Lower Thames Crossing

6.3 Environmental Statement Appendices
Appendix 10.8 – Generic Quantitative Risk Assessment Report for the Phase 1 Investigation

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Lower Thames Crossing

Appendix 10.8 – Generic Quantitative Risk Assessment Report for the Phase 1 Investigation

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1 Executive summary

1.1.1 The aim of this Generic Quantitative Risk Assessment Report for the Phase 1 Investigation is to present and to carry out an assessment of the data collected as part of the Phase 1 ground investigation, completed between September 2017 – February 2018 and September 2018 – January 2019.

1.1.2 The report aims to use the environmental data presented herein to highlight potential risks relating to soil, groundwater and/or gas contamination in the vicinity of the tunnel portals.

1.1.3 Three of the potential contamination sources identified in the Preliminary Risk Assessment Report (Application Document 6.3, Appendix 10.6) lie broadly within the area covered by environmental sampling undertaken as part of the Phase 1 ground investigation.

1.1.4 Further coverage and assessment of the identified credible sources within the Phase 2 investigation is presented in the Generic Quantitative Risk Assessment Report for the Phase 2 Investigation (Application Document 6.3, Appendix 10.9, Annex A–D).

1.1.5 A Generic Quantitative Risk Assessment (GQRA) has been undertaken to determine the significance of the measured concentrations of contaminants from the chemical analysis. A preliminary assessment of the ground gas data has also been undertaken using screening concentrations.

1.1.6 A total of 110 soil samples were collected and analysed. The human health Generic Assessment Criteria (GAC) for lead was exceeded in six samples taken from the Made Ground within the area of Goshems Farm Landfill to the north of the River Thames. Asbestos was also detected in four samples taken from Goshems Farm Landfill. As the asbestos was only detected at depths greater than 3m below ground level (bgl) it does not initially present a significant risk. A total of 13 soil leachate samples were collected and analysed. Concentrations of metals were recorded as exceeding the water resources GAC in 12 samples. Chloride and sulphate exceeded the screening criteria in one out of two samples (BH2384 and BH2372 respectively) both of which are located in Goshems Farm Landfill. Phenol concentrations exceeded the screening criteria in the two samples collected in the South Portal area.

1.1.7 The assessment of groundwater is based on maximum concentrations taken from data available from the Phase 1 investigations. Groundwater samples exceeded the water resource GAC for the majority of the heavy metals, inorganics and some of the Total Petroleum Hydrocarbon (TPH) products. Contaminants exceeded thresholds in samples in both the North and South Portal areas. However, the magnitude by which concentrations exceed criteria are generally greatest in samples taken from the North Portal.

1.1.8 Initial ground gas results suggest there is potential for pockets of material within the peat and alluvial layers to the north of the River Thames to generate high concentrations of gases. Exceedances of the screening criteria used for methane and carbon dioxide were recorded from a number of locations there. Significant ground gas was not generally recorded in monitoring locations within the South Portal area.

1.1.9 Based on the data available from the Phase 1 investigation it is considered that, further investigation in relation to ground gas was required. The subsequent Phase 2 investigation undertook gas monitoring and this is reported in Appendix 10.9: GQRA for the Phase 2 Investigation (Application Document 6.3). Further action may include remediation via methods identified in the Remediation Options Appraisal and Outline Remediation Strategy (Application Document 6.3, Appendix 10.11) or via engineering controls included in the construction design. There may be other contaminants for which further action is also necessary that are identified in the subsequent phases of work, but which have not been encountered during the Phase 1 investigation.

1.1.10 The primary purpose of the Phase 1 investigation was to collect geotechnical information. Although there may be areas within which measured contaminant concentrations do not exceed screening criteria for certain contaminants, the data collected as part of the Phase 1 works alone is insufficient to eliminate any of the potential risks or pollutant pathways identified from the Preliminary Risk Assessment Report (Application Document 6.3, Appendix 10.6), and these risks are, therefore, assumed to still apply. As environmental investigation is a continuous process of refinement, the results of the Phase 1 assessment have been used to inform the Phase 2 investigation. During this phase of works, further geo-environmental data has been collected and used to refine the assessment through the production of a GQRA. The results of this assessment are provided in the GQRA Report for the Phase 2 Investigation (Application Document 6.3, Appendix 10.9, Annex A–D).

2 Introduction

2.1 Background

2.1.1 This report provides an assessment of the Phase 1 environmental data collected between September 2017 – February 2018 and September 2018 – January 2019 around the portal areas of the A122 Lower Thames Crossing (the Project) route.

2.2 Aims and objectives

2.2.1 The primary objective of this report is to present the environmental data collected as part of the Phase 1 ground investigation and carry out an initial assessment of that data.

2.2.2 As the Phase 1 investigation was primarily focused on geotechnical requirements, there is insufficient data to be able to rule out any of the potential risks identified in the Preliminary Risk Assessment Report (Application Document 6.3, Appendix 10.6). In line with the land contamination management process, set out below and presented in Plate 2.1, the report therefore aims to use the environmental data presented to highlight potential risks in the vicinity of the tunnel portals.

2.3 Report scope and structure

2.3.1 A summary of the Preliminary Risk Assessment Report (Application Document 6.3, Appendix 10.6) is provided in this report, including findings on potentially contaminative features identified. Environmental data, including laboratory analysis of samples collected during the initial phases of ground works and ground gas monitoring data, is also presented herein.

2.3.2 In line with Land Contamination: Risk Management (LCRM) (Environment Agency, 2021), a Generic Quantitative Risk Assessment (GQRA) has been undertaken to determine the significance of the measured concentrations of contaminants from the chemical analysis. The GQRA compares measured concentrations of contaminants in the soil and groundwater samples with applicable Generic Assessment Criteria (GAC), along with a preliminary assessment of ground gas data.

2.3.3 The structure of this report is as follows:

a. Available data summarises the data available from the Phase 1 investigation

b. below summarises the potential sources identified from the Preliminary Risk Assessment Report (Application Document 6.3, Appendix 10.6).

c. below presents a summary of the environmental sampling and testing works undertaken.

d. below presents the analysis results and interpretation for environmental samples collected as part of the investigation.

e. below summarises the potential significant risks identified at this stage and provides recommendations for further ground investigation work.

2.4 Site description and route layout

2.4.1 The A122 Lower Thames Crossing (the Project) would provide a connection between the A2 and M2 in Kent and the M25 south of junction 29, crossing under the River Thames through a tunnel.

2.4.2 The A122 would be approximately 23km long, 4.25km of which would be in tunnel. On the south side of the River Thames, the Project route would link the tunnel to the A2 and M2. On the north side, it would link to the A13, M25 junction 29 and the M25 south of junction 29. The tunnel portals would be located to the east of the village of Chalk on the south of the River Thames and to the west of East Tilbury on the north side.

2.4.3 Junctions are proposed at the following locations:

a. New junction with the A2 to the south-east of Gravesend

b. Modified junction with the A13/A1089 in Thurrock

c. New junction with the M25 between junctions 29 and 30

2.4.4 To align with National Policy Statement for National Networks (Department for Transport, 2014) policy and to help the Project meet the Scheme Objectives, it is proposed that road user charges would be levied in line with the Dartford Crossing. Vehicles would be charged for using the new tunnel.

2.4.5 The Project route would be three lanes in both directions, except for:

a. link roads

b. stretches of the carriageway through junctions

c. the southbound carriageway from the M25 to the junction with the A13/A1089, which would be two lanes

2.4.6 In common with most A-roads, the A122 would operate with no hard shoulder but would feature a 1m hard strip on either side of the carriageway. It would also feature technology including stopped vehicle and incident detection, lane control, variable speed limits and electronic signage and signalling. The A122 design outside the tunnel would include emergency areas. The tunnel would include a range of enhanced systems and response measures instead of emergency areas.

2.4.7 The A122 would be classified as an ‘all-purpose trunk road’ with green signs. For safety reasons, walkers, cyclists, horse riders and slow-moving vehicles would be prohibited from using it.

2.4.8 The Project would include adjustment to a number of local roads. There would also be changes to a number of Public Rights of Way, used by walkers, cyclists and horse riders. Construction of the Project would also require the installation and diversion of a number of utilities, including gas pipelines, overhead

electricity powerlines and underground electricity cables, as well as water supplies and telecommunications assets and associated infrastructure.

2.4.9 The Project has been developed to avoid or minimise significant effects on the environment. The measures adopted include landscaping, noise mitigation, green bridges, floodplain compensation, new areas of ecological habitat and two new parks.

2.4.10 The Phase 1 ground investigation works were primarily located around the portal areas located to the north and south of the River Thames. The investigation was primarily focused on collecting geotechnical information as tunnelling works proposed within these locations present the highest constructability risk to the Project.

2.5 Land Contamination: Risk Management process

2.5.1 The assessment presented herein is based upon the process laid out in the LCRM guidance (Environment Agency, 2021). In brief, the assessment is a tiered process with increased site-specific understanding required at each level:

a. **Stage 1: Risk assessment** – The three tiers are:

   i. Preliminary Risk Assessment (PRA)

   ii. Generic Quantitative Risk Assessment (GQRA)

   iii. Detailed Quantitative Risk Assessment (DQRA)

b. **Stage 2: Options appraisal** – The three tiers are:

   i. Identify feasible remediation options

   ii. Detailed evaluation of options

   iii. Select your final remediation options

c. **Stage 3: Remediation** – The three tiers are:

   i. Develop a remediation strategy

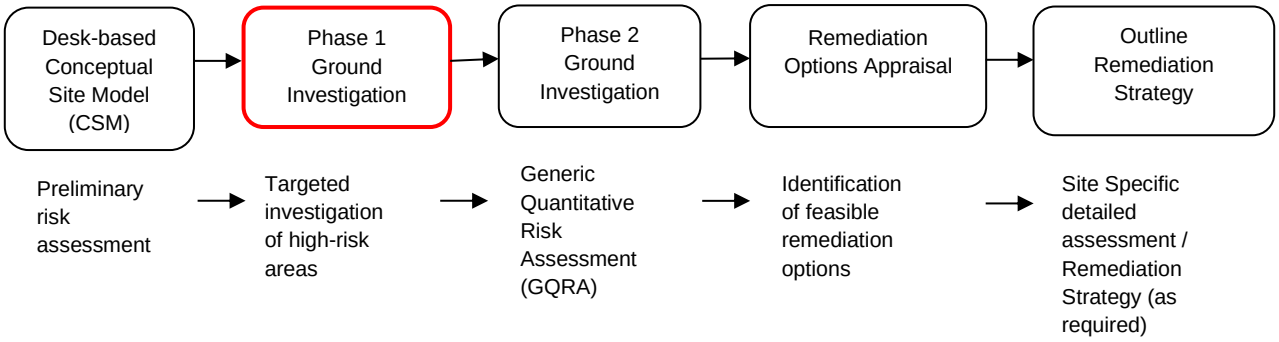
   ii. Remediation and verification

   iii. Long term monitoring and maintenance, if required

2.5.2 The contaminated land risk assessment for the Project falls within stage 1 of the LCRM process. For the purposes of the Project, the risk assessment has been separated into various phases of work. The phases and how they relate to the LCRM are presented in Plate 2.1.

2.5.3 This report is based upon the data collected as part of the Phase 1 ground investigation works. Phase 1 was intended as a limited scope investigation to target the high-risk construction and contamination zones identified from the Preliminary Risk Assessment Report and which were located around the tunnel portals.

Plate 2.1 Summary of the Project phases in relation to the LCRM process Plate



3 Available data

3.1 Introduction

3.1.1 This report has utilised data gathered from the Phase 1A and Phase 1B ground investigations. The Phase 1A ground investigation covers areas both north and south of the River Thames, whilst the Phase 1B ground investigation covers areas south of the Thames only.

3.1.2 The following report summarises the sources of this data and outlines the scope of works that have been undertaken between September 2017 and January 2019, and the subsequent monitoring completed between February 2018 and December 2018.

3.2 Phase 1A ground investigation

3.2.1 The initial phase of ground investigation works was carried out between September 2017 and February 2018. This phase of work consisted of intrusive and non-intrusive investigation, *in situ* testing, and geotechnical and geo-environmental laboratory testing.

3.2.2 The complete scope of works comprised the following:

a. 64 inspection pits

b. 18 cable percussion boreholes with rotary follow-on drilling

c. Six dynamic sampling boreholes with rotary follow-on drilling

d. Four cable percussion only boreholes

e. Four rotary core only boreholes

f. Two dynamic sampling only boreholes

g. 44 cone penetrometer tests

h. Standard penetration tests

i. High pressure dilatometer tests

j. Double packer tests

k. Variable head tests

l. Downhole and surface geophysical testing

m. Groundwater/ground gas installations and monitoring

n. Vibrating wire piezometers

o. Geotechnical and geo-environmental laboratory testing

3.2.3 Soil, soil leachate, groundwater and surface water samples were collected and scheduled for laboratory analysis. A full summary of the testing regime and investigation is provided in the Phase 1 Ground Investigation Factual Report (AECOM, 2018a).

3.3 Phase 1B ground investigation

3.3.1 The second phase of ground investigation works took place between September 2018 and January 2019. The primary objective of this second phase of ground investigation was to form exploratory holes in order to facilitate hydrogeological testing and characterisation around the North and South Portal areas. Following completion of the works, pumping tests were scheduled to be carried out in two monitoring wells.

3.3.2 The full scope of works comprises the following:

a. 21 inspection pits

b. Four cable percussion boreholes

c. 13 cable percussion boreholes which were extended by rotary coring

d. One rotary cored borehole

e. One rotary open borehole

f. Two cable percussion boreholes which were extended by rotary open hole drilling

g. Standard penetration tests.

h. Variable head tests

i. Downhole geophysical logging

j. Installation and test of pumping test apparatus

k. Groundwater installations and monitoring.

l. Geotechnical and geo-environmental laboratory testing

3.3.3 Full details of the testing regime and investigation are provided within the Phase 1 Pumping Test Ground Investigation (AECOM, 2018b).

3.3.4 One pumping test had been completed as of 30 August 2019 around the South Portal.

4 Summary of potentially contaminative features identified

4.1 Preliminary Risk Assessment Report

4.1.1 The Preliminary Risk Assessment Report (Application Document 6.3, Appendix 10.6) was produced to identify and outline potential risks from contaminated soil, water and contaminative land uses present along the Project route.

4.1.2 Only those land uses which were noted as having a possible impact on the Project, for example those which may form part of a potential pollution linkage, were assessed.

4.1.3 A Preliminary Risk Assessment in line with LCRM was carried out for each source, detailing the receptors which could be impacted by each pollution pathway and assigning an associated risk rating from low to high.

4.1.4 A table summarising the results of the full Preliminary Risk Assessment can be found in the Preliminary Risk Assessment Report (Application Document 6.3, Appendix 10.6). Sources relating to the Phase 1A and Phase 1B ground investigations are presented in Annex A.

