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CLIENT: TIDEWAY

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THAMES TIDEWAY TUNNEL – CENTRAL

SITE SPECIFIC REMEDIATION STRATEGY AND VERIFICATION PLAN CHELSEA EMBANKMENT FORESHORE

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SITE SPECIFIC REMEDIATION STRATEGY AND VERIFICATION PLAN - CHELSEA EMBANKMENT FORESHORE (CHEEF)

Contaminated land

4602-FLOJV-CHEEF-490-NZ-PQ-0100001

TIDEWAY

Site Specific Remediation Strategy and Verification Plan – Chelsea Embankment Foreshore (CHEEF)

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Abbreviations

AEP	Annual Exceedance Probability
ALL	Alluvium
ATD	Above Tunnel Datum
BB	Bullhead Bed
BRE	Building Research Establishment
BS	British Standard
BTEX	Benzene Toluene Ethylbenzene Xylenes
CEMP	Construction Environmental Management Plan
CHEEF	Chelsea Embankment Foreshore
CLR	Contaminated Land Report
CSM	Conceptual Site Model
CSO	Combined Sewer Overflow
EA	Environment Agency
FLO	Ferrovial Agroman Laing O'Rourke Joint Venture
GAC	Generic Assessment Criteria
GEMDMS	Groundwater Environmental Management – Dewatering and Management Strategy
GSHP	Ground Source Heat Pump
Ha	Hectares
HE	High Explosive
HHSC	Human Health Screening Criteria
LB	Laminated Beds
LCF	London Clay Formation
LG	Lambeth Group
LLAU	Limits of Land to be Acquired or Used
PRoW	Public Right of Way
mATD	Meters Above Tunnel Datum

mBGL	Metres Below Ground Level
MG	Made Ground
OS	Ordnance Survey
PAH	Polycyclic Aromatic Hydrocarbons
PID	Photo-ionisation Detector
PHA	Public Health Authority
RB	Royal Borough
RTD	River Terrace Deposits
SCL	Sprayed Concrete Lining
SCK	Seaford Chalk Formation
SVOC	Semi-Volatile Organic Compounds
SOM	Soil Organic Matter
S4ULs	Suitable 4 Use Levels
TPH	Total Petroleum Hydrocarbons
TSF	Thanet Sand Formation
UF	Upnor Formation
UXB	Unexploded Bomb
UXO	Unexploded Ordnance
VOC	Volatile Organic Compounds
WRGAC	Water Resources Generic Assessment Criteria
WWII	World War Two

1 Introduction

1.1 Terms

1.1.1 AECOM Limited has been commissioned by Ferrovial Agroman Laing O'Rourke Joint Venture (FLOJV) on behalf of Thames Tideway Tunnel (TTT) to produce a site specific remediation strategy and verification plan. This document is required to support the satisfactory discharge of the land contamination requirements of the Development Consent Order (DCO) at the Chelsea Embankment Foreshore (CHEEF) worksite.

1.2 Background

1.2.1 The Chelsea Embankment Foreshore (CHEEF) worksite (herein 'the site') lies in the Royal Borough (RB) of Kensington and Chelsea on the northern bank of the River Thames. It comprises an area of the River Thames foreshore (the foreshore works area), a section of pavement and roadway of the Chelsea Embankment (A3212), and a small part of Ranelagh Gardens (the highway works area). The location of the worksite and the boundary of the site are indicated in Figure 4602-FLOJV-CHEEF-490-NZ-DH-010001.

1.2.2 The proposed foreshore development is described in Section 1.4.

1.3 Site specific documentation

1.3.1 This document should be read in conjunction with other project and site related documents.

1.3.2 Background site information is presented in the Contaminated Land Risk Assessment (Doc Ref: 4602-FLOJV-CHEEF-490-NZ-RG-010001) which has been written to satisfy part 1a of the DCO. The above referenced document contains a review of existing information (literature and existing ground investigation data) to provide a generic and preliminary assessment of land quality conditions at the site. The reader is referred back to the above referenced document for information concerning site setting and the basis of the Conceptual Site Model.

1.3.3 Other pertinent information is considered to be contained within:

a. Code of Construction Practice (CoCP Part A: General Requirements). Doc Ref: APP205.01.

   i. Identifies good working practice that should be applied during construction to safeguard the environment.

b. Code of Construction Practice (CoCP Part B - CHEEF). Doc Ref: APP178.21.

   i. Identifies site-specific measures where deviations from the general requirements are indicated in Part A.

c. Groundwater Environmental Management – Dewatering and Monitoring Strategy (GEMDMS). Doc Ref: 1000-ENV-ZZZZZ-ZZZ-ZZ-PX | AG | March 2014 – Revised July 2015.

   i. Identifies the overarching groundwater management plan for the Tideway project.

