PAHs, metals; and
- potential off site historical sources, including Cannon Street Station approximately 200m west of the Whole Block Site, and unidentified wharves by the River Thames approximately 100m south of the Arthur Street Work Site – TPH, PAHs, metals, unknown contaminants, although the distance from these sources to the site mean that the likelihood of them impacting on the site is low.

Contamination Impacts during Utilities and Potential Grouting Works

14.7.6 The likelihood of significant contamination in soils and groundwater within minor utilities work sites, Low Level 2 Sewer work site, and within the potential grout shaft sites is considered to be low. Previous shallow ground disturbance may have resulted in some localised contamination in Made Ground. The most material contamination risks from the BSCU and utilities/grout shaft works are assessed as being risks to construction/demolition workers during development works and risks from UXO to construction workers and the built environment during construction. These risks will be appropriately mitigated through ensuring works are undertaken in accordance with the draft CoCP and appropriate Health and Safety management. It is considered that, provided appropriate mitigation measures are employed during development, the BSCU utilities works will not result in any significant environmental effects in relation to land contamination.

Contamination Impacts during BSCU Demolition and Construction 2016 - 2021

Risk to Construction Workers/Demolition Workers

14.7.7 Risks to construction workers may arise from dermal contact and ingestion of contaminated soil and shallow groundwater on-site, and inhalation of contaminated soil dusts, gases and vapours which may be encountered during the ground investigation, tunnelling, Arthur Street Shaft construction and foundation construction works. Significant groundwater is unlikely to be present in Made Ground and consist only as perched water.

14.7.8 The possible presence of asbestos fibres in the Made Ground or from the demolition of existing structures, should be given consideration by the Contractor when preparing health and safety documentation.

14.7.9 Ground-gas potentially poses an inhalation risk if significant volatile contaminants are present beneath the Whole Block and Arthur Street Work Sites, however based on historical information and professional judgement the likelihood of this is low.

Risk to Adjacent Site Users

14.7.10 Contamination risks to adjacent site users are considered to be moderate to low, and restricted to nuisance risks which may arise as a result of dust generation during construction/demolition works.

Risks to Groundwater

14.7.11 Groundwater quality is not considered as a significant risk due to the absence of historical sources of contamination and the average quality of the shallow aquifers within an urban environment. The underlying Principal Aquifer within the Chalk is not likely to be at risk due to the presence of a thick layer of London Clay between the superficial deposits and underlying Chalk.

14.7.12 Suitable environmental controls, as outlined within the draft CoCP, will be implemented by the Contractor to mitigate contamination risks to the underlying aquifers during ground investigation and construction works.

14.7.13 Earthworks for the Arthur Street Shaft (*c*. 34m deep), Station Entrance Hall and the escalator to the Northern Line (maximum depth *c*. 31m) are proposed to terminate in the London Clay, approximately 10m above the top of the Lambeth Group (*c*. 45m deep at its shallowest point along the proposed tunnel) which is in turn underlain by the Thanet Sands and the Upper Chalk formation at depth. 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 low.

14.7.14 Running tunnels would extend through the River Terrace Deposits and into the London Clay to a maximum depth of approximately 42m. Taking this into consideration, the risk from potential contaminative materials introduced by the tunnel construction such as fuels, hydraulic fluids and bentonite based slurries to the underlying Chalk aquifer is considered to be low.

Risk to Surface Water

14.7.15 Due to the distance of the River Thames (approximately 120m from the Arthur Street Work Site and 300m from the Whole Block Site), no significant risks are deemed to be present with regards to surface water.

Contamination Impacts during the Blockade

14.7.16 No intrusive works are required as a result of the blockade, therefore no significant land contamination risks/effects are deemed likely to occur.

Unexploded Ordnance (UXO) Impacts during Demolition and Construction 2016 - 2021

14.7.17 The MACC International study indicated that there was a medium to high risk from UXO with respect to intrusive engineering works at the Whole Block Site. URS consulted with MACC International with respect to the Arthur Street Work Site who confirmed that the findings of the existing UXO study would also be applicable to the Arthur Street Work Site.

Contamination Impacts during Operation (Beginning 2021)

Risk to Future Site Users and Adjacent Site Users

14.7.18 Future users of the Whole Block Site (once operational), will not come into contact with any soils and groundwater.