4.2 Key sources of potential contamination

4.2.1 The Preliminary Risk Assessment Report (Application Document 6.3, Appendix 10.6) identified over 200 sources of potential contamination along the Project. Out of those identified, three lie broadly within the area covered by the Phase 1 ground investigation. Although geotechnical testing was carried out in every location within the Phase 1 works, environmental samples were only collected from holes drilled across three out of the six locations. The three sources are briefly outlined below and presented in Figure A:

a. **Goshems Farm Landfill (HLU0526):** A historical landfill covering 78 hectares, filled between the late 19th century and 1958. The waste type is recorded as household and refuse ash. The site has been undergoing restoration works from 1998 to the present with the aim of restoring the site to conditions suitable for grazing agriculture.

b. **Tilbury Ash Disposal (HLU0527, HLU0528, HLU0529):** A pulverised fuel ash landfill operated by RWE npower. The ash field was linked to the former Tilbury Power Station and covers 126 hectares. The site is split into seven sections, but ground investigation works were focused in areas C, C2 and B (shown in the Preliminary Risk Assessment Report). Investigation points lie within HLU0527 and HLU0528 only.

c. **Southern Valley Golf Course (HLU0324):** A 60-hectare golf course with associated clubhouse, car parks and storage areas constructed in 1988. Waste and gas storage is present on site along with a groundwater abstraction borehole. A trade discharge consent was issued to the site in 1999 for ‘process water’ discharge to land. Whilst investigation points were positioned in the general area of the golf course, all lie outside the boundary of this potential source.

4.2.2 Although these sources fall near the Phase 1 ground investigation, they have not been specifically investigated for presence of contamination at this stage in the investigation. More geo-environmentally focused investigation of contamination has been completed as part of the Phase 2 investigations to inform the Development Consent Order assessments. Collection of data relating to the credible sources of contamination identified above is an ongoing process of refinement, as detailed in Plate 2.1.

4.2.3 Phase 1 was intended as a targeted investigation of the high-risk construction and contamination zones identified in the Preliminary Risk Assessment Report (Application Document 6.3, Appendix 10.6). As such, a precautionary approach has been taken as the potential risks relating to contamination and the presence of any pollution linkages within the entire Project area cannot be discounted at this stage. Further data has been collected as part of the Phase 2 works and a GQRA has been undertaken to get a better understanding of the magnitude of risk from contamination encountered associated with the geo-environmental sources identified in the Preliminary Risk Assessment Report (Application Document 6.3, Appendix 10.6). The GQRA and Phase 2 results are presented in the GQRA Report for the Phase 2 Investigation (Application Document 6.3, Appendix 10.9, Annex A–D).

5 Ground investigation summary

5.1 Ground conditions encountered

5.1.1 A summary of the locations and composition of the strata encountered during the Phase 1A and Phase 1B ground investigations is presented below. As per the two ground investigation reports (AECOM, 2018a; 2018b), the data has been split by phase. The Phase 1A ground investigation covers areas both north and south of the River Thames, whilst the Phase 1B ground investigation covers areas south of the Thames only. Borehole locations are shown in Figure A.

Phase 1A

5.1.2 Table 5.1 summarises the strata encountered in the ground works which were undertaken as part of the Phase 1A investigation. Detailed information regarding the strata encountered in the Phase 1A ground investigation can be found in the Phase 1 Ground Investigation Factual Report (AECOM, 2018a).

Table 5.1 Strata encountered in Phase 1A

Strata	Minimum depth encountered (m)	Maximum depth encountered (m)
Topsoil	0	0.5
Made Ground	0	10.7
Alluvium	0.15	26.1
Head Deposits	0	7.0
River Terrace Deposits	1	30.70
Thanet Formation	3.7	14.0
Chalk	0.5	64.80*

** To base of borehole*

Phase 1B

5.1.3 Table 5.2 summarises the strata encountered in the Phase 1B ground investigation. Detailed information regarding the strata encountered in the Phase 1B ground investigation can be found in the Phase 1 Pumping Tests Ground Investigation Report (AECOM, 2018b).

Table 5.2 Strata encountered in Phase 1B

Strata	Minimum depth encountered (m)	Maximum depth encountered (m)
Topsoil	0	0.50
Made Ground	0	0.4
Alluvium	0.05	15.0
Head Deposits	0.35	2.50
River Terrace Deposits	1.8	22
Chalk	0.4	52.75*

** To base of borehole*

5.2 Hydrogeology

North of River Thames

5.2.1 Groundwater was encountered in 15 boreholes within the Phase 1A works to the north of the River Thames. The depths of the strikes and the strata in which they were encountered are summarised in Table 5.3. Full details are provided in the Phase 1 Ground Investigation Factual Report (AECOM, 2018a).

Table 5.3 Groundwater encountered north of the River Thames

Location	Depth to water strike (m below ground level (bgl))	Groundwater rest level (m bgl)	Groundwater rest elevation (m above ordnance datum (AOD))
BH1306	23.70 (**White Chalk**), 24.30 (**White Chalk**)	14.00	-6.6
BH1308A	15.00 (**Head Deposits**)	-	-
BH1309A	4.00 (**Made Ground**)	3.40	1.9
BH2370	6.00 (**Alluvium**)	5.10	3.5
BH2372	5.50 (**Made Ground**), 23.50 (**Alluvium**)	5.35 to 14.10	3.84 to -4.91
BH2374	5.10 (**Made Ground**), 21.00 (**Alluvium**)	5.10 to 11.90	3.41 to -3.39
BH2384	8.45 (**Made Ground**), 26.10 (**River Terrace Deposits**)	6.80 to 9.60	1.99 to -0.81
BH2385	6.45 (**Made Ground**), 17.00 (**Alluvium**), 24.00 (**White Chalk**)	5.85 to 16.10	1.29 to -8.96
BH2392A	20.40 (**River Terrace Deposits**)	-	-
BH2602A	5.00 (**Made Ground**), 18.00 (**Alluvium**), 22.30 (**River Terrace Deposits**)	4.25 to 17.47	0.8 to -12.42
BH2603A	5.00 (**Made Ground**)	4.50	1.02
BH2604	4.00 (**Made Ground**)	-	-
BH2604A	9.00 (**Alluvium**)	6.90	-1.16
BH2612	5.00, 5.35 (**River Terrace Deposits**)	4.20 to 5.35	1.01 to -0.14
BH2613	2.00 (**River Terrace Deposits**), 11.00 (**Thanet Formation**)	1.40 to 1.70	1.33 to 1.03

South of River Thames

5.2.2 Groundwater was encountered in seven boreholes in Phase 1A and 15 boreholes in Phase 1B in the area to the south of the River Thames. The strike depths and the strata in which they were encountered are presented in Table 5.4. Full details regarding the groundwater encountered can be found in the Phase 1 Ground Investigation Factual Report (AECOM, 2018a) and the Phase 1 Pumping Tests Ground Investigation Report (AECOM, 2018b).

Table 5.4 Groundwater encountered south of the River Thames

Location	Depth to water strike (m bgl)	Groundwater rest level (m bgl)	Groundwater rest elevation (m AOD)
BH2302	4.90 (**Head**), 7.00 (**White Chalk**)	3.90 to 4.80	-0.13 to -1.03
BH2306	5.90 (**Head**)	2.90	1.17
BH2308	7.00 (**Thanet Formation**)	1.78	0.42
BH2313	7.00 (**Alluvium**)	5.90	-3.77
BH2316	0.90 (**Alluvium**), 10.00 (**River Terrace Deposits**), 13.00 (**River Terrace Deposits**)	0.90 to 10.00	1.28 to -7.82
BH2322	14.40 (**River Terrace Deposits**)	1.80	0.48
BH2335	14.00 (**River Terrace Deposits**)	2.00	0.5
BH2313A	1.00 (**Alluvium***), 18.40 (**River Terrace Deposits**)	2.10	0.01
OH04001	0.90 (**Alluvium***)	0.70	1.71
OH04001A	0.90 (**Alluvium***)	0.70	1.75
OH04002	1.20 (**Alluvium***), 3.60 (**River Terrace Deposits**), 6.00 (**River Terrace Deposits**)	3.55 to 4.80	-1.45 to -2.7
OH04003	0.70 (**Alluvium***), 12.50 (**River Terrace Deposits**), 14.70 (**River Terrace Deposits**)	0.60 to 8.50	1.43 to -6.47
OH04004	1.20 (**Alluvium**), 10.00 (**Alluvium**), 14.50 (**River Terrace Deposits**)	2.10 to 9.25	0.24 to -6.91
OH04005	4.00 (**River Terrace Deposits**)	2.80	-0.65
OH04006	10.00 (**Alluvium**)	8.00	-5.8
OH04007	1.10 (**Alluvium***), 5.10 (**River Terrace Deposits**), 12.70 (**River Terrace Deposits**), 16.60 (**River Terrace Deposits**)	1.80 to 10.70	0.32 to -8.58

Location	Depth to water strike (m bgl)	Groundwater rest level (m bgl)	Groundwater rest elevation (m AOD)
OH04008	9.45 (**River Terrace Deposits**), 15.50 (**River Terrace Deposits**)	1.35 to 6.80	0.98 to -4.47
OH05001	15.00 (**Alluvium**)	3.80	-1.71
OH05002	15.00 (**River Terrace Deposits**)	3.80	-1.47
OH05003	10.00 (**Alluvium**), 13.80 (**River Terrace Deposits**)	-	-
PW04001	0.90 (**Alluvium**)	-	-
PW04001A	6.00 (**Alluvium**)	-	-

**Interpreted in AECOM (2018a and 2018b) as superficial deposits.*

5.3 Soil sampling summary

5.3.1 A total of 110 soil samples were sent for laboratory analysis from 29 locations: 16 to the north of the River Thames and 13 to the south. Samples were taken from a range of depths to provide coverage of the different strata encountered. The sampling depths and associated strata are summarised in Table 5.5.

Table 5.5 Sampling depth and associated strata

Strata	Depth range of samples (m bgl)	Number of samples taken
Topsoil	0-0.4	5
Made Ground	0.2-8	43
Head Deposits	0.4-1.5	13
Alluvium	1-23.3	21
River Terrace Deposits	1.8-24.5	13
Chalk	0.9-30.8	15

5.3.2 All samples have been tested by an accredited laboratory. As a minimum, soil samples have been tested for a standard suite of determinands. However, where field observations meant more detailed analysis of contaminants was required, an extended suite of analysis was adopted. The analysis suites are summarised in Table 5.6.

Table 5.6 Summary of analysis suites adopted for soil samples

Analysis suite	Determinands
Standard suite	Asbestos Chromium (hexavalent) Metals Cyanide (free) Cyanide (total) Moisture content pH Phenols – total (monohydric)

Analysis suite	Determinands
	Stone content Total organic carbon Total polycyclic aromatic hydrocarbons (PAHs) Total Petroleum Hydrocarbons (TPH)
Extended suite	Metals Asbestos Boron (water soluble) Chromium (hexavalent) Cyanide (free) Cyanide (total) Moisture content pH Phenols (monohydric) Speciated PAH Stone content Total organic carbon Volatile organic compounds Semi volatile organic compounds TPH – Criteria Working Group (CWG)

Asbestos

5.3.3 Asbestos was identified within four soil samples collected from three borehole locations to the north of the River Thames. There was no asbestos detected within any of the samples collected south of the Thames.

5.3.4 The four soil samples were collected from the Made Ground at Goshems Farm Landfill. As such, the presence of asbestos in these samples may relate to the site's historical use as a landfill and is not unexpected at this type of site. The quantities and interpreted asbestos types for each sample is presented in Table 5.7.

Table 5.7 Summary of asbestos identified in soil samples

Location	Sample depth (m)	Asbestos type identified	Asbestos quantity (% w/w)
BH1306	3.0	Chrysotile	0.004
BH2374	6.10	Anthophyllite	<0.001
	6.70	Crocidolite	0.003
BH2384	5.0	Chrysotile	<0.001

Soil leachate analysis

5.3.5 Soil leachate analysis was undertaken on a total of 13 samples, collected from 12 boreholes from the North and South Portal areas. The sample depths and the strata from which they were taken are summarised in Table 5.8.

Table 5.8 Sampling depth and associated strata

Location ID	Sample depth (m bgl)	Strata
BH1306	3.0	Made Ground
BH2036	0.1	Topsoil
BH2301	0.5	Head Deposits
BH2302	0.4	Head Deposits
BH2370	3.0	Made Ground
BH2372	4.0	Made Ground
BH2384	11.1	Alluvium
BH2392	1.0	Made Ground
BH2602	3.8	Made Ground
BH2603	0.6	Made Ground
BH2604	1.9	Made Ground
	5.9	
BH2612	0.6	Head Deposits

5.3.6 All soil leachate samples were analysed for the following suite of determinands:

a. Ammoniacal nitrogen

b. Calcium, magnesium, sodium, potassium

c. Chloride, fluoride and sulphate

d. Cyanide (free)

e. Cyanide (total)

f. Electrical conductivity

g. pH

h. Phenols (monohydric)

i. Metals

5.4 Groundwater sampling summary

5.4.1 Monitoring wells were installed into selected borehole locations as part of the Phase 1A and 1B ground investigation. Groundwater samples have been collected from 26 monitoring wells installed at locations both to the north and south of the River Thames.

5.4.2 The groundwater data assessed in this report is based on the information presented in Annex B. The data available covers the groundwater monitoring completed over the period September 2018 to December 2018.

5.4.3 Groundwater samples had been collected from the following 26 monitoring wells: BH1306; BH1308A; BH1309A; BH2370; BH2301; BH2316; BH2322; BH2372; BH2374; BH2384; BH2385; BH2392; BH2392A; BH2602A; BH2603A; BH2604A; OH03002; OH04002; OH04003; OH04004; OH04005; OH04006; OH04007; OH04008; OH05002; and PW03001.

5.4.4 The dates of the groundwater sampling included in this report are 20/09/2018; 17/10/2018; 13/11/2018; 14/11/2018; 21/11/2018; and 11/12/2018.

5.4.5 All samples have been tested by an accredited laboratory. As a minimum, samples have been tested for a standard suite of determinands. An extended suite has been adopted in areas where field observations required a more detailed analysis of contaminants or where detailed assessment of the hydrogeological baseline was required. The suites of analysis are provided in Table 5.9.

Table 5.9 Summary of analysis suites adopted for groundwater samples

Analysis suite	Determinands
Standard suite	Metals Chromium (hexavalent) Cyanide (free) Cyanide (total) Dissolved organic carbon Electrical conductivity pH Phenols (monohydric) Total PAH TPH
Extended suite	Ammoniacal nitrogen Other metals Biological Oxygen Demand (BOD) Calcium, magnesium, potassium, sodium Chloride, fluoride, sulphate Chromium (hexavalent) Chemical Oxygen Demand (COD) Cyanide (free) Cyanide (total) Dissolved organic carbon Electrical conductivity pH Phenols (monohydric) Volatile organic compounds Speciated PAH Speciated TPH-CWG

5.5 Ground gas monitoring

5.5.1 The ground gas assessment presented in this report is limited to the information presented within Annex C and which covers the period 13 February 2018 to 17 May 2018.