1.4 Proposed development

1.4.1 The proposed foreshore development will comprise construction of the combined sewer overflow (CSO) drop shaft, an overflow weir chamber to connect to the northern Low Level Sewer No.1 (LLN1) under Chelsea Embankment and an interception chamber to intercept the Ranelagh CSO. A connection culvert will also be constructed to link the flows to the shaft. A short connection tunnel (Ranelagh connection tunnel) will link the shaft to the main Thames Tideway Tunnel located beneath the River Thames.

1.4.2 The CSO drop shaft will be approximately 12m internal diameter and approximately 45m deep, corresponding to a level of approximately 59.95m Above Tunnel Datum (ATD)[1]. The base of the CSO drop shaft will be approximately 4.5m thick and will extend to approximately 55.3m ATD corresponding to the upper units of the Lambeth Group.

1.4.3 The Ranelagh connection tunnel will be constructed with a 4.8m internal diameter de-aeration chamber of length 46m and an approximately 5m long section of 4.0m diameter connection tunnel. The connection tunnel/deaeration chamber will be constructed using sprayed concrete lining techniques.

1.4.4 The Ranelagh connection culvert, linking the LLN1 overflow chamber with the shaft, will have an approximately 23m long, 3.5m diameter curved section of de-aeration chamber constructed using sprayed concrete lining techniques. A further 120m long, 2.5m diameter straight section of connection culvert will be constructed using pre-cast concrete rings as a primary liner.

1.4.5 The worksite will be created by the construction of a temporary cofferdam which will facilitate the construction of a permanent foreshore structure with the creation of a new permanent river wall. This foreshore structure will be completed with landscaping to incorporate public space along the embankment.

1.4.6 A detailed presentation of the construction sequence is given in Section 1.2 of the Contaminated Land Risk Assessment (4602-FLOJV-CHEEF-490-NZ-RG-010001). The reader is directed to this document for reference to the construction sequence.

[1] In general, the measurements of depth are expressed as metres Above Tunnel Datum (mATD). The standard zero point for mATD scale is -100maOD (metres above Ordnance Datum is based on Newlyn datum point for mean sea level). The use of the mATD scale avoids the need for use of negative values, and is widely used for large scale sub-surface projects.

1.5 Objectives and scope

1.5.1 This document has been written to fulfil the requirements of a Remediation Strategy and Verification Plan for Chelsea Embankment Foreshore to fully address Part 1b of the Development Consent Order (DCO) (Schedule 3).

1.5.2 This document has been prepared in general accordance with CLR11 Model Procedures for the Management of Land Contamination (Defra & Environment Agency, 2004). The guidance defines "remediation" as the action taken to prevent, minimise, remedy or mitigate the effects of any unacceptable risks. The remediation works should be carried out to the degree that the site will not qualify as contaminated land under Part 2A of the Environmental Protection Act 1990 in relation to the intended use of the land after remediation.

1.5.3 This report is technically a working document which will be reviewed if the ground conditions encountered require it to be e.g. design changes or unexpected ground conditions encountered. The Contractor shall develop detailed method statements in order to meet the objectives identified.

1.5.4 This document provides the following:

a. Summary of site setting and project background;

b. Update of Conceptual Site Model (CSM) through review and assessment of additional groundwater monitoring data received since production of the Contaminated Land Risk Assessment;

c. Remediation objectives and remediation criteria;

d. Discovery Strategy for identifying and dealing with previously undiscovered contamination;

e. Verification Plan - Requirements for collating evidence to demonstrate the activities carried out;

f. Contact details for principal stakeholders.

2 Background information

2.1 Summary

2.1.1 This section summarises the site setting and findings of the Contaminated Land Risk Assessment (Doc Ref: 4602-FLOJV-CHEEF-490-NZ-RG-010001). Reference should be made to the full document for further information.

2.2 Site location

2.2.1 The CHEEF worksite is located in the RB of Kensington and Chelsea on the northern bank of the River Thames. The approximate National Grid reference at the center of the proposed drop shaft is 528262E, 177828N.

2.2.2 The site is bounded to the north by the Chelsea Embankment, the Royal Hospital Chelsea and its South Grounds and Ranelagh Gardens. The River Thames bounds the site to the east, south and west. Residential properties (mid-rise flats) and the Lister Hospital are located to the northeast. Further to the east is Chelsea Bridge (A3216) and Chelsea Bridge Gardens. Western Pumping Station is located approximately 400m to the east along Chelsea Embankment.