14.7.19 As previously discussed, the likelihood of elevated ground-gas concentrations is considered to be low based on historical land-use and professional judgement. If significant ground-gas is identified however, appropriate mitigation in accordance with guidance provided in *CIRIA C665* and *BS 8485:*2007 would be incorporated into final BSCU design.

14.7.20 With regards to the Arthur Street Work Site, the proposed shaft is to be decommissioned as part of the operations hence there will be no risk.

Risk to Groundwater and Surface Water Receptors

14.7.21 Once operational, the Whole Block Site will not pose a contamination risk to surface water receptors as there will be limited opportunity for surface water run-off to come in contact with soils underlying the site once the OSD is in place.

14.7.22 There will also be no contamination risk to groundwater, as the proposed development will be hydraulically separated from underlying groundwater.

Risk to Proposed Structures and Below Ground Services

14.7.23 Certain contaminants in soil or groundwater (hydrocarbons, solvents, ammoniacal nitrogen) can permeate through or corrode pipe work and possibly contaminate water supplies. 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. These risks are not considered to be significant due to the low likelihood of significant contamination being present beneath the Whole Block Site and the Arthur Street Work Site.

UXO Impacts during Operation (Beginning 2021)

14.7.24 The risks from UXO during operation are negligible, because there will be no ongoing ground intrusion works once the BSCU is completed.

Assessment of Effects

14.7.25 Table 14.9 sets out the assessed potential effects with the incorporated contamination specific mitigation during both the construction and operational phases of the BSCU, based on the sources as identified from the baseline data and assessment of the pathway-receptor linkages from the description of the BSCU, provided in Chapter 4: The Proposed Development of this ES in order to identify which risks are unacceptable and require mitigation. The level of the risk from each hazard upon the identified receptor is also set out.

Table 14.9: Potential Effects with Incorporated Contamination Specific Mitigation

Source and Potential Impact Magnitude (Taken from Table 14.1)	Receptor and Sensitivity (Taken from Table 14.2)	Possible Pathway	Strength of Pathway	Potential Effects Without Contam-ination Specific Mitigation (Taken from Table 14.3)	Risk Prior to Mitigation	Mitigation	Overall Likelihood With Mitigation	Residual Effect (Post Mitigation)	Risk (Post Mitigation)
Contaminated soils **Medium hazard rating**	Construction/ Demolition workers Very High	Inhalation, ingestion and dermal contact with contaminated soils	Strong	Major	High	PPE, activities to be undertaken under CoCP with appropriate site controls such as dust suppression	Low	Minor	Low
	Adjacent Site Users Residential - High		Weak	Moderate	Moderate to Low		Low	Minor	Low
	Surface Water Features High	Contamination of local surface water features via run off or groundwater	Weak	Moderate	Moderate to Low	Adoption of Appropriate Environment Agency Piling/ Ground Improvement Techniques	Low	Minor	Low

Source and Potential Impact Magnitude (Taken from Table 14.1)	Receptor and Sensitivity (Taken from Table 14.2)	Possible Pathway	Strength of Pathway	Potential Effects Without Contam-ination Specific Mitigation (Taken from Table 14.3)	Risk Prior to Mitigation	Mitigation	Overall Likelihood With Mitigation	Residual Effect (Post Mitigation)	Risk (Post Mitigation)
	Groundwater Medium to High	Contamination of Principal / Secondary Aquifer	Weak – Principal Aquifer Moderate – Secondary Aquifer	Minor to Moderate	Moderate to Low	and incorporation of a groundwater monitoring programme during piling/ tunnelling for early identification of impacts	Low	Minor	Low
UXO **High hazard rating**	Construction / Demolition Workers Very High	Explosion	Strong	Major	Very High	Supervision of UXO specialist during any ground investigations In situ magnetometer surveys during ground investigations and excavations.	Low	Minor	Low
	Built Environment High		Moderate	Major to Moderate	High		Low	Minor	Low
	Groundwater High		Moderate	Major	High		Low	Minor	Low

Source and Potential Impact Magnitude (Taken from Table 14.1)	Receptor and Sensitivity (Taken from Table 14.2)	Possible Pathway	Strength of Pathway	Potential Effects Without Contam-ination Specific Mitigation (Taken from Table 14.3)	Risk Prior to Mitigation	Mitigation	Overall Likelihood With Mitigation	Residual Effect (Post Mitigation)	Risk (Post Mitigation)
Contaminated groundwater **Low hazard rating**	Groundwater High	Migration of water borne contaminants	Moderate	Moderate	Moderate to Low	PPE, activities to be undertaken under CoCP with appropriate site controls	Low	Minor	Low
	Surface Water Features High		Weak	Moderate	Moderate to Low		Low	Minor	Low
Contaminated dust **Low hazard rating**	Adjacent Site Users Residential - High	Inhalation of contaminated dusts	Strong	Moderate	Moderate to Low	PPE, activities to be undertaken under CoCP with appropriate site controls such as dust suppression	Low	Minor	Low