5.5.2 The Phase 1 works included the installation of groundwater standpipes at 15 locations (BH2029, BH2034, BH2036, BH2301, BH2302, BH2316, BH2322, BH2384, BH2385, BH2392A, BH2602A, BH2603A, BH2604A, BH2612 and BH2613). Seven of the locations were to the south of the River Thames, and eight to the north. During the ground investigation works, the possibility of ground gases being present in the area became evident. Although the 15 standpipes were not initially designed to monitor ground gases, ground gas monitoring has been undertaken and recorded in these locations for initial assessment purposes.

5.5.3 During drilling works at BH2374, positioned north of the River Thames in Goshems Farm Landfill, olfactory evidence suggested the presence of hydrogen sulphide. A monitoring installation was constructed to assess the potential source of the gas. A further ground gas installation (BH1309A) was constructed at Goshems Farm Landfill, to monitor the unsaturated zone above the pulverised fuel ash layers and the top of the Alluvium layers. These two ground gas monitoring wells are in addition to the 15 groundwater standpipes.

5.5.4 Data was collected between 13 February 2018 and 17 May 2018. Full monitoring data are provided in Annex C. The majority of the 17 locations had been monitored either once or twice over the period, with the exception of dedicated gas monitoring points BH1039A and BH2374 which had been monitored on 13 and 11 occasions, respectively.

6 Generic Quantitative Risk Assessment

6.1 Introduction

6.1.1 A GQRA has been undertaken to determine the significance of the measured concentrations of contaminants from the chemical analysis. The GQRA comprises comparison of measured concentrations of contaminants in the soil and groundwater samples with applicable GAC. A preliminary assessment of the ground gas data has also been undertaken using screening concentrations.

6.1.2 The selection of applicable GAC and screening criteria is described in the sections below, along with the results of the assessment and a discussion of the findings.

6.2 Soil assessment

Selection of assessment criteria

6.2.1 The assessment of soil is primarily focused on the potential risk to human health. The risk to water resource receptors has been assessed by leachate and groundwater concentrations.

6.2.2 Human health receptors identified in the Preliminary Risk Assessment Report (Application Document 6.3, Appendix 10.6) included:

a. onsite future construction workers

b. onsite future operations staff

c. onsite future road users

d. adjacent residential land users

e. adjacent commercial land users

f. adjacent recreational land users

6.2.3 Assessment criteria were selected in order to provide protection to the human health receptors identified from onsite measured soil concentrations. As such, in many cases the criteria selected may be overly conservative but provide an initial screen.

6.2.4 The risk to future construction workers has not been specifically considered in this assessment. The potential risk to construction workers would be managed via general construction working practice, suitable for development of a brownfield site, and adherence to applicable health and safety regulations (e.g. Construction (Design and Management) Regulations 2015) (HM Government 2015). This may include, but is not limited to, dust monitoring and suppression, and use of personal protective equipment.

6.2.5 The soil chemical data has been screened against the current Land Quality Management/Chartered Institute of Environmental Health (LQM/CIEH) Suitable for Use Levels (S4UL) for public open space near residential housing (POSresi)

(Nathanail *et al*., 2015). In the absence of a S4UL for lead, the Category 4 Screening Level (C4SL) has been adopted, Development of Category 4 Screening Levels for Assessment of Land Affected by Contamination (Contaminated Land: Applications in Real Environments, 2014).

6.2.6 A soil organic matter content of 1% has been used in the assessment. This is the lowest soil organic matter content for which S4UL criteria have been derived. It therefore represents the most conservative of the S4UL criteria.

Soil assessment results

6.2.7 Table 6.1 summarises the determinands that were recorded above the GAC adopted as screening criteria. The locations were all positioned in the Goshems Farm site to the north of the River Thames as shown on Plate 6.1. The complete set of laboratory data is presented in the Phase 1 Ground Investigation Factual Report (AECOM, 2018a) and the Phase 1 Pumping Tests Ground Investigation Report (AECOM 2018b).

6.2.8 A measured concentration greater than the GAC does not necessarily mean there is a significant risk to a receptor but may indicate the need for further assessment. Where contaminant concentrations in soils sampled are below GAC, they are considered unlikely to pose a significant risk.

Table 6.1 Summary of GAC exceedances in soil

Determinand	GAC (mg/kg)	Samples exceeding GAC	Result (mg/kg)
Lead	630 C4SL	Six of 108	
		BH2385 6.0m	774
		BH2384 8.0m	908
		BH2374 4.7m	4,300
		BH2374 6.1m	1,570
		BH2370 6.0m	1,910
		BH1306 3.0m	2,690

6.2.9 With the exception of lead, measured concentrations were below either the laboratory Method Detection Limit (MDL) or the adopted screening criteria.

Plate 6.1 Locations of soil samples recording exceedances in lead

Key

- Route alignment – earthworks
- Route alignment – highway alignment
- Order Limits
- Sample location
- High risk rating HLU
- Medium risk rating HLU
- Low risk rating HLU

Scale 500m

Risk ratings obtained from the Preliminary Risk Assessment Report (Application Document 6.3, Appendix 10.6)

Soil assessment discussion

6.2.10 The GAC for lead was exceeded in six samples, all from five locations within the Made Ground at Goshems Farm Landfill site between 3.0m bgl and 8.0m bgl. The five locations were distributed across the landfill. The six samples recorded concentrations of lead ranging from 774mg/kg to 4,300mg/kg. The borehole logs for five of the locations recorded the Made Ground as brown to black, sandy, gravelly material containing brick, concrete, ceramics and glass. The borehole log for BH2374 (located within the centre of Goshems Farm), also noted clinker and flint within the material.

6.2.11 Other determinands were detected within soil samples at concentrations below the GAC. Therefore, they are unlikely to pose a significant risk.

6.2.12 It is noted that the laboratory MDL for dibenz(a,h)anthracene in several samples was higher than the GAC. The majority of the samples have MDL for dibenz(a,h)anthracene which is lower than the GAC. Given this, and that none of the remaining samples exceed the GAC, measured concentrations of dibenz(a,h)anthracene are considered unlikely to present a significant risk.

6.2.13 Asbestos, for which no GAC is readily available, was also recorded in four samples collected from three locations, at depths between 3.0m bgl and 6.7m bgl. The three locations are located within the Goshems Farm Landfill. As the asbestos has only been encountered at depth, they do not currently present a significant risk. However, given that the North Portal tunnel is planned to be located in this area, extensive groundworks are likely to occur. Further investigation and assessment of the data has been undertaken as part of the Phase 2 works and GQRA. The results of the assessment are presented in the GQRA Report for the Phase 2 Investigation (Application Document 6.3, Appendix 10.9, Annex A–D).

6.3 Leachate assessment

Selection of assessment criteria

6.3.1 The assessment of leachate is primarily focused on the potential risk to water resource receptors. Water resource receptors identified in the Preliminary Risk Assessment Report (Application Document 6.3, Appendix 10.6) include both surface water and groundwater receptors.

6.3.2 Soil leachate chemical data has been screened against both UK Drinking Water Standards (DWS) (The Water Supply (Water Quality) Regulations 2016), and UK freshwater Environmental Quality Standards (EQS) (The Water Environment Regulations 2017) in order to provide protection to both surface waters and aquifers. Freshwater EQS have been used for the protection of surface water as the majority of the Project is located inland.

6.3.3 The exploratory locations closest to the Thames Estuary are located within Goshems Farm Landfill to the north of the River Thames. As the exploratory locations are positioned inland, it is considered most appropriate to assess the potential contamination risk in relation to freshwater receptors as opposed to saline receptors.

Leachate assessment results

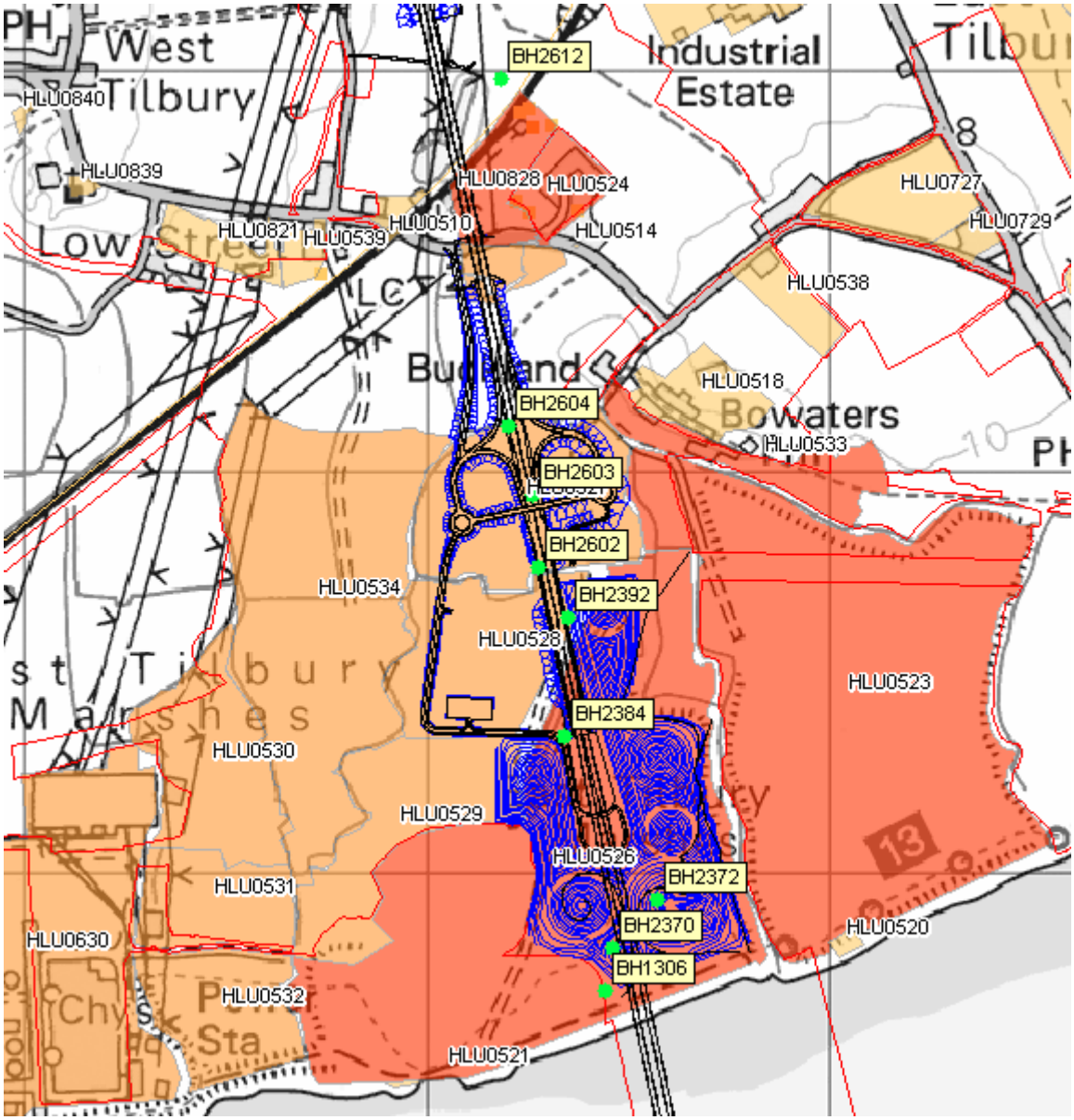
6.3.4 Table 6.2 summarises the determinands that were recorded above the GAC adopted as screening criteria. The locations are also shown on Plate 6.2 and Plate 6.3. The complete set of laboratory data is presented in the AECOM (2018a and 2018b) reports.

Table 6.2 Summary of DWS and EQS exceedances in soil leachate samples

Determinand	Screening criteria exceeded	Number of exceedances	Concentration of exceedances (µg/l)	Samples exceeding
Antimony	5 – UK DWS	4/10	7 – 195	BH1306 BH2372 BH2384 BH2392
Arsenic	10 – UK DWS	3/12	11 – 20	BH2603 BH2604
Boron	1,000 – UK DWS 2,000 – UK EQS	1/1	2,700	BH1306
Chromium (III)	4.7 – UK EQS	3/12	5 – 6	BH2302 BH2392 BH2604
Copper	1 – UK EQS*	6/12	2 – 11	BH1306 BH2036 BH2301 BH2302 BH2384 BH2612
Lead	10 – UK DWS 1.2 – UK EQS*	4/13	3 – 29	BH1306 BH2301 BH2302 BH2384
Molybdenum	70 – UK DWS	1/3	81	BH2384
Nickel	4 – UK EQS*	3/12	5 – 8	BH2302 BH2384 BH2612
Selenium	10 – UK DWS	1/12	22	BH2392
Vanadium	20 – UK EQS	2/8	33	BH2392 BH2602
Zinc	10.9 – UK EQS*	5/9	18 – 55	BH2036 BH2301 BH2032 BH2384 BH2612
Chloride	250 – UK DWS 250 – UK EQS	1/2	299	BH2384
Sulphate	250 – UK DWS	1/2	394.57	BH2372
Phenols	7.7 – UK EQS	2/13	300 – 470	BH2301 BH2302