2.2.3 There is no existing vehicle access to the foreshore. Grosvenor College Stairs just to the west of the site provide pedestrians access to the foreshore. The Thames Path National Trail public right of way (PRoW) runs along the southern pavement of Chelsea Embankment within the boundaries of the site. The closest transport stations are Sloane Square Underground Station and Battersea Park Station, which are situated approximately one kilometre (km) north and south of the site respectively.

2.3 Site description

2.3.1 The site extent is defined by the limits of land to be acquired or used (LLAU) and covers an area of approximately 2.5 hectares (ha). The site comprises a section of the River Thames foreshore, a section of pavement and roadway of the Chelsea Embankment (A3211) and a small part of Ranelagh Gardens.

2.3.2 The site is located on a relatively flat area on the north bank of the River Thames with a very gentle slope down to the south, toward the River Thames. The current street level of Chelsea Embankment is at approximately 104.9m ATD (4.9m AOD). The street level rises to the east up to approximately 109.5m ATD at the northern approach of Chelsea Bridge. The foreshore portion of the site lies at approximately 100.3m ATD and drops to 98.3m ATD at the bottom of the foreshore, as exposed at low tide. The crest level of the CHEEF river wall existing flood defences is 105.41m ATD.

2.4 Summary of site history

2.4.1 A detailed review of historical site use is presented in Section 4 of the Preliminary Risk Assessment.

2.4.2 In summary the site setting has altered little from the mid to late 19th Century, consisting of the Chelsea Reach of the River Thames foreshore, together with a section of the Chelsea Enbankment and circular road entrance. A small portion of the north eastern section of the site enters the Ranelagh Gardens. The low level sewer runs beneath the Embankment.

2.4.3 Surrounding land uses include Chelsea Suspension Bridge to the east (E), Chelsea Embankment to the west (W), Smith Street sewer outfall 160m west (W), Ranelagh Gardens to the north (N), two Timber Yards (130m and 180m north east (NE), Grosvernor Canal and associated Dock (115m NE), Sewage Works approximately 150m NE, Battersea wharf 245m to the south east (SE), Lister Hospital 115m NE, a Disinfection Station 120m E, iron works 400m NE and a motor car depot 450m NE.

2.5 Potential contaminants of concern

2.5.1 Onsite potential contaminants of concern are limited to potential sources within the Made Ground forming the Chelsea Embankment as the majority of the site is located within the foreshore and so has not been subject to specific development. Sediments within the foreshore may also represent a potential source of contamination. Contaminants of concern may include polyaromatic hydrocarbons (PAHs), total petroleum hydrocarbons (TPH), heavy metals, asbestos and coliform.

2.5.2 Offsite sources of contamination are located some distance away. Potential contaminants could include polyaromatic hydrocarbons (PAHs), total petroleum hydrocarbons (TPH), heavy metals, phenols, sulphide, sulphates, fuel oil, lubricating oil, greases, solvents, asbestos, chlorinated aromatic and aliphatic hydrocarbons, heavy metals, glycol, polychlorinated biphenyls (PCBs), cresols and ground gases.

2.6 Previous site investigation

2.6.1 Ground investigations conducted by Tideway between 2009 and 2012 include five overland boreholes and three overwater boreholes, together with: CPT, grab sampling and Vibrocore sampling.

2.6.2 Figure 1 below (extract of 4602-FLOJV-CHEEF-490-NZ-DH-010003) identifies boreholes which have been drilled in the vicinity as part of the Tideway scheme and a summary of the boreholes is given in Table 2.1 below.