Source and Potential Impact Magnitude (Taken from Table 14.1)	Receptor and Sensitivity (Taken from Table 14.2)	Possible Pathway	Strength of Pathway	Potential Effects Without Contam-ination Specific Mitigation (Taken from Table 14.3)	Risk Prior to Mitigation	Mitigation	Overall Likelihood With Mitigation	Residual Effect (Post Mitigation)	Risk (Post Mitigation)
Ground gases **Medium hazard rating** in absence of ground investigation data	Construction workers Very High	Inhalation of ground gases, explosive risk	Weak	Major	Moderate	Future ground investigation and laboratory analysis will inform and advise adherence to suitable guidance	Low	Minor	Low

14.8 Mitigation

14.8.1 The sites' development history suggests that the potential for contamination is low and therefore that contamination can be adequately managed through the incorporated mitigation measures detailed in Section 14.6. If unexpected contamination is encountered during demolition or construction works, it will be reported to the local authority with advice sought from a contamination specialist.

14.9 Residual Effects

14.9.1 With the mitigation implemented as indicated within this chapter, including adherence to the measures within the draft CoCP and relevant guidance, the likelihood of residual effects due to contaminated ground or groundwater during the construction and operational phases is considered to be low.

14.10 Inter-relationships and Cumulative Effects

14.10.1 The potential for cumulative effects was assessed for the BCSU during the periods where the construction programme could potentially overlap with the construction of a replacement OSD. In addition, potential cumulative effects between the BSCU and other relevant third party schemes within 500m of the Whole Block and Arthur Street Work Sites as identified in Chapter 17: Inter-relationships and Cumulative Effects were considered.

14.10.2 Given the low likelihood of contamination in the area, and the nature of the works being undertaken within the consented and pending nearby developments, no significant cumulative effects associated with land contamination have been identified for the construction and operational phases of the BSCU.

14.11 Assumptions and Limitations

14.11.1 Where any data or information supplied by London Underground Limited or other external sources, including that from previous desk studies or reports has been used, it has been assumed that the information is correct.

14.11.2 The findings and opinions expressed are relevant to those dates of the reported enquiries and should not be relied upon to represent conditions at substantially later dates.

14.12 Conclusions

14.12.1 As the areas around the work sites have long been developed primarily for commercial purposes (office uses), the likelihood of significant contamination in soils and groundwater beneath the BSCU Work Sites is considered to be low. The most likely source of contamination arises from made ground in shallow soils likely to be present beneath the BSCU Work Sites. The historical presence of above ground fuel tanks, electricity sub-stations and oil use activities may have resulted in localised contamination in the made ground.

14.12.2 No soil or groundwater chemical test results or waste classification test results are currently available for the BSCU Work Sites and therefore a conservative approach to the land quality assessment, based on applying professional judgement and experience to the information gained from the desktop data was adopted. Ground Investigation works will be undertaken in support of the final detailed design of the BSCU

14.12.3 At present, the most material contamination risks from the BSCU are assessed as being risks to construction/demolition workers during development works (construction/demolition phase), and risks from UXO to construction workers and the built environment during construction. These risks will be appropriately mitigated through ensuring works are undertaken in accordance with the draft CoCP and appropriate Health and Safety management.

14.12.4 Operational contamination risks associated with the Whole Block Site development are assessed as being low. This is because once the site is developed there will be no exposure pathway to soils or groundwater. Should ground investigations indicate an inhalation risk to future users from site derived ground-gas, this would be appropriately mitigated through the incorporation of gas protection measures into the design and construction of the station building. With regards to the Arthur Street Work Site, the proposed shaft is to be decommissioned as part of the construction phase hence there will be no risk.

14.12.5 Based on the data currently available, it is therefore concluded that contamination does not pose an unacceptable constraint to the BSCU.

14.12.6 It is considered that, provided appropriate mitigation measures are employed during each phase of the development, the BSCU will not result in any significant environmental effects in relation to land contamination.

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