**Minimum EQS presented. EQS based on bioavailable fraction and can be made site-specific following further assessment.*

Plate 6.2 Location of soil leachate exceedances, north of the River Thames

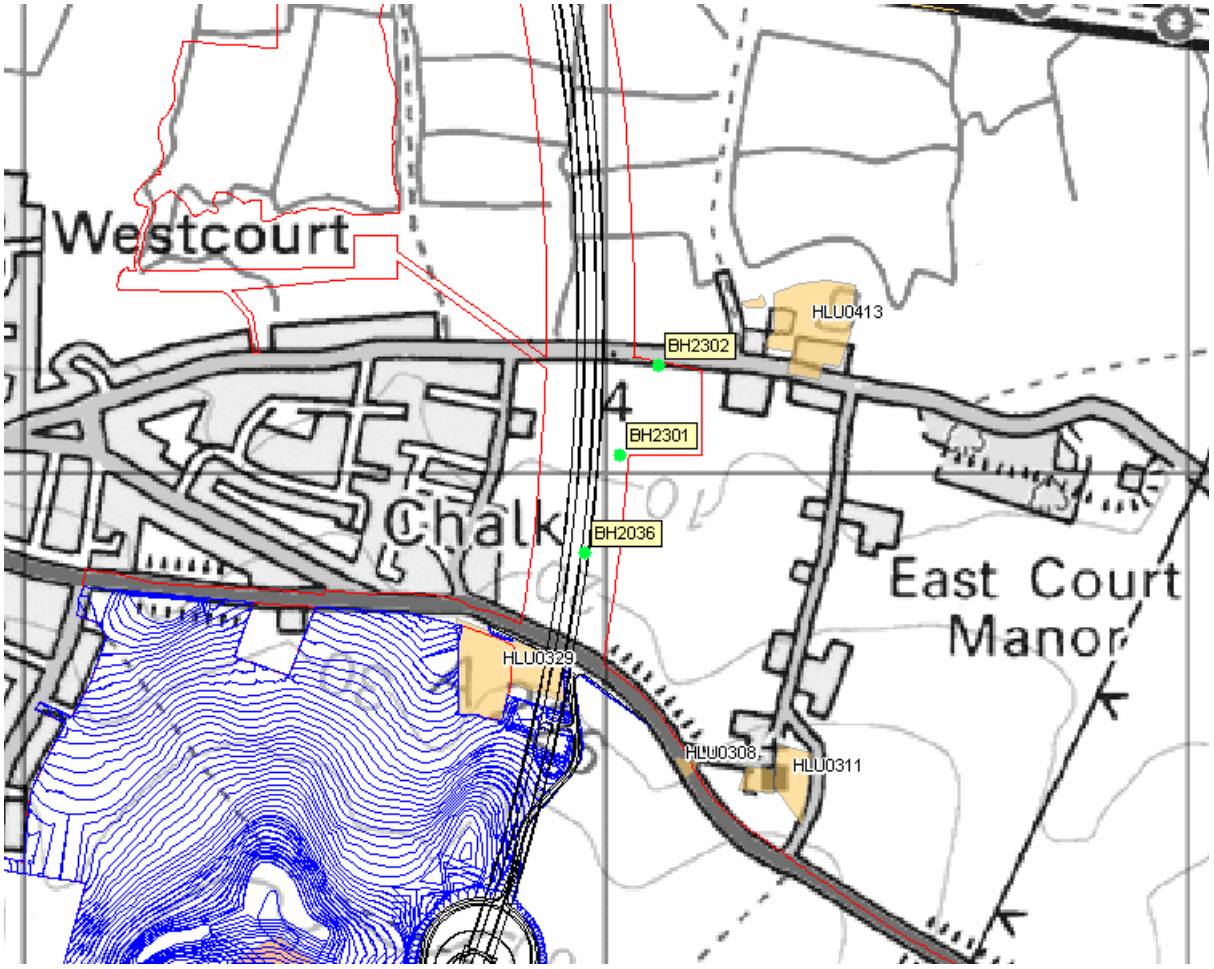


Key

- Route alignment – earthworks
- Route alignment – highway alignment
- Order Limits
- Sample exceedance
- High risk rating HLU
- Medium risk rating HLU
- Low risk rating HLU

Risk ratings obtained from the Preliminary Risk Assessment Report (Application Document 6.3, Appendix 10.6)

Plate 6.3 Location of soil leachate exceedances, south of the River Thames



Risk ratings obtained from the Preliminary Risk Assessment Report (Application Document 6.3, Appendix 10.6)

Leachate assessment discussion

6.3.5 To the north of the River Thames, nine samples were collected from Goshems Farm Landfill and the Tilbury Ash Disposal fields. A further single sample was collected from the area to the north of the Tilbury and Southend Railway (BH2612).

6.3.6 Within these 10 samples, concentrations of one or more metals were recorded as exceeding the screening criteria in nine samples. The samples were collected from depths of between 0.6m bgl and 11.1m bgl in the landfill areas, and also in the sample collected north of the railway at 0.6m bgl.

6.3.7 Chloride and sulphate concentrations exceeded the screening criteria in one out of the two samples analysed (BH2384 and BH2372 respectively). BH2384 was sampled from the Alluvium at 11.1m bgl, and BH2372 was sampled from the Made Ground at 4.0mbgl. Both locations are within Goshems Farm Landfill.

6.3.8 To the south of the Thames, three samples were collected from the South Portal area (BH2036, BH2301, BH2302). Measured concentrations exceeded for metals (three samples) and phenols (two samples). Metal concentrations were generally marginal falling within the same order of magnitude above criteria, for chromium, copper, lead, zinc and nickel. The sampling locations are from areas used for agriculture and have not been highlighted within the Preliminary Risk Assessment Report (Application Document 6.3, Appendix 10.6) as areas of potential contamination.

6.3.9 It is noted that the laboratory MDL for cyanide (free and total), mercury, cadmium and hexavalent chromium in a number of samples is higher than the UK freshwater EQS. As such, it is not possible to confirm whether or not these concentrations are above or below EQS. Given that concentrations are below the MDL, and that the MDL is lower than the DWS, concentrations of these contaminants of concern are considered unlikely to present a significant risk.

6.4 Groundwater assessment

Selection of assessment criteria

6.4.1 The assessment of groundwater considers the potential risk to water resource receptors. Water resource receptors identified in the Preliminary Risk Assessment Report (Application Document 6.3, Appendix 10.6) include both surface water and groundwater receptors.

6.4.2 Groundwater chemical data has been screened against both UK DWS (The Water Supply (Water Quality) Regulations 2016) and UK freshwater EQS (The Water Environment Regulations 2017) in order to provide protection to both surface waters and aquifers. This is in line with the leachate assessment.

Groundwater assessment results

6.4.3 The groundwater assessment has been based on data presented within Annex B.

6.4.4 Based on the groundwater data available, maximum determinand concentrations have been screened against the criteria described above. The exceedances are presented in Table 6.3 and Table 6.4.

Table 6.3 Summary of screening exceedances north of the River Thames

Determinand	Screening criteria exceeded (µg/l)	Maximum result
Arsenic	10 – UK DWS 50 – UK EQS	76 (µg/l)
Boron	1,000 – UK DWS 2,000 – UK EQS	58,300 (µg/l)

Determinand	Screening criteria exceeded (µg/l)	Maximum result
Chromium	50 – UK DWS	22 (µg/l)
Copper	1 – UK EQS	22 (µg/l)
Iron	200 – UK DWS 1,000 – UK EQS	49,400 (µg/l)
Lead	1.2 – UK EQS	9 (µg/l)
Manganese	50 – UK DWS 123 – UK EQS	13,200 (µg/l)
Mercury	1 – UK DWS 0.07 – UK EQS	0.5 (µg/l)
Nickel	20 – UK DWS 4 – UK EQS	65 (µg/l)
Zinc	10.9 – UK EQS	2,405 (µg/l)
Ammoniacal nitrogen	0.6 – UK EQS	94.6mg/L
Chloride	250 – UK DWS 250 – UK EQS	11,200mg/L
Cyanide (total)	1 – UK EQS	25mg/l
Fluoride	1,000 – UK EQS	1,040mg/l
Sodium	200 – UK DWS	7,810mg/l
Sulphate	250 – UK DWS 400 – UK EQS	2,480mg/l
Naphthalene	2 – UK EQS	2.36 (µg/l)
Fluoranthene	0.0063 – UK EQS	2.06 (µg/l)
Benzo(b)fluoranthene	0.025 – UK DWS	1.1 (µg/l)
Benzo(k)fluoranthene	0.025 – UK DWS	0.37 (µg/l)
Benzo(a)pyrene	0.01 – UK DWS 0.00017 – UK EQS	0.88 (µg/l)
Benzo(g,h,i)perylene	0.025 – UK DWS	0.68 (µg/l)
Benzene	1 – UK DWS	1 (µg/l)
Indeno(1,2,3-c,d)pyrene	0.025 – UK DWS	0.79 (µg/l)
>C21-C35 Aliphatics	10 – UK DWS	42 (µg/l)
Total >C5-C35 Aliphatics	10 – UK DWS	42 (µg/l)
TPH	10 – UK DWS	42

Table 6.4 Summary of screening exceedances south of the River Thames

Determinand	Screening criteria exceeded (µg/l unless stated)	Result
Boron	1,000 – UK DWS	1,510 (µg/l)
Chromium	3.4 – UK EQS	5 (µg/l)
Copper	1 – UK EQS	15 (µg/l)
Manganese	123 – UK EQS	618 (µg/l)
Mercury	0.07 – UK EQS	0.2 (µg/l)
Nickel	4 – UK EQS	13 (µg/l)
Zinc	10.9 – UK EQS	36 (µg/l)
Ammoniacal nitrogen	0.6mg/L – UK EQS	3.36mg/L
Chloride	250 – UK DWS 250 – UK EQS	6,130mg/L
Cyanide (total)	1 – UK EQS	12 (µg/l)
Sodium	200 – UK DWS	2,750 (µg/l)
Sulphate	250 – UK DWS 400 – UK EQS	1,640 (µg/l)
>C10-C12 Aliphatics	10 – UK DWS 50 – UK EQS	14 (µg/l)
>C16-C21 Aliphatics	10 – UK DWS 50 – UK EQS	31 (µg/l)
Total >C5-C35 Aliphatics	10 – UK DWS 50 – UK EQS	42 (µg/l)
>EC10-EC12 Aromatics	10 – UK DWS 50 – UK EQS	14 (µg/l)
>EC16-EC21 Aromatics	10 – UK DWS 50 – UK EQS	1,027 (µg/l)
>EC21-EC35 Aromatics	10 – UK DWS 50 – UK EQS	16 (µg/l)
Total >EC5-EC35 Aromatics	10 – UK DWS 50 – UK EQS	1,052 (µg/l)
TPH	10 – UK DWS 50 – UK EQS	1,094 (µg/l)

Groundwater assessment discussion

6.4.5 As shown by Table 6.3 and Table 6.4, groundwater samples have exceeded the screening criteria for the majority of the heavy metals, inorganics and some of the TPH products.

6.4.6 Heavy metal exceedances are recorded for the samples taken from the locations north of the River Thames, the majority of which are based in landfill sites. The metal exceedances were most notable for boron, iron, manganese and zinc. Within these samples, exceedances were also recorded for chloride, sodium and sulphate. For samples which were collected south of the Thames, exceedances were generally recorded for inorganics and TPH.

6.5 Ground gas Preliminary Risk Assessment

6.5.1 As part of each round of monitoring methane, carbon dioxide and oxygen were measured and recorded. A preliminary screening of the methane and carbon dioxide results has been carried out against a 1% by volume (v/v) methane and 5% v/v carbon dioxide screening threshold, in line with CIRIA C665 (CIRIA, 2007) and BS 8485 (British Standards Institution, 2019). Table 6.5 summarises the number of exceedances and the locations at which they were recorded. A full summary of the ground gas results can be found in Annex C.

Table 6.5 Summary of ground gas exceedances

Total exceedances		Number of exceedances by location		
Methane	**Carbon dioxide**	**Location (number of monitoring rounds)**	**Methane**	**Carbon dioxide**
28 of 47	19 of 47	BH2385 (2)	2	1
		BH2604A (2)	2	0
		BH2392A (2)	1	0
		BH2374 (11)	10	5
		BH1309A (13)	13	13

6.5.2 The current site information and the initial ground gas monitoring data suggest the methane is likely to be generated by bacterial degradation of Peat within the Alluvium. There is a potential, although less likely, that the ground gases are produced from the historic landfills.

6.5.3 Based on the potential ground gas hazard presented within this report, an additional assessment has been undertaken as part of the Phase 2 works. The results of the assessment have been provided in the GQRA Report for the Phase 2 Investigation (Application Document 6.3, Appendix 10.9, Annex A–D).

6.5.4 A total of 13 rounds of monitoring were carried out at BH1309A located within the Tilbury Ash Disposal site. Concentrations of methane and carbon dioxide were recorded above the threshold values of 1% v/v methane and 5% v/v carbon dioxide from every round. For methane, values ranged between 47.8% to 83.2% v/v, and for carbon dioxide values ranged between 10.1% and 16.9% v/v.

6.5.5 A total of 11 rounds of monitoring were carried out at BH2374 located in the Goshems Farm Landfill site between 21 February 2018 and 17 May 2018 (13 visits were attempted, but the well could not be accessed on two occasions). In total, 10 exceedances (greater than the 1% v/v threshold) were recorded for methane, with concentrations ranging between 0.2% and 70.9% v/v. Five exceedances (greater than the 5% v/v threshold) were recorded for carbon dioxide, with concentrations ranging between 0.4% and 12.9% v/v.

6.5.6 In BH2374, the greatest range in methane and carbon dioxide concentrations was measured. Assessment of the fluctuations in atmospheric pressure changes does not indicate a clear correlation with methane and carbon dioxide concentrations. Repeated removal of the gas valve was noted in the earlier rounds of monitoring. This may in part explain the poor correlation and indicates that data collected from BH2374 at this time should be interpreted with caution.

6.5.7 The datasets for BH2374 and BH1309A suggest the presence of pockets of material within the Alluvial and Peat layers with the potential to generate high concentrations of gases. Elevated methane/carbon dioxide or depleted oxygen readings were observed at all locations except BH2603A. In general, the concentrations were not as high as at BH1309A and BH2374. However, given that these locations were not primarily designed for monitoring of ground gas, any abnormal readings from such installations could indicate that more significant adverse conditions have simply not been detected.

7 Conclusions and Further Works

7.1 Conclusions

7.1.1 The objective of this report was to carry out an initial assessment of the data collected as part of the Phase 1 ground investigation. The report aimed to use the environmental data presented, to highlight key risks relating to soil, groundwater and/or gas contamination with the expectation that these issues should be investigated in more detail as part of the Phase 2 ground investigation (reported in Appendix 10.9, Application Document 6.3).

7.1.2 Soil, groundwater, leachate and ground gas data have been compared to adopted screening criteria. A number of contaminants were identified as exceeding screening criteria. Metals within groundwater exceeded water quality criteria by the greatest factor (manganese was the highest with a measured concentration of 13,200µg/l vs. criteria of 200µg/l), indicating the highest hazard index. Measured ground gas concentrations of up to 83.2% methane and 16.9% carbon dioxide were also recorded at BH13009A, compared to screening criteria of 1% v/v and 5% v/v respectively.

7.1.3 The primary purpose of the Phase 1 investigation was to collect geotechnical information. Whilst there are areas in which certain measured contaminants do not exceed the applicable screening criteria, the Phase 1 investigation does not provide sufficient environmental data alone to eliminate any of the potential risks identified from the Preliminary Risk Assessment Report (Application Document 6.3, Appendix 10.6). As such, there may be other contaminants for which further action and/or phases of work were identified and these were subsequently carried out has part of Phase 2 investigations (reported in Appendix 10.9, Application Document 6.3).