2. Background information

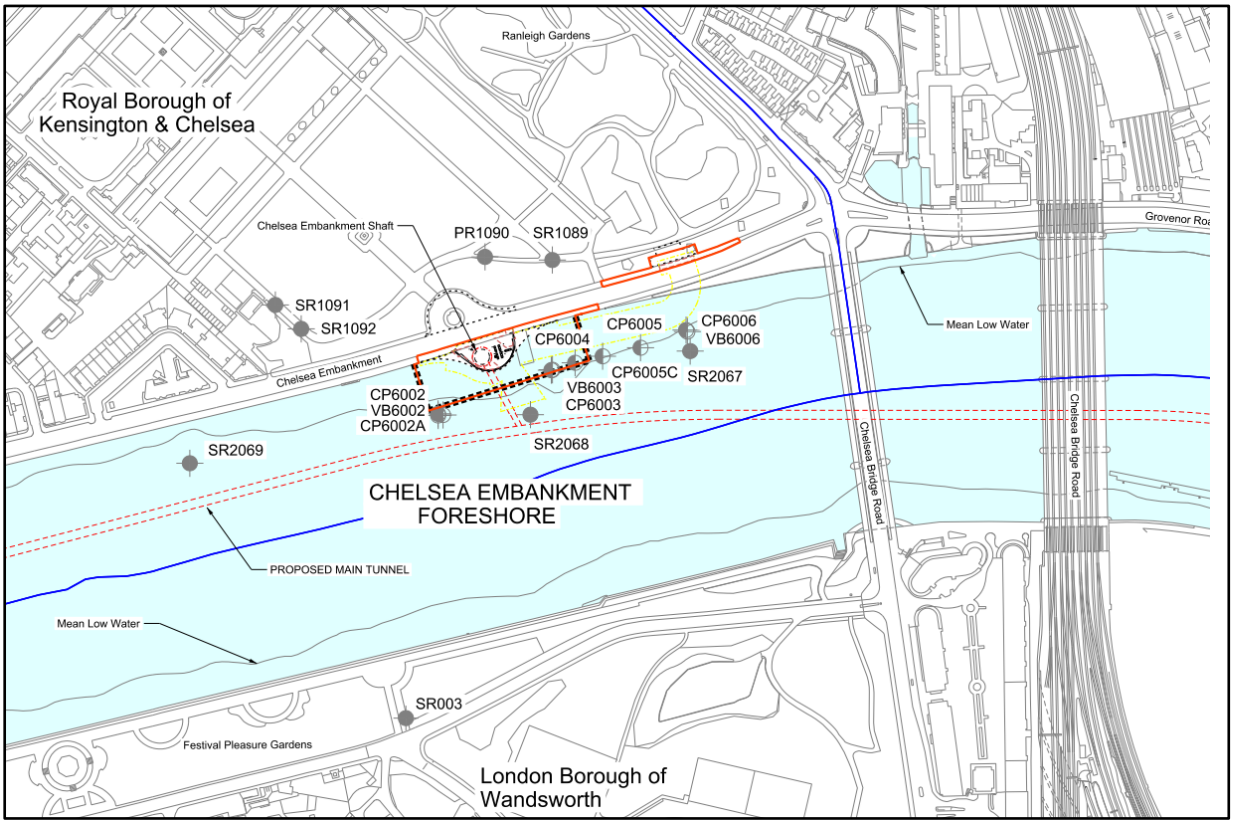

Figure 1 – Borehole locations (CHEEF)

Table 2.1 – Summary of on- and off-site boreholes

	BH ID	Location	Date	Depth (m)	Installation (m)	Soil Testing
Onsite * ^	*Thames Tunnel (December 2010). Phase 2: Over-water Boreholes (5LYG-G71) Final Factual Report on Ground Investigation. Report No: NEA091003, Fugro Engineering Services Limited. Document No: 100-RG-GEO-FESXX-000035 to 000050 and 100-MD-GEO-FESXX-000081*					
	SR2068	Overwater	May 2010	70.2	None	Soil suite (1.0mbgl, 38.6mbgl) WAC suite (49.2mbgl, 55.8mbgl, 65mbgl)
Offsite^	*LTT - Thames Tunnel (May 2010). Homefield to NESR (5LYG-G70) Final Factual Report on Ground Investigation. Report No: WAL080092, Fugro Engineering Services Limited. Document No: 100-RG-GEO-FESXX-000002, 000005 to 000013, 000017, 000028 and 000029*					
	PR1090	Overland	June – July 2009	70.0	PR1090-1: 25mm SP, 49.50 – 54.60, LG-UMB to LG-LMB PR1090-2: 50mm SP, 61.50 – 64.00, LG-LMB to TF	Soil suite (1.0mbgl, 3.9mbgl) Leachate suite (1.0mbgl) Water suite (54mbgl, 64mbgl)
	SR1089	Overland	July 2009	56.0	SR1089-1: 25mm SP, 44.60 – 45.80 , LG-USB SR1089-2: 50mm SP, 64.00 – 70.00, TF	Soil suite (0.4mbgl, 8.0mbgl) Water suite (44.9mbgl, 66mbgl)
	SR1091	Overland	June -	70.4	SR1091-1: 50mm SP,	Soil suite (2mbgl,

			July 2009		4.00 – 7.10, RTD SR1091-2: 25mm SP, 47.00 – 52.10, LG-UMB	7.8mbgl) Leachate suite (2mbgl) Water suite (6.5mbgl, 51.3mbgl)
	SR1092	Overland	June - July 2009	70.0	SR1092-1: 50mm SP, 18.00 – 24.10, LCF-B to LCF-A3ii SR1092-2:25mm SP, 43.60 – 45.60, LCF-A2 to LG-USB	Soil suite (0.3mbgl, 3.8mbgl) Leachate suite (1.0mbgl) Water (23.55mbgl, 45mbgl)
	Thames Tideway Tunnel (January 2009).Report on a Ground Investigation and Trial of Sonic Drilling Techniques for the Thames Tideway Tunnel from Fulham to Battersea, Report No. F15325, Northwest Holst. Document No: 303-RG-GEO-NWHXX-000002					
	SR003	Overland	September 2008	77.3	SR003-1: 19mm Piezo,49.00 – 50.50, LG-USB to LG-UMB	None
	Thames Tunnel (December 2010). Phase 2: Over-water Boreholes (5LYG-G71) Final Factual Report on Ground Investigation. Report No: NEA091003, Fugro Engineering Services Limited. Document No: 100-RG-GEO-FESXX-000035 to 000050 and 100-MD-GEO-FESXX-000081					
	SR2067	Overw ater	May 2010	68.40	None	None
	SR2069	Overw ater	May 2010	69.80	None	Soil suite (0.5mbgl) WAC suite (10mbgl)

NOTES:

*on-site means limits of land to be acquired or used (LLAU)

^ additional overwater CPT, vibrocone and foreshore sediment testing undertaken on site (CP6002, CP6002A, CP6003, CP6004, CP6005C, VB6002, VB6003, CBC01, CBC02, CBC03 and CBC04).

^^ additional overwater CPT and vibrocone testing undertaken on off-site (CP6005, CP6006, VB6006).

Additional report references are:

Thames Tunnel (May 2012). Overwater Magnetometer Cone Penetrometer Testing and Vibrocore Sampling (5LYG-C116), Report No: Q10/12, Port of London Authority. Document No:323-RG-GEO-00000-000010

Thanes Tunnel (Dec 2011). Foreshore Contamination Sampling (5LYG.C.116) Report No: 113-300-063. Port of London Authority. Document No. 323-RG-GEO-00000-000003_AA_1.

2.7 Further site investigation

2.7.1 No further site investigation for land contamination purposes is proposed by FLO with the exception of a single land-based borehole due to be drilled in summer 2017. The borehole is proposed to be referenced as SR7502 and be constructed by cable percussive with rotary follow-on methods to a depth of 60m. The borehole is primarily intended to investigate ground conditions for the river wall and connection culvert but will also be used as an opportunity to collect geo-chemical soil data and for installation of a shallow monitoring standpipe. The results from this borehole will be reviewed against the recommendations made within this report and if there is perceived to be a requirement for additional remediation measures they will be considered in the Construction Environmnetal Management Plan (CEMP).

2.7.2 The site access constraints make additional onsite investigation difficult as the majority of the site is located within the River Thames.

2.7.3 Reference has been made to observations from river wall investigatory works undertaken in May/June 2017. These investigations were not undertaken for the purposes of land contamination but for specialist surveys of the river wall however records have been made of the encountered shallow ground conditions.

2.8 Site specific geology

2.8.1 The geological profile from on- and off-site boreholes is summarised in Table 2.2.

Table 2.2 – Summary site specific geological profile

Stratum		Base of stratum		Full Thickness, m
		Elevation, mATD	Depth, mBGL	
Made Ground		103.57 to 100.95 (101.76)	1.20 to 3.25 (2.47)	1.20 to 3.25 (2.47)
Alluvium		100.87 to 96.83 (98.52)	0.10 to 5.40 (2.52)	0.10 to 3.40 (1.24)
River Terrace Deposits		96.57 to 94.69 (96.07)	0.04 to 9.00 (3.59)	0.04 to 5.10 (1.94)
London Clay Formation	Unit B	85.97 to 82.41 (83.53)	11.45 to 21.65 (17.91)	9.80 to 14.00 (12.38)
	Unit A3	72.14 to 69.38 (70.60)	24.45 to 34.82 (30.84)	11.00 to 15.00 (12.93)
	Unit A2	60.60 to 58.28 (59.28)	35.52 to 45.92 (42.15)	10.60 to 13.00 (11.31)
Harwich Formation	Swanscombe Member	60.51 to 58.21 (59.21)	35.61 to 45.99 (42.87)	0.05 to 0.25 (0.11)
Lambeth Group	Upper Shelly Beds	59.17 to 55.41 (57.33)	36.95 to 49.36 (44.11)	1.25 to 4.09 (1.86)
	Upper Mottled Beds	54.47 to 50.74 (52.24)	41.65 to 53.30 (49.19)	1.24 to 6.10 (4.88)
	Upper Mottled Beds – Sand Channel	55.66 to 53.55 (54.43)	41.25 to 50.30 (44.24)	0.15 to 1.90 (0.68)
	Laminated Beds	52.26 to 49.64 (50.94)	43.86 to 54.00 (50.49)	0.30 to 5.94 (1.62)
	Lower Shelly Beds	50.76 and 50.17 (50.47)	46.54 and 54.17 (50.36)	0.03 and 1.13 (0.58)
	Lower Mottled Beds	44.28 to 41.36 (42.56)	52.65 to 62.50 (58.46)	6.25 to 9.31 (8.33)
	Upnor Formation	42.57 to 40.28 (40.99)	53.55 to 63.90 (60.10)	0.90 to 4.00 (1.75)
Thanet Formation	Thanet Sand	30.72 to 29.14 (29.67)	65.40 to 68.16 (67.10)	10.51 to 11.85 (11.40)