7.2 Further Works

7.2.1 A phase 2 of additional ground investigation and testing in accordance with BS 10175 (British Standards Institution, 2017) and LCRM (Environment Agency, 2021) has been undertaken to further characterise the ground conditions across the Phase 1 area and across the wider Project. This has been guided by the findings of both this report and the Preliminary Risk Assessment Report (Application Document 6.3, Appendix 10.6) and included the following:

a. This additional ground investigation, including further installations of exploratory boreholes across the Phase 1 area and remaining route to better inform the characterisation, extent and location of contamination sources, with testing of soil and groundwater samples and subsequent quantitative risk assessment undertaken for human health and controlled waters to assess the level of risk in more detail that contamination would pose to the progression of the Project, where applicable.

b. Ground gas points designed and installed in accordance with best practice and with subsequent monitoring, to further assess the source of ground gases and the potential risks they pose to the Project.

c. The results from the Phase 1 and Phase 2 investigations have been used to refine the contaminated land risk assessment and produce a GQRA for the Project. The results of the Phase 2 assessment are provided in the GQRA Report for the Phase 2 Investigation (Application Document 6.3, Appendix 10.9, Annex A–D).

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Figures

Figure A Historic land uses and Phase 1 ground investigation exploratory hole locations

OH04006
BH2313A
BH2313
OH04007
OH04005
OH04005A
OH04002
OH04001
OH04001A
BH2308
BH2306
BH2302
BH2301
BH2036
BH2034
BH2034A
OH03002
OH03001
OH03003
PW03001
BH2035
BH2032
BH2031
BH2029
HLU0324

Marshes
Settlement
Queen's Farm
Fiborough Farm
Chalk
East Court Manor
Church Lane
Polperro
West Court
College
Sch
Recn Gd
Crematorium
Longten's Cottages
Green Farm
Pit (dis)
Lower Ro
BSs
BS
Schs
Sports Ground
Riverview Park
Southern Valley Golf Course
SHORNE CP
Muggins Lane
Crown Lane
Gravesend R
Smith's Farm
The Warren
Shorne Hill
Harts Hill
Ifield
Liby
PO
CH

0 0.1 0.2 0.3 0.4 KM

Rev	Status	Rev. Date	Purpose of revision	Drawn	Chck'd	Apprv'd
P01	S8	05/10/2022	DCO Application	SW	CM	TW

Notes:

1) All dimensions are in metres unless otherwise stated.

Legend

- Order Limits
- Credible contaminant source
- Cable Percussion
- Cable Percussion / Rotary Core
- Dynamic Sample / Rotary Core
- Pumping Test
- Rotary Core
- Rotary Open Hole / Rotary Core

Client: national highways

Project: LOWER THAMES CROSSING

Status: DCO APPLICATION | Original Size: A3 | Revision: P01

Application Document Number: TR010032/APP/6.3 | Scale: 1:10,000

Drawing Title: Credible Contaminant Sources and Phase 1 ground investigation exploratory hole locations
Page 1 of 3

Drawing Number: HE540039-CJV-GEN-GEN-MAP-GEO-00220

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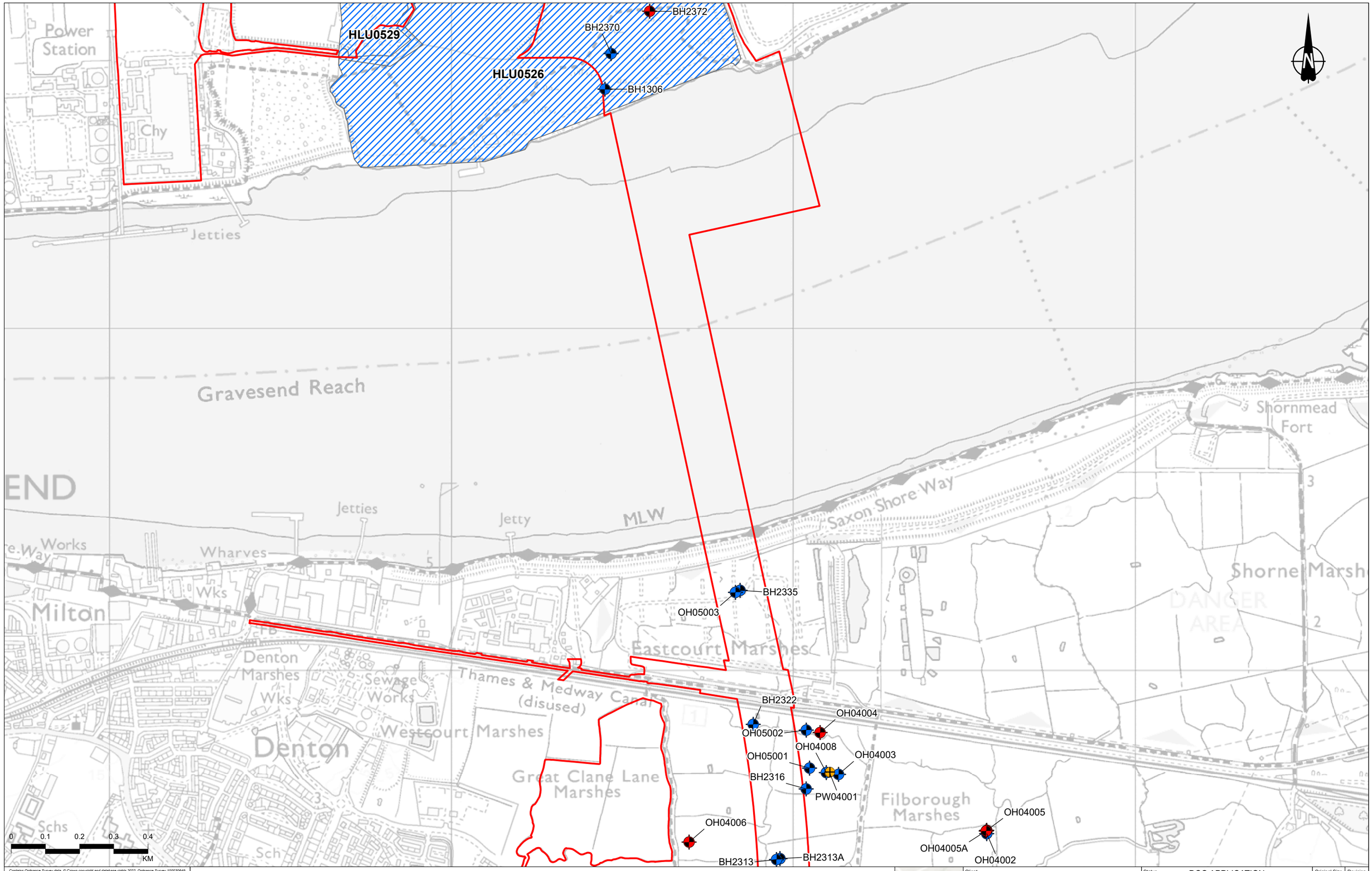

Notes:

1) All dimensions are in metres unless otherwise stated.

Legend

- Order Limits
- Credible contaminant source
- Cable Percussion
- Cable Percussion / Rotary Core
- Pumping Test

Rev	Status	Rev. Date	Purpose of revision	Drawn	Chck'd	Apprv'd
P01	S8	05/10/2022	DCO Application	SW	CM	TW

Client: national highways

Project: LOWER THAMES CROSSING

Status	DCO APPLICATION
Original Size	A3
Revision	P01
Application Document Number	TR010032/APP/6.3
Scale	1:10,000

Drawing Title: Credible Contaminant Sources and Phase 1 ground investigation exploratory hole locations
Page 2 of 3

Drawing Number: HE540039-CJV-GEN-GEN-MAP-GEO-00220

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BH2613
BH2612
BH2604A
BH2604
BH2603
HLU0527
BH2602A
BH2602
BH2392
BH2392A
BH1309A
HLU0528
BH2385
BH1309
BH1308A
BH2384
BH1308
HLU0529
HLU0526
BH2374
BH2372
BH2370
Holford Farm
Manor Farm
West Tilbury
Gun Hill
Low Street
Church Road
Hall Hill
Polwicks
Gravelpit Farm
Pit (dis)
Cooper Shaw Road
Parsonage Common
Buckland
Bowaters Farm
Station Road
Gushem's Farm
Barvills Farm
Love Lane
Princess Margaret Road
East Tilbury
Industrial Park
Sand and Gravel Pit
Coalhouse Battery (dismantled)
Mean High Water
Coalhouse Fort
Walton Common
West Tilbury Marshes
East Tilbury Marshes
Coalhouse Point
Power Station
Wks
0 0.1 0.2 0.3 0.4 KM

Rev	Status	Rev. Date	Purpose of revision	Drawn	Chck'd	Apprv'd
P01	S8	05/10/2022	DCO Application	SW	CM	TW

Notes:

1) All dimensions are in metres unless otherwise stated.

Legend

- Order Limits
- Credible contaminant source
- Cable Percussion
- Cable Percussion / Rotary Core
- Dynamic Sample
- Dynamic Sample / Rotary Core
- Rotary Core

Client: national highways

Project: LOWER THAMES CROSSING

Status	DCO APPLICATION
Original Size	A3
Revision	P01
Application Document Number	TR010032/APP/6.3
Scale	1:10,000

Drawing Title: Credible Contaminant Sources and Phase 1 ground investigation exploratory hole locations
Page 3 of 3

Drawing Number: HE540039-CJV-GEN-GEN-MAP-GEO-00220

Z:\Environment\Environmental Statement\10. Geology and Soils\Appendix 10.8new\App10_11_Figures.aprx

Annexes

Annex A Extract of Preliminary Risk Assessment Table

					Location and Geology			Potential Pathways									Human Health Receptors						Controlled Water Receptors			
	Name	Ref. No	Description	Potential Contaminants associated with contaminant source	Location with respect to Order Limits and Study Area	Generalised Superficial Geology	Generalised Bedrock Geology	D-S	D-G	A	V	F	S-G	G-L	G-SW	R-SW	RH01	RH02	RH03	RH04	RH05	RH06	Superficial Aquifer	Bedrock Aquifer	SPZ	Surface Water
						Superficial Geology provided by BGS	Bedrock Geology provided by BGS	Direct/dermal contact and incidental ingestion of contaminated soil	Direct/dermal contact and incidental ingestion of contaminated groundwater	Ingestion of soil or wind-blown dust	Build-up of vapours or gases in confined spaces	Inhalation of vapours, gases or wind-blown dust or fibres	Leaching of contaminants from soil into groundwater	Migration of contaminated groundwater on or off site	Groundwater migration to surface waters	Contaminated runoff (water and sediment) from land to surface waters	Construction workers	Operational staff	Road users	Adjacent land users - residents	On site and adjacent land users — public open space	Adjacent land users – industrial, commercial and agricultural workers, and users of recreational sites	Aquifer(s)	Aquifer(s)	SPZ	Distance to SW (m)
1	2	3	4	5		9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
	Southern Valley Golf Course	**HLU0324**	Golf course (1998 to present).	Metals, petroleum hydrocarbons, PAH, asbestos, herbicides, pesticides.	Within Order Limits and study area	Head (Clay, Silt, Sand and Gravel)	Seaford Chalk Formation and Newhaven Chalk Formation (Undifferentiated) (Chalk); Thanet Formation (Sand)	x		x		x	x	x			x	x	x	x		x	Secondary Aquifer - Undifferentiated	Secondary Aquifer - A; Principal Aquifer	None	484
	Goshems Farm Landfill	**HLU0526**	Former late 19th/early 20th century landfill, reportedly mostly ash and bottles, dock and river dredgings. Currently undergoing restoration .	Metals, inorganics, petroleum hydrocarbons, PAH, PFAS, ammoniacal nitrogen, asbestos, tributyltin (TBT), SVOC, VOC, hazardous gases.	Within Order Limits and study area	Alluvium (Clay, Silty, Peaty, Sandy)	Seaford Chalk Formation and Newhaven Chalk Formation (Undifferentiated) (Chalk)	x	x	x	x	x	x	x	x	x	x	x	x		x		Secondary Aquifer - Undifferentiated; Unproductive Strata	Principal Aquifer	SPZ III	0
	Tilbury Ash Disposal Site - Area C2	**HLU0527**	PFA landfill for Tilbury Power Station (and potential for unrecorded disposal of other materials).	Metals, inorganics, petroleum hydrocarbons, PAH, ammoniacal nitrogen, asbestos, SVOC, VOC, hazardous gases.	Within Order Limits and study area	Alluvium (Clay, Silty, Peaty, Sandy)	Seaford Chalk Formation and Newhaven Chalk Formation (Undifferentiated) (Chalk); Thanet Formation (Sand)	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	Secondary Aquifer - Undifferentiated	Principal Aquifer; Secondary Aquifer - A	SPZ III	0
	Tilbury Ash Disposal Site - Area C	**HLU0528**	PFA landfill for Tilbury Power Station (and potential for unrecorded disposal of other materials).	Metals, inorganics, petroleum hydrocarbons, PAH, ammoniacal nitrogen, asbestos, SVOC, VOC, hazardous gases.	Within Order Limits and study area	Alluvium (Clay, Silty, Peaty, Sandy)	Seaford Chalk Formation and Newhaven Chalk Formation (Undifferentiated) (Chalk)	x	x	x	x	x	x	x	x	x	x	x	x		x		Secondary Aquifer - Undifferentiated	Principal Aquifer	SPZ III	0
	Tilbury Ash Disposal Site - Area B	**HLU0529**	PFA landfill for Tilbury Power Station (and potential for unrecorded disposal of other materials).	Metals, inorganics, petroleum hydrocarbons, PAH, ammoniacal nitrogen, asbestos, SVOC, VOC, hazardous gases.	Within Order Limits and study area	Alluvium (Clay, Silty, Peaty, Sandy)	Seaford Chalk Formation and Newhaven Chalk Formation (Undifferentiated) (Chalk)	x	x	x	x	x	x	x	x	x	x						Secondary Aquifer - Undifferentiated	Principal Aquifer	SPZ III	0

Annex B Initial Groundwater Data

Table B.1 Groundwater contamination summary – South Portal area samples

Determinand	Units	Minimum	Maximum
pH (w)	pH	7.01	7.98
Electrical conductivity @ 20degC (w)	µS/cm	420	17870
COD (settled)	mg/l	25	164
BOD (settled, 5 day)	mg/l	<1	5
Alkalinity by titration (total) (pH 4.5) (w)	mg/l Ca CO3	212	1175
Hardness Total	mg/l Ca CO3	163	2340
Ammoniacal nitrogen as N (w)	mg/l	0.1	3.36
Chloride (w)	mg/l	10	6130
Fluoride (w)	mg/l	0.16	0.6
Sulphate (w)	mg/l	30	1640
Cyanide (free) (w)	mg/l	<0.005	<0.005
Cyanide (total) (w)	mg/l	<0.005	0.012
Phenols - Total by HPLC (w)	mg/l	<0.01	<0.01
DOC (w)	mg/l	2.6	11.8
Arsenic (dissolved)	µg/l	<1	8
Boron (dissolved)	µg/l	27	1510
Cadmium (dissolved)	µg/l	<0.2	<0.2
Calcium (dissolved)	mg/l	60	398
Copper (dissolved)	µg/l	1	15
Chromium (dissolved)	µg/l	<1	5
Chromium (hexavalent) (w)	mg/l	<0.01	<0.01
Iron (dissolved)	µg/l	11	166
Lead (dissolved)	µg/l	<1	<1
Manganese (dissolved)	µg/l	7	618
Magnesium (dissolved)	mg/l	3	327
Mercury (dissolved)	µg/l	<0.1	0.2
Nickel (dissolved)	µg/l	3	13
Potassium (dissolved)	mg/l	3	122
Selenium (dissolved)	µg/l	<1	330
Sodium (dissolved)	mg/l	19	2750
Zinc (dissolved)	µg/l	3	36

Determinand	Units	Minimum	Maximum
PAH 16MS (w)			
Acenaphthene (w)	µg/l	<0.01	<0.01
Acenaphthylene (w)	µg/l	<0.01	<0.01
Anthracene (w)	µg/l	<0.01	<0.01
Benzo(a)anthracene (w)	µg/l	<0.01	<0.01
Benzo(a)pyrene (w)	µg/l	<0.01	<0.01
Benzo(b)fluoranthene (w)	µg/l	<0.01	<0.01
Benzo(ghi)perylene (w)	µg/l	<0.01	<0.01
Benzo(k)fluoranthene (w)	µg/l	<0.01	<0.01
Chrysene (w)	µg/l	<0.01	<0.01
Dibenzo(ah)anthracene (w)	µg/l	<0.01	<0.01
Fluoranthene (w)	µg/l	<0.01	<0.01
Fluorene (w)	µg/l	<0.01	<0.01
Indeno(123-cd)pyrene (w)	µg/l	<0.01	<0.01
Naphthalene (w)	µg/l	<0.01	0.36
Phenanthrene (w)	µg/l	<0.01	<0.01
Pyrene (w)	µg/l	<0.01	<0.01
Total PAH 16MS (w)	µg/l	<0.01	0.37
TPH CWG (w)			
Ali >C5-C6 (w)	µg/l	<1	<1
Ali >C6-C8 (w)	µg/l	<1	3
Ali >C8-C10 (w)	µg/l	<1	<1
Ali >C10-C12 (w)	µg/l	<5	14
Ali >C12-C16 (w)	µg/l	<5	8
Ali >C16-C21 (w)	µg/l	<5	31
Ali >C21-C35 (w)	µg/l	<5	<5
Total Aliphatics (w)	µg/l	<5	42
Aro >C5-C7 (w)	µg/l	<1	<1
Aro >C7-C8 (w)	µg/l	<1	<1
Aro >C8-C9 (w)	µg/l	<1	<1
Aro >C9-C10 (w)	µg/l	<1	<1
Aro >C10-C12 (w)	µg/l	<5	14
Aro >C12-C16 (w)	µg/l	<5	8
Aro >C16-C21 (w)	µg/l	<5	1027
Aro >C21-C35 (w)	µg/l	<5	16

Determinand	Units	Minimum	Maximum
Total Aromatics (w)	µg/l	<5	1052
TPH (Ali & Aro) (w)	µg/l	<5	1094
BTEX - Benzene (w)	µg/l	<1	<1
BTEX - Toluene (w)	µg/l	<1	<1
BTEX - Ethyl Benzene (w)	µg/l	<1	<1
BTEX - m & p Xylene (w)	µg/l	<1	<1
BTEX - o Xylene (w)	µg/l	<1	<1
MTBE (w)	µg/l	<1	<1
Alkalinity (total) (w) Colorimetry	mg/l CaCO3	214	457
Alkalinity by titration (bicarbonate) (w)	mg/l CaCO3	1105	1175
Ammonia / Ammoniacal Nitrogen as NH3 (w)	mg/l	<0.024	0.056
Iodide (w)	mg/l	<0.1	<0.1
Molybdenum (dissolved)	ug/l	0.5	15.1
Phosphate (orthophosphate) as PO4 (w)	mg/l	<0.02	<0.02
Strontium (dissolved)	ug/l	212	4260
Vanadium (dissolved)	ug/l	<1	2

Table B.2 Groundwater contamination summary – North Portal area samples

Determinand	Units	Minimum	Maximum
pH (w)	pH	6.41	7.99
Electrical conductivity @ 20degC (w)	µS/cm	3920	26000
COD (settled)	mg/l	49	906
BOD (settled, 5 day)	mg/l	<1	34
Alkalinity (total) (w) Colorimetry	mg/l Ca CO3	190	6125
Alkalinity by titration (bicarbonate) (w)	mg/l Ca CO3	195	6125
Hardness Total	mg/l Ca CO3	711	6300
Ammoniacal nitrogen as N (w)	mg/l	0.13	94.6
Chloride (w)	mg/l	1000	11200
Fluoride (w)	mg/l	0.14	1.04
Nitrate (w)	mg/l	0.35	40.09
Sulphate (w)	mg/l	10	2480
Cyanide (free) (w)	mg/l	<0.005	<0.005
Cyanide (total) (w)	mg/l	<0.005	0.025
Phenols - Total by HPLC (w)	mg/l	<0.01	1.45
DOC (w)	mg/l	0.6	60.4
Arsenic (dissolved)	µg/l	2	76
Boron (dissolved)	µg/l	677	58300
Cadmium (dissolved)	µg/l	<0.2	<1.0
Calcium (dissolved)	mg/l	133	1430
Copper (dissolved)	µg/l	2	22
Chromium (dissolved)	µg/l	<1	22
Chromium (hexavalent) (w)	mg/l	<0.01	<0.01
Iron (dissolved)	µg/l	22	49400
Lead (dissolved)	µg/l	<1	9
Manganese (dissolved)	µg/l	14	13200
Magnesium (dissolved)	mg/l	136	1140
Mercury (dissolved)	µg/l	<0.1	0.5
Molybdenum (dissolved)	µg/l	1	2
Nickel (dissolved)	µg/l	1	65
Potassium (dissolved)	mg/l	41	372
Selenium (dissolved)	µg/l	1	6
Sodium (dissolved)	mg/l	562	7810
Vanadium (dissolved)	µg/l	1	2

Determinand	Units	Minimum	Maximum
Zinc (dissolved)	µg/l	1	2405
Organotins (w)			
Tetrabutyltin (w)	µg/l	<0.001	<0.001
Tributyltin (w)	µg/l	<0.05	<10
Triphenyltin (w)	µg/l	<0.05	<0.05
Dibutyltin (w)	µg/l	<0.05	<0.05
Monobutyltin (w)	µg/l	<0.05	<0.05
PAH 16MS (w)			
Acenaphthene (w)	µg/l	<0.01	0.28
Acenaphthylene (w)	µg/l	<0.01	0.02
Anthracene (w)	µg/l	<0.01	0.15
Benzo(a)anthracene (w)	µg/l	0.02	1.01
Benzo(a)pyrene (w)	µg/l	0.02	0.88
Benzo(b)fluoranthene (w)	µg/l	0.03	1.1
Benzo(ghi)perylene (w)	µg/l	0.02	0.68
Benzo(k)fluoranthene (w)	µg/l	<0.01	0.37
Chrysene (w)	µg/l	<0.01	1.16
Dibenzo(ah)anthracene (w)	µg/l	<0.01	0.17
Fluoranthene (w)	µg/l	<0.01	2.06
Fluorene (w)	µg/l	<0.01	0.14
Indeno(123-cd)pyrene (w)	µg/l	<0.01	0.79
Naphthalene (w)	µg/l	<0.01	2.36
Phenanthrene (w)	µg/l	<0.01	0.32
Pyrene (w)	µg/l	<0.01	1.85
Total PAH 16MS (w)	µg/l	<0.01	10.5
VOC (w)			
Dichlorodifluoromethane	µg/l	<1	<1
Chloromethane	µg/l	<10	<10
Vinyl Chloride	µg/l	<1	<1
Bromomethane	µg/l	<1	<1
Chloroethane	µg/l	<1	<1
Trichlorofluoromethane	µg/l	<1	<1
trans 1,2-Dichloroethene	µg/l	<1	<1
Dichloromethane	µg/l	<5	<5
Carbon Disulphide	µg/l	<1	1

Determinand	Units	Minimum	Maximum
1,1-Dichloroethene	µg/l	<1	<1
1,1-Dichloroethane	µg/l	<1	<1
cis 1,2-Dichloroethene	µg/l	<1	<1
Bromochloromethane	µg/l	<5	<5
Chloroform	µg/l	<1	<1
2,2-Dichloropropane	µg/l	<1	<1
1,2-Dichloroethane	µg/l	<2	<2
1,1,1-Trichloroethane	µg/l	<1	<1
1,1-Dichloropropene	µg/l	<1	<1
Benzene	µg/l	<1	1
Carbon Tetrachloride	µg/l	<1	<1
Dibromomethane	µg/l	<1	<1
1,2-Dichloropropane	µg/l	<1	<1
Bromodichloromethane	µg/l	<10	<10
Trichloroethene	µg/l	<1	<1
cis 1,3-Dichloropropene	µg/l	<1	<1
trans 1,3-Dichloropropene	µg/l	<1	<1
1,1,2-Trichloroethane	µg/l	<1	<1
Toluene	µg/l	<1	<1
1,3-Dichloropropane	µg/l	<1	<1
Dibromochloromethane	µg/l	<3	<3
1,2-Dibromoethane	µg/l	<1	<1
Tetrachloroethene	µg/l	<1	<1
1,1,1,2-Tetrachloroethane	µg/l	<1	<1
Chlorobenzene	µg/l	<1	<1
Ethylbenzene	µg/l	<1	<1
m & p Xylene	µg/l	<1	<1
Bromoform	µg/l	<1	<1
Styrene	µg/l	<1	<1
1,1,2,2-Tetrachloroethane	µg/l	<1	<1
o-Xylene	µg/l	<1	<1
1,2,3-Trichloropropane	µg/l	<1	<1
Isopropylbenzene	µg/l	<1	<1
Bromobenzene	µg/l	<1	<1
2-Chlorotoluene	µg/l	<1	<1

Determinand	Units	Minimum	Maximum
n-propylbenzene	µg/l	<1	<1
4-Chlorotoluene	µg/l	<1	<1
1,2,4-Trimethylbenzene	µg/l	<1	<1
4-Isopropyltoluene	µg/l	<1	<1
1,3,5-Trimethylbenzene	µg/l	<1	<1
1,2-Dichlorobenzene	µg/l	<1	<1
1,4-Dichlorobenzene	µg/l	<1	<1
sec-Butylbenzene	µg/l	<1	<1
tert-Butylbenzene	µg/l	<2	<2
1,3-Dichlorobenzene	µg/l	<1	<1
n-butylbenzene	µg/l	<1	<1
1,2-Dibromo-3-chloropropane	µg/l	<2	<2
1,2,4-Trichlorobenzene	µg/l	<3	<3
1,2,3-Trichlorobenzene	µg/l	<3	<3
Hexachlorobutadiene	µg/l	<1	<1
TPH CWG (w)			
Ali >C5-C6 (w)	µg/l	<1	1
Ali >C6-C8 (w)	µg/l	<1	1
Ali >C8-C10 (w)	µg/l	<1	<1
Ali >C10-C12 (w)	µg/l	<5	<10
Ali >C12-C16 (w)	µg/l	<5	<10
Ali >C16-C21 (w)	µg/l	<5	<10
Ali >C21-C35 (w)	µg/l	<5	42
Total Aliphatics (w)	µg/l	<5	42
Aro >C5-C7 (w)	µg/l	<1	1
Aro >C7-C8 (w)	µg/l	<1	1
Aro >C8-C9 (w)	µg/l	<1	<1
Aro >C9-C10 (w)	µg/l	<1	6
Aro >C10-C12 (w)	µg/l	<5	<10
Aro >C12-C16 (w)	µg/l	<5	<10
Aro >C16-C21 (w)	µg/l	<5	<10
Aro >C21-C35 (w)	µg/l	<5	<10
Total Aromatics (w)	µg/l	<5	<10
TPH (Ali & Aro) (w)	µg/l	<5	42
BTEX - Benzene (w)	µg/l	<1	1

Determinand	Units	Minimum	Maximum
BTEX - Toluene (w)	µg/l	<1	1
BTEX - Ethyl Benzene (w)	µg/l	<1	<1
BTEX - m & p Xylene (w)	µg/l	<1	<1
BTEX - o Xylene (w)	µg/l	<1	<1
MTBE (w)	µg/l	<1	<1
Alkalinity by titration (total) (pH 4.5) (w)	mg/l CaCO3	190	2150

Annex C Ground Gas Data

Table C.1 Summary of gas monitoring data – BH1309A

Date	Depth to water (m)	Response Zone (m bgl)	Measurement (% by volume)		
			Methane	Carbon dioxide	Oxygen
13/02/2018	3.63	1.5-6.5	74.7-75.2	14.7-14.9	6.4-0.0
21/02/2018	3.63	1.5-6.5	73.9-74.4	14.7-15.0	7.4-0.0
06/03/2018	3.95	1.5-6.5	67.4-67.5	14.5-14.9	13.0-0.0
15/03/2018	3.58	1.5-6.5	47.8-77.0	10.1-13.7	8.0-0.8
21/03/2018	3.69	1.5-6.5	54.6-83.2	12.1-16.9	6.4-0.5
27/03/2018	3.55	1.5-6.5	73.1-77.4	14.8-15.3	5.4-0.3
05/04/2018	3.54	1.5-6.5	73.2-74.4	14.6-15.0	4.1-0.0
13/04/2018	3.49	1.5-6.5	65.2-68.5	15.0-15.4	3.1-0.2
19/04/2018	3.47	1.5-6.5	57.3–71.9	13.1–15.7	5.3-0.1
26/04/2018	3.46	1.5-6.5	77.9-78.6	15.6-16.1	2.0-0.0
03/05/2018	3.46	1.5-6.5	74.6-75.7	15.4-15.7	3.4-0.0
10/05/2018	3.46	1.5-6.5	72.4-73.7	15.8-16.3	2.0-0.0
17/05/2018	3.47	1.5-6.5	78.4-79.2	16.3-16.5	12.5-0.0