Stratum		Base of stratum		Full Thickness, m
		Elevation, mATD	Depth, mBGL	
	Bullhead Bed	30.51 to 28.77 (29.42)	65.61 to 68.31 (67.35)	0.15 to 0.39 (0.25)
White Chalk Subgroup	Seaford Chalk Formation	Proven to 27.47	Proven to 77.30	Proven 2.79

Notes:
1. Average values in brackets ( )
2. Table extracted from 2014 Tideway Chelsea Embankment Foreshore ground investigation report (100-RG-GEO-PKC4X-000006|AB|20 February 2014

2.9 Site specific hydrogeology

2.9.1 Groundwater monitoring records have been reviewed from previous on and off-site ground investigations in relation to the Thames Tideway project and a summary is presented in Table 2.3 below.

2.9.2 Recorded groundwater levels from the installation in the River Terrace Deposits (SR1091) range from 99.27m ATD to 99.96m ATD. These water levels consistently remain above the top of the formation at 96.57m ATD, suggesting that this unit is fully saturated and confined by the overlying Alluvium at this location.

2.9.3 Groundwater flow in the River Terrace Deposits is expected towards the south, towards the river. Groundwater flow direction and pressure is likely to be affected by tidal influences.

2.9.4 The regional groundwater flow in the Chalk is anticipated to be towards the north (based on groundwater contours provided in the EA Management of the London Basin Chalk Aquifer Status Report 2016).

2.9.5 Groundwater levels in the Chalk (as recorded in the EA Management of the London Basin Chalk Aquifer Status Report 2016) have consistently remained at approximately 80mATD between 2000 and 2016. The confined response level would correspond to an approximate level within the upper units of the London Clay (Unit A3 and B) at the CHEEF site. The EA has a regional network of monitoring boreholes, mainly within the lower aquifer, across London, but unfortunately none are found in the vicinity of the CHEEF site.

2.9.6 While the White Chalk Subgroup lithology was encountered during drilling at the CHEEF site (in 3 overwater locations and 1 land location on the southern side of the River Thames), no groundwater monitoring wells were completed within the lower aquifer response zone. The deepest installation at the CHEEF site is installed within the Thanet Formation between 39.64 and 33.64m ATD.

2.9.7 The recorded water levels (piezometric head) in the Harwich Formation/ Upper Shelly Beds range from 80.59 to 84.44mATD. These levels consistently remain above the top of the Harwich Formation at 58.4mATD, suggesting that these units are fully saturated and are confined by the overlying London Clay Formation.

Table 2.3 – Groundwater summary (based on a number of separate ground investigation and monitoring phases, 2009-17)

Borehole ID	Installation depth, mBGL (slotted section)	Strata	Groundwater level, mBGL	Groundwater level, mATD
SR003 (SR003-1)	49.00 to 50.50	LG-USB to LG-UMB	15.84 to 11.19	88.93 to 93.58
PR1090 (PR1090-1)	49.50 to 54.60	LG-UMB to LG-LMB	6.05 to 4.45	98.15 to 99.75
PR1090 (PR1090-2)	61.50 to 64.00	LG-LMB to TF	6.03 to 3.95	98.17 to 100.25
SR1089 (SR1089-1)	44.60 to 45.80	LG-USB	23.05 to 13.72	80.59 to 89.92
SR1089 (SR1089-2)	64.00 to 70.00	TF	35.36 to 19.32	68.28 to 84.32
SR1091 (SR1091-1)	4.00 to 7.10	RTD	5.07 to 3.76	99.27 to 100.58
SR1091 (SR1091-2)	47.00 to 52.10	LG-UMB	20.23 to 9.81	84.11 to 94.53
SR1092 (SR1092-1)	18.00 to 24.10	LCF-B to LCF-A3ii	5.07 to 3.96	99.11 to 100.22
SR1092 (SR1092-2)	43.60 to 45.60	LCF-A2 to LG-USB	7.45 to 3.92	96.73 to 100.26