Plate C.1 Summary of gas monitoring data – BH1309A

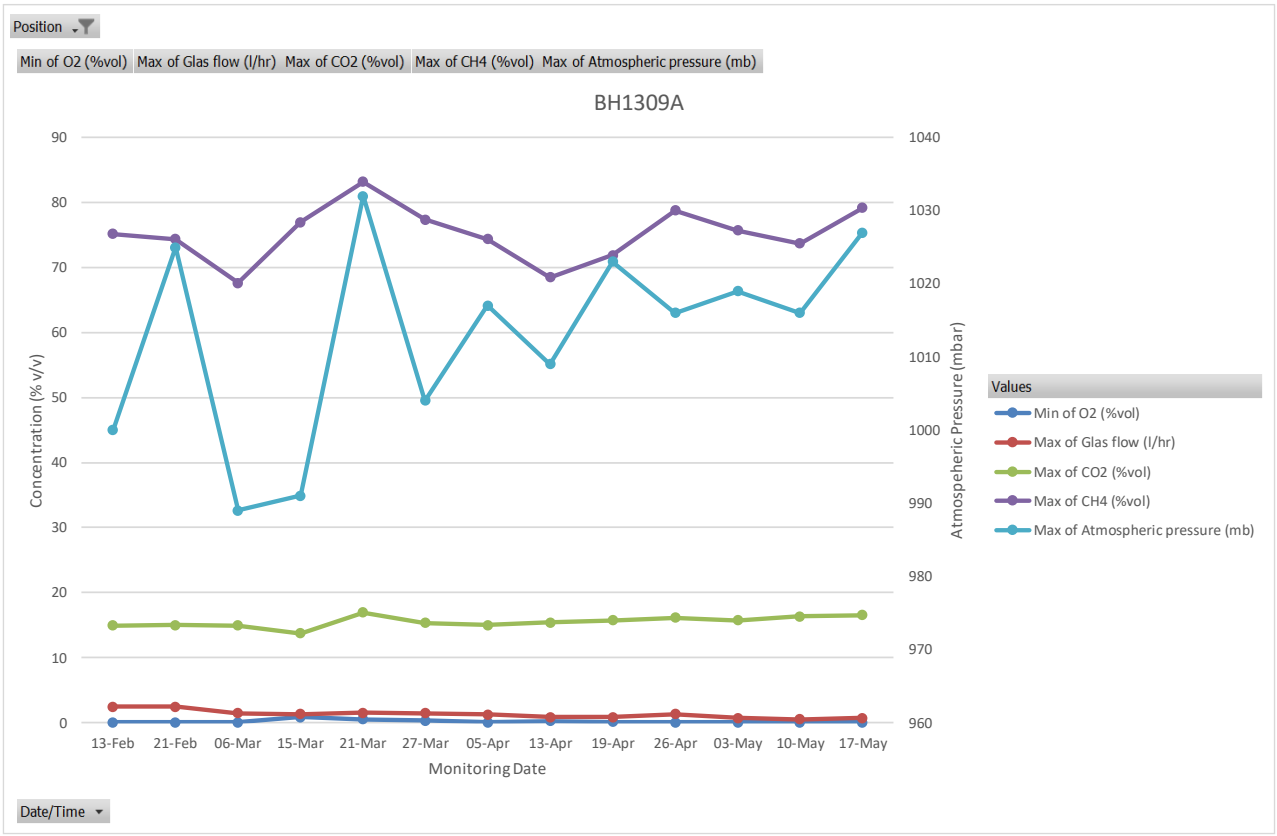

Table C.2 Summary of gas monitoring data – BH2374

Date	Depth to water (m)	Response Zone (m bgl)	Measurement (% by volume)		
			Methane	Carbon dioxide	Oxygen
13/02/2018	-	6.0-21.0	Could not be monitored due to faulty lock/dangerous ground conditions		
21/02/2018	7.82	6.0-21.0	70.9-17.0	13.1-4.0	15.7-3.2
06/03/2018	7.74	6.0-21.0	67.7-67.3	12.7-12.9	7.0-0.0
15/03/2018	-	6.0-21.0	No access due to difficult ground conditions		
21/03/2018	7.66	6.0-21.0	0.2-0.4	0.2-0.3	20.2-20.1
27/03/2018	7.26	6.0-21.0	1.3-9.5	7.6-9.4	14.7-5.3
05/04/2018	7.27	6.0-21.0	6.1-6.6	5.5-5.8	16.4-13.7
13/04/2018	6.96	6.0-21.0	0.4-4.7	0.4-5.2	20.7-16.1
19/04/2018	7.22	6.0-21.0	0.3-3.5	0.4-3.2	19.7-15.3
26/04/2018	6.89	6.0-21.0	0.2-2.2	0.4-2.8	20.4-18
03/05/2018	7.09	6.0-21.0	0.1-1.0	0.2-2.3	20.7-18.5
10/05/2018	6.91	6.0-21.0	0.5-4.3	0.5-3.8	20.1-15.9
17/05/2018	6.97	6.0-21.0	0.5-2.0	0.5-2.4	19.8-17.7

Notes: Readings on 06 and 21 March 2018 compromised by gas tap being blown off before readings taken.

Plate C.2 Summary of gas monitoring data – BH2374

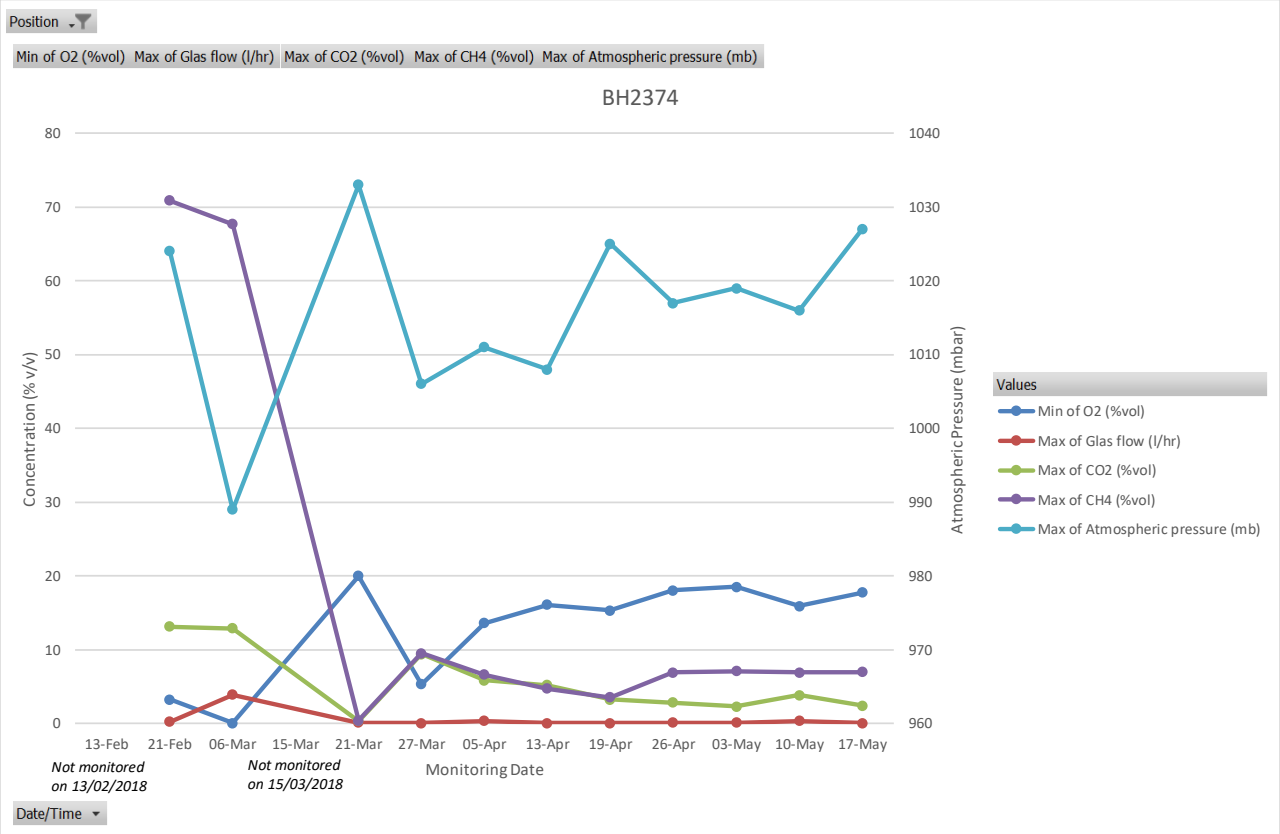

Table C.3 Summary of gas monitoring data – additional wells

Monitoring location	Depth to water (m)	Response Zone (m below bgl)	Measurement (% by volume)		
			Methane	Carbon dioxide	Oxygen
27/03/2018					
BH2384	8.10	26.50-29.50	0.0-0.0	0.1-0.2	20.9-20.8
BH2385	6.34	45.00-50.00	3.6-3.6	5.1-5.3	15.8-5.3
BH2392A	3.71	8.00-12.00	0.2-0.6	0.8-2.0	16.5-8.0
BH2602A	3.18	10.00-14.00	0.6-0.8	0.4-0.6	17.6-7.1
BH2603A	4.96	27.00-30.00	0.0-0.0	0.2-0.2	20.0-18.1
BH2604A	4.93	37.00-41.00	2.1-7.7	0.2-0.4	15.1-6.3
BH2612	3.67	22.00-25.00	0.0-0.0	0.4-1.8	20.7-17.7
BH2613	1.12	1.00-5.00	No data	No data	No data
05/04/2018					
BH2029	29.93	27.00-30.00	0.0-0.0	1.1-1.3	20.3-18.6
BH2034	21.77	23.00-27.00	0.0-0.0	0.1-0.3	20.7-20.5
BH2036	15.31	24.50-28.50	0.0-0.0	0.1-0.2	20.9-20.8
BH2301	6.87	36.50-40.50	0.0-0.0	0.7-1.2	19.5-14.5

Monitoring location	Depth to water (m)	Response Zone (m below bgl)	Measurement (% by volume)		
			Methane	Carbon dioxide	Oxygen
BH2302	1.65	31.10-34.10	0.0-0.0	0.8-1.2	19.1-16.0
BH2316	1.68	30.50-33.50	0.0-0.0	0.1-0.1	20.8-21.2
BH2322	1.94	41.00-46.00	0.0-0.0	0.1-0.1	20.8-20.7
13/04/2018					
BH2384	8.01	26.50-29.50	0.0-0.0	0.1-0.2	20.8-20.7
BH2385	6.28	45.00-50.00	2.5-2.5	3.8-3.9	16.6-8.0
BH2392A	3.76	8.00-12.00	2.0-9.0	0.7-2.5	19.6-17.5
BH2602A	3.17	10.00-14.00	0.6-0.8	0.2-0.7	20.2-17.9
BH2603A	4.93	27.00-30.00	0.0-0.0	0.2-0.2	17.8-15.4
BH2604A	4.87	37.00-41.00	0.8-1.3	0.1-0.1	19.7-17.8
BH2612	3.86	22.00-25.00	0.0-0.0	0.4-0.7	20.6-20.1
BH2613	0.88	1.00-5.00	0.0-0.0	0.1-0.1	20.8-20.8

Annex D Acronyms and Glossary

Term	Abbreviation	Explanation
Annual Average	**AA**	N/A
Above ordnance datum	**AOD**	Above ordnance datum, vertical datum used by an ordnance survey as the basis for delivering altitudes on maps.
AGS data format		Data in AGS format (.ags) is a text file format used to transfer data reliably, between organisations in the site investigation industry, independent of software, hardware or operating system.
Annual Average		Annual average (AA). Concentration or parameter value average over 12 months and based on a minimum of 12 individual sample results.
Anthropogenic		Created by people or caused by human activity.
Area of Outstanding Natural Beauty	**AONB**	Statutory designation intended to conserve and enhance the ecology, natural heritage and landscape value of an area of countryside.
Aquifers – Principal		These are layers of rock or drift deposits that have high intergranular and/or fracture permeability – meaning they usually provide a high level of water storage. They may support water supply and/or river base flow on a strategic scale. In most cases, principal aquifers are aquifers previously designated as major aquifer.
Aquifers – Secondary A		Permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important source of base flow to rivers. These are generally aquifers formerly classified as minor aquifers.
Aquifers – Secondary B		Mainly lower permeability layers that may store and yield limited amounts of groundwater through characteristics like thin cracks (called fissures) and openings or eroded layers.
Aquifers – Secondary undifferentiated		Secondary undifferentiated are aquifers where it is not possible to apply either a Secondary A or B definition because of the variable characteristics of the rock type. These have only a minor value.
Asbestos Containing Material	**ACM**	Any material containing more than one percent asbestos. These materials are considered hazardous and associated with certain diseases and health concerns
Association of Geotechnical and Geo-Environmental Specialists	**AGS**	A not-for-profit trade association established to improve the profile and quality of geotechnical and geoenvironmental

Term	Abbreviation	Explanation
		engineering. The membership comprises UK organisations and individuals having a common interest in the business of site investigation, geotechnics, geoenvironmental engineering, engineering geology, geochemistry, hydrogeology, and other related disciplines.
Benzene, toluene, ethylbenzene and xylenes	**BTEX**	A group of volatile organic compounds, comprising benzene, toluene, ethylbenzene and xylene
Biological Oxygen Demand	**BOD**	The amount of dissolved oxygen needed by aerobic biological organisms to break down organic material present in a given water sample at certain temperature over a specific time period.
Borehole	**BH**	A hole bored into the ground, usually as part of investigations, typically to test the depth and quality of soil, rock and groundwater. A borehole can also be used to dewater the ground.
British Geological Survey	**BGS**	A partly publicly funded body which aims to advance geoscientific knowledge of the United Kingdom landmass and its continental shelf by means of systematic surveying, monitoring and research.
British Standard	**BS**	Standards produced by the British Standards Institution, which is incorporated under royal charter and formally designated as the national standards body for the UK.
British Standards Institution	**BSI**	The national standards body of the UK, producing technical standards for various industries.
BritPits		An abbreviation of British Pits. The database holds information on: • names of mines, quarries, oil wells, gas wells, ash and desulphogypsum plants • geographic location • address • operator • mineral planning authorities • geology • mineral commodities produced • end-uses (where known)
C4SL		Category 4 Screening Levels for assessment of land affected by contamination as published by DEFRA in document SP1010, produced by CL:AIRE.
Chartered Institute of Environmental Health	**CIEH**	The Chartered Institute of Environmental Health (CIEH) is the membership and

Term	Abbreviation	Explanation
		awarding body for the environmental health sector.
Chemical Oxygen Demand	**COD**	The amount of oxygen required to oxidise all soluble and insoluble organic compounds present in a volume of water
Combined sewer overflow	**CSO**	Combined sewer systems are sewers that are designed to collect rainwater runoff, domestic sewage, and industrial wastewater in the same system.
Conceptual site model	**CSM**	A land contamination CSM refers to the source-pathway-receptor (SPR) linkage approach for identifying pollutant linkages. Development and refinement of the CSM is part of the process defined in LCRM guidance.
Construction Environmental Management Plan	**CEMP**	The primary environmental management document that defines the procedures for achieving the objectives set out in the environmental policy. It incorporates environmental performance targets set for the Project.
Construction Industry Research Information Association	**CIRIA**	A not-for-profit, independent organisation that facilitates a range of collaborative activities to help improve the construction industry.
Contaminant of Concern	**CoC**	N/a
Contaminated Land: Applications in Real Environments	**CL:AIRE**	independent not-for-profit organisation established to stimulate the regeneration of contaminated land in the UK.
Controlled Waters		Waters including groundwater, freshwater and saline water as defined in the UK Water Resources Act 1991.
Control of Major Accident Hazards	**COMAH**	The regulatory framework to prevent and mitigate the effects of major accidents involving dangerous substances which can cause serious damage/harm to people and/or the environment.
Department for Environment, Food and Rural Affairs	**Defra**	Department for Environment, Food and Rural Affairs: the government department responsible for environmental protection, food production and standards, agriculture, fisheries and rural communities in the United Kingdom of Great Britain and Northern Ireland.
Deneholes		An underground structure consisting of a number of small chalk caves entered by a vertical shaft.
Detailed Quantitative Risk Assessment	**DQRA**	Tier 3 of the risk assessment process according to LCRM guidance on the assessment of land contamination. A DQRA uses detailed site-specific information to estimate risk.
Dichlorodiphenyltrichloroethane	**DDT**	A synthetic organic compound used as an insecticide.

Term	Abbreviation	Explanation
Digital Terrain Model	**DTM**	A bare-earth model that contains elevations of natural terrain features such as ridge tops and river valleys. Elevations of vegetation and features, such as buildings and roads, are digitally removed.
Drinking Water Standards	**DWS**	Concentrations of substances or other parameter values and properties define by regulation or guidance, below which water is considered 'wholesome' and fit for potable use. In the UK, DWS are defined by the Water Supply (Water Quality) Regulations 2016
Duplicate sample		A sample taken for quality assurance purposes. A duplicate sample is a sample which is obtained from the same location and depth, at the same time and on the same day, and via the same sampling method as the original or 'parent' sample.
ESdat		Specialist environmental database system; used to validate, import and analyse environmental data.
Environment Agency	**EA**	A non-departmental public body of Defra. The Environment Agency is the leading public body for protecting and improving the environment in England.
Environmental Impact Assessment	**EIA**	A process by which information about environmental effects of a proposed development is collected, assessed and used to inform decision making. For certain projects, EIA is a statutory requirement, reported in an Environmental Statement.
Environmental Permitting (England and Wales) Regulations 2016 (as amended)	**EPR**	N/a
Environmental Quality Standards	**EQS**	Concentrations of substances or other parameter values and properties define by regulation or guidance for the protection of the environment.
Field Blank		A blank or 'clean' sample taken for quality assurance purposes and created in the field by the sampler.
Generic Assessment Criteria	**GAC**	Parameter values, such as substance concentrations, defined based on generic assumptions (i.e, non site-specific) for the quantitative assessment of risk. Concentrations below a GAC typically present a low or minimal risk to the receptor(s) which they are defined as protective of. Concentrations above a GAC do not necessarily represent a risk, but may indicate the need for action such as further assessment.
Generic Quantitative Risk Assessment	**GQRA**	Tier 2 of the risk assessment process according to LCRM guidance on the assessment of land contamination. A GQRA

Term	Abbreviation	Explanation
		uses generic assessment criteria and assumptions to estimate risk.
Geographic information system	**GIS**	An integrated collection of computer software and data used to view and manage information about geographic places, analyse spatial relationships, and model spatial processes.
Grab sample	**GS**	Samples of any media are either involve grab sampling or composite sampling. Grab samples are collected at one location and at one point in time.
Ground investigation	**GI**	N/a
Heavy fuel oil	**HFO**	A residual fuel incurred during the distillation of crude oil.
Hectares	**Ha**	N/a
Historical Land Use Data	**HLUD**	A Landmark dataset
Historical Land Use	**HLU**	N/a
Historical Tanks and Energy Facilities	**HTEF**	A Landmark dataset
HoleBASE		Geotechnical data knowledge management system
Industrial, Commercial, Agricultural and Recreational	**ICAR**	A land use
Integrated Pollution Prevention and Control	**IPPC**	Refers to the minimising of pollution from various industrial sources throughout the European Union (EU), as established by the IPPC Directive (Directive 2008/1/EC of 15 January 2008 concerning integrated pollution prevention and control).
Interceptor		Part of a wastewater treatment system that collects substances such as silt, grit and soil, as well as traces of oil and fuel prior to discharge or further treatment.
Intermediate bulk container	**IBC**	Industrial-grade containers engineered for the mass handling, transport, and storage of liquids, semi-solids, pastes, or solids.
International Organization for Standardisation	**ISO**	An international standard setting organisation, composed of a network of national standards bodies.
Litres per hour	**l/h**	N/a
Land Contamination: Risk Management	**LCRM**	Formerly CLR11 Model Procedures for the Management of Land Contamination.
Light Detection and Ranging	**LiDAR**	A surveying method that measures distance to a target by illuminating that target with a laser light.
Light Non-Aqueous Phase Liquid	**LNAP**	A contaminant that is not soluble in water and has lower density than water.

Term	Abbreviation	Explanation
Limits of deviation	**LOD**	The tolerances, both laterally and vertically, that any parts of the Project can be constructed from the lines and situations shown on the Works Plans (Application Document 2.6) and the levels shown on the Engineering Section Drawings (Application Document 2.9).
Liquified petroleum gas	**LPG**	A fuel gas which contains a flammable mixture of hydrocarbon gases, specifically propane and butane
Local Authority Pollution Prevention and Control	**LAPPC**	A system which applies an integrated environmental approach to regulate certain industrial activities.
Local geological sites	**LGS**	Locally non-statutory designated geological sites of local, national or regional importance.
Local nature reserve	**LNR**	Locally designated nature site protected through the planning system.
Local wildlife site	**LWS**	A non-statutory designation for sites with substantive nature conservation value.
Long term monitoring	**LTM**	N/a
LQM/CIEH Suitable for Use Levels		Human health generic assessment criteria produced by Land Quality Management and the Chartered Institute of Environmental Health.
Maximum allowable concentration	**MAC**	An EQS for a pollutant may either be an AA or a MAC. MAC are used to assess individual monitoring events from continuous or regular monitoring when the AA of the pollutant is below the AA EQS.
Made ground		Anthropogenic soils placed by man.
Metal Bioavailability Assessment Tool		The toxicity of metals is dependent on a range of water quality parameters that influence the amount of dissolved metal that is bioavailable, i.e. responsible for toxic effects on aquatic plants and animal. The M-BAT tool allows the bioavailable concentration of metals dissolved in water to be calculated.
Method Detection Limit	**MDL**	Method Detection Limit
Methyl Tert-Butyl Ether	**MTBE**	An organic compound used as a fuel (petrol) additive.
Metres below datum	**Mbdat**	Vertical datum used by an ordnance survey as the basis for delivering altitudes on maps.
Metres below ground level	**M bgl**	N/a
Millibar	**Mbar**	N/a
Ministry of Housing, Communities and Local Government	**MHCLG**	Formed in January 2018, the MHCLG took over the duties of the former Department for Communities and Local Government. In September 2021, it was renamed the

Term	Abbreviation	Explanation
		Department for Levelling Up, Housing and Communities.
National Grid Reference	**NGR**	A system of geographic grid references used in Great Britain to enable positional reference on the Ordnance Survey National Grid.
National Planning Policy Framework	**NPPF**	Published in March 2012 by the UK's Department of Communities and Local Government, consolidating over two dozen previously issued documents called Planning Policy Statements (PPS) and Planning Policy Guidance Notes (PPG) for use in England.
Nitrate vulnerable zone	**NVZ**	Areas covering 62% of England designated as a result of the European Union's Nitrates Directive in order to reduce the level of nitrates in surface and groundwater. Farmers with land in nitrate vulnerable zones have to follow mandatory rules to tackle nitrate loss from agriculture.
Notification of Installations Handling Hazardous Substances	**NIHHS**	
Ordnance datum	**OD**	A standardised point representing average (mean) sea level, used by the Ordnance Survey as the basis for measurement of height (altitude) on UK maps, reported as metres 'above ordnance datum'.
Ordnance Survey	**OS**	The national mapping agency of Great Britain.
Organo-phosphorus	**OP**	Organophosphorus compounds are organic compounds containing phosphorus. They are used primarily in pest control as an alternative to chlorinated hydrocarbons that persist in the environment.
Parts per million by volume	**ppmv**	n/a
Per-/Poly-Fluoroalkyl Substances	**PFAS**	A family of human-made chemicals found in a wide range of products used by consumers and industry. Many PFAS are resistant to grease, oil, water, and heat.
Perfluoro-octane-sulfonic acid	**PFOS**	A chemical compound having an eight-carbon fluorocarbon chain and a sulfonic acid functional group and thus a perfluorosulfonic acid. It is an anthropogenic fluorosurfactant, now regarded as a global pollutant.
Perfluorooctanoate	**PFOA**	A perfluorinated carboxylic acid produced and used worldwide as an industrial surfactant in chemical processes and as a material feedstock
Persistent Organic Pollutants	**POP**	N/a
Petrol filling station	**PFS**	N/a
Photo-Ionisation Detector	**PID**	A type of gas detector.

Term	Abbreviation	Explanation
Pollutant linkage		A pollutant linkage comprises a source, pathway and receptor. A contaminant source, environmental and/or exposure pathway and sensitive receptor is a pollutant linkage which gives rise to a potential risk to the receptor.
Polychlorinated biphenyls	**PCBs**	A group of man-made compounds that were widely used in the past, mainly in electrical equipment, but which were banned at the end of the 1970s in many countries because of environmental concerns. Because these compounds are generally very stable, they remain present in the environment today.
Polycyclic aromatic hydrocarbons	**PAHs**	A group of several hundred chemically related, environmentally persistent, organic compounds of various structures and varied toxicity.
Port of London Authority	**PLA**	A self-funding public trust established by The Port of London Act 1908 to govern the Port of London. Its responsibility extends over the Tideway of the River Thames and its continuation (the Kent/Essex strait). It maintains and supervises navigation, and protects the river's environment.
Predicted No-Effect Concentrations	**PNEC**	the concentration of a chemical which marks the limit at which below no adverse effects of exposure in an ecosystem are measured.
Preliminary Environmental Information Report	**PEIR**	An early output of the EIA process, and part of the DCO application process.
Preliminary Risk Assessment	**PRA**	Tier 1 of the risk assessment process according to LCRM guidance on the assessment of land contamination. A PRA develops a conceptual site model.
Preliminary Sources Study Report	**PSSR**	N/a
Public Health England	**PHE**	PHE was an executive agency of the Department of Health and Social Care in the UK that began operating on 1 April 2013. PHE’s mission was ‘to protect and improve the nation’s health and to address inequalities’. From 1 October 2021, PHE's health protection functions were formally transferred into the UK Health Security Agency, while its health improvement functions were transferred to the Office for Health Improvement and Disparities, NHS England and NHS Digital.
Public open space	**PoS**	Land use
Pulverised Fuel Ash	**PFA**	Also referred to as fly ash, is the ash resulting from the burning of pulverised coal in coal-fired electricity power stations.
Qualitative Risk Assessment	**QRA**	Refinement of the CSM by reviewing qualitative and quantitative information sources.

Term	Abbreviation	Explanation
Ramsar site		A wetland of international importance, designated under the Ramsar convention.
River Terrace Deposits	**RTD**	Sand and gravel, locally with lenses of silt, clay or peat.
Semi-volatile organic compounds	**SVOC**	Organic compounds that tend to have a higher molecular weight and higher boiling point temperature than VOCs.
Special Area of Conservation	**SAC**	Land designated under Directive 92/43/EEC on the Conservation of Natural Habitats and of Wild Fauna and Flora. SACs protect habitats and species considered to be of European interest.
Special Protection Area	**SPA**	Land classified under Directive 79/409 on the Conservation of Wild Birds. SPAs protect rare and vulnerable birds and regularly occurring migratory species.
Site of Special Scientific Interest	**SSSI**	Land notified as an SSSI under the Wildlife and Countryside Act (1981), as amended. SSSI are the finest sites for wildlife and natural features in England, supporting many characteristic, rare and endangered species, habitats and natural features.
Source-Pathway-Receptor linkage	**SPR linkage**	The approached used to describe pollutant linkages where a source is a known or potential source of contamination and a receptor is an environmental, human or built receptor which may be caused harm. A pathway is the route linking a source and receptor by which exposure or harm occurs.
Source protection zone	**SPZ**	Part of a groundwater catchment used for public water supply. SPZ are designated by the Environment Agency for the protection of public water supply from contamination from potentially polluting activities and accidental releases of pollutants.
Superceptor		A brand model of interceptor. A Superceptor is full retention interceptor, meaning that all flow is treated, and oil or fuel retained. Designed for use in areas where there is the possibility of spillage of pollutants such as petrol filling stations where all of the discharge from the area must be intercepted.
Surface water	**SW**	N/a
sustainable drainage system	**SuDS**	A sustainable drainage system designed to reduce the potential impact of new and existing developments with respect to surface water drainage discharges.
Synthetic Pyrethroid (pesticide)	**SP**	Lipophilic insecticides whose biological activity seems to be directly related to their chemical structure.
Tentatively Identified Compound	**TIC**	Non-target compound tentatively identified during analysis from a library of potential

Term	Abbreviation	Explanation
		compounds. Reported concentration maybe semi-quantitative and unaccredited.
Total Organic Content	**TOC**	N/a
Total Petroleum Hydrocarbons	**TPHs**	A term used for any mixture of hydrocarbons that are found in crude oil.
Tributyltin	**TBT**	A toxic chemical used for various industrial purposes, including prevention of growth of marine organisms on the hulls of ships, disinfection of circulating industrial cooling waters, and the preservation of wood.
Trip blank		A clean sample of a matrix (eg water) is taken from the laboratory to the sampling site and transported back to the lab without having been exposed to the sampling procedure.
UK Drinking Water Standards	**UK DWS**	Standards for a wide range of substances, organisms and properties of water as set by the European Drinking Water Directive (98/83/EC) and national standards in order to protect public health.
UK Power Network	**UKPN**	An energy network operator. Owns and maintains the electricity cables in South East England, the East of England and London.
Unexploded bomb	**UXB**	See 'unexploded ordnance'.
Unexploded ordnance	**UXO**	Explosive remnants of war that did not explode when they were deployed and may still pose a risk of detonation. Sometimes referred to as UXBs.
Unproductive strata		Rock layers or drift deposits with low permeability that have negligible significance for water supply or river base flow.
Volatile organic compound	**VOC**	Organic compound that is volatile under normal environmental/atmospheric conditions, although it can be found in the ground in the solid, liquid and dissolved phase form as well as in gaseous phase
Water Framework Directive	**WFD**	A European Community Directive (2000/60/EC) of the European Parliament and council designed to integrate the way water bodies are managed across Europe.
volume per volume	**% v/v**	Volume concentration of a solution, expressed as % v/v, which stands for volume per volume
weight per weight	**% w/w**	Weight concentration of a solution, expressed as % w/w, which stands for weight per weight

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