Note:
1. Groundwater levels may be susceptible to fluctuations arising from tidal, seasonal or other effects.
2. MG = Made Ground; RTD = River Terrace Deposits; LCF-B = London Clay Formation – Unit B; LCF-A3 = London Clay Formation – Unit A3; LCF-A2 = London Clay Formation – Unit A2; LG-USB = Lambeth Group – Upper Shelly Beds; LG-UMB = Lambeth Group - Upper Mottled Beds; LG-LMB = Lambeth Group – Lower Mottled Beds; TF = Thanet Formation.
3. Table extracted from 2014 Tideway Chelsea Embankment Foreshore ground investigation report (100-RG-GEO-PKC4X-000006|AB|20 February 2014, supplemented with 2015 Tideway monitoring data.

2.10 Visual and olfactory evidence of contamination

2.10.1 There is a single borehole drilled on site (SR2068) which is located within the River Thames adjacent to the proposed new cofferdam structure. No description of visual or olfactory contamination is noted in this borehole and only 1m of superficial deposit (River Terrace Deposits) is noted above the London Clay.

2.10.2 Evidence of anthropogenic contamination has been noted in a limited number of offsite, land based boreholes in the vicinity of the site in the form of ash, coal, shale, clinker, brick, concrete and slag within the Made Ground. No evidence of olfactory or free phase contamination has been noted. It should be noted that the Alluvium in the vicinity is noted as being very organic rich and is often described as having an organic odour. The observations are summarised in Table 2.4.

2.10.3 No photoionisation detector (PID) measurements are available from the previous ground investigations.

2.10.4 A number of trial pits were sunk as part of the river wall investigatory works on the foreshore at the front face of the river wall. Trial pit B, located adjacent to the

outfall encountered very dark brown/black silty clay at shallow depth which was noted to have a strong odour. Although not confirmed it is likely that this could be impact from sewage discharges from the nearby outfall which would not be unexpected.

Table 2.4 – Summary of visual and olfactory indicators of contamination

Formation	Location	Indicator
Made Ground	SR2068	brick, pottery fragments
	PR1090	brick, concrete fragments, clinker, coal fragments
	SR1089	brick, concrete and pottery fragments, ash
	SR1091	brick, concrete, ceramic pipe fragments, charcoal
	SA1092	clinker, charcoal, ceramic pipe and tiles fragments, brick, concrete
	SR003	brick
Alluvium	PR1090	organic odour
	SR1089	slight organic odour
	SR1091	organic odour
	SA1092	organic odour
	SR2067	brick and glass fragments

3 Generic Quantitative Risk Assessment

3.1 Introduction

3.1.1 In accordance with CLR11 a Preliminary Risk Assessment has been undertaken (4602-FLOJV-CHEEF-490-NZ-RG-010001-P03) which includes a summary of the geo-chemical data available for the site and a Conceptual Site Model.

3.1.2 No further ground investigation works have been undertaken between the contaminated land risk assessment and this report due to inherent constraints with site access. As discussed in Section 2.7, the results from the planned borehole SR7502 will be reviewed in context with the recommendations made within this report. Any updates to the recommendations made in this report as a result will be documented in the Contractors methodologies and recorded in the Verification Report.

3.1.3 The following GQRA provides the assessment presented in the Contaminated Land Risk Assessment and is supplemented by additional monitoring data where available. The various risk assessment methodologies are discussed in the next sections.

3.2 Human Health Risk Assessment

Screening criteria

3.2.1 The results of the soil (sediment) testing have been compared to the Tideway Human Health Screening Criteria (HHSC), as well as the 'Suitable 4 Use Levels' (S4ULs) for commercial / industrial land uses.

3.2.2 The HHSC values are based on the lowest value from a standard set of literature screening values for a commercial / industrial land use. The values are all based on 1% soil organic matter (SOM) and are limited by soil saturation limits where applicable. These screening values were considered best practice at the time of writing and approval but we acknowledge that development of guidelines may result in an amendment to the Generic Assessment Criteria (GAC).

3.2.3 The HHSC were derived in 2014 and circulated in 2015. They are based on the following:

- Soil Guideline Values (EA, 2009);
- The LQM/CIEH Generic Assessment Criteria for Human Health Risk Assessment (2nd Edition). Nathanail et.al (2009);
- The LQM/CIEH S4ULs for Human Health Risk Assessment, Nathanail et.al (2015);
- British Standard 3882:2007. Specification for topsoil and requirements for use.

3.2.4 The S4ULs were developed by LQM – a specialist UK environmental consultancy (Nathanail et al, 2015). These limits are based on Health Criteria which represent minimal or tolerable levels of risk to health. For each substance, S4ULs have been derived for a range of generic land uses and soil organic matter contents.

For the CHEEF site, the S4ULs adopted were based on a commercial use assuming the geology as sandy/loam and 1% SOM.

Results

3.2.5 No soil testing is available within the terrestrial limits of the site.

3.2.6 Two sediment tests have been undertaken from the overwater borehole and three foreshore sediment samples were tested for a range of determinands as part of a Port of London survey undertaken in 2011.

3.2.7 The results of the testing is presented in Table 3.1 and analysed below.

Table 3.1 – Summary of soil (sediment) testing

Determinand	Unit	S4ULs	HHSC (Source)	SR2068 (1.0m)	SR2068 (38.6m)	CBC 01 (0-0.2m)	CBC02 (0-0.2m)	CBC04 (0-0.2m)	Exceedance?
Arsenic	mg/kg	640	640 (S4ULs)	15	17	11	15	26	No
Cadmium	mg/kg	190	190 (S4ULs)	0.7	1.3	0.36	0.41	0.19	No
Chromium	mg/kg	33	33 (S4ULs)	43	36	22	274	26	Yes – S4ULs / HHSC
Copper	mg/kg	68000	68000 (S4ULs)	22	45	41	78	73	No
Lead	mg/kg	2300* (Defra C4SL)	1100** (Defra C4SL)	24	15	160	320	380	No
Mercury	mg/kg	1100	26 (EA SGV)	0.05	<0.05	0.45	0.72	2.7	No
Zinc	mg/kg	730000	730000 (S4ULs)	72	150	120	170	120	No
Acenaphthalene	ug/kg	84000 (solubility 57000)	57000 (solubility)	<100	<100	-	180	500	No
Acenaphthylene	ug/kg	83000 (solubility 86000)	86000 (solubility)	<100	<100	-	<100	<100	No
Anthracene	ug/kg	520,000,000	520,000,000 (S4ULs)	<100	<100	-	<100	750	No
Benz(a)anthracene	ug/kg	170,000	90,000 (LQM/CIEH 2009)	<100	<100	-	<100	1500	No
Benzo(a)pyrene	ug/kg	35,000	14,000 (LQM/CIEH 2009)	<100	<100	-	<100	2100	No
Chrysene	ug/kg	350,000	140,000 (LQM/CIEH 2009)	<100	<100	-	<100	1300	No
Dibenz(a,h)-anthracene	ug/kg	3,500	3,500 (S4ULs)	<100	<100	-	<100	<100	No
Fluoranthene	ug/kg	23,000,000	23,000,000 (S4ULs)	<100	<100	-	790	2900	No
Fluorene	ug/kg	63,000 (solubility 31,000)	31,000 (solubility)	<100	<100	-	200	470	No
Naphthalene	ug/kg	190,000 (solubility	76,000 (solubility)	<100	<100	-	2100	5800	No

Determinand	Unit	S4ULs	HHSC (Source)	SR2068 (1.0m)	SR2068 (38.6m)	CBC 01 (0-0.2m)	CBC02 (0-0.2m)	CBC04 (0-0.2m)	Exceedance?
		76,000)							
Phenathrene	ug/kg	22,000,000	22,000,000 (S4ULs)	<100	300	-	750	1900	No
Pyrene	ug/kg	54,000,000	54,000,000 (S4ULs)	<100	<100	-	740	2500	No

Notes:

1. S4ULs (2015) for Commercial / Industrial at 1% SOM
2. EA SGV: Soil Guideline Values (EA, 2009);
3. LQM/CIEH 2009: The LQM/CIEH Generic Assessment Criteria for Human Health Risk Assessment (2nd Edition). Nathanail et.al (2009);
4. * S4UL for lead is not available so the mid range of Defra C4SL 12/2014 was used.
5. **Defra C4SL has a range from 1100-6000mg/kg – the combined HHSC uses the lowest C4SL value.

Analysis

3.2.8 The sediment results have been compared against the HHSC provided by Tideway as well as the S4ULs.

3.2.9 The concentrations of Chromium in sediment samples from SR2068 are 36mg/kg and 43mg/kg which exceed the HHSC (and S4UL) of 33mg/kg however, this criteria is based upon Hexavalent Chromium which has been adopted as a conservative screening threshold. A suitable human health screening criteria for Trivalent Chromium is considered to be 8600mg/kg. The chromium test is unspeciated and it is suspected that the result represents Trivalent Chromium (the naturally occurring form of Chromium). Hexavalent Chromium usually originates from industrial processes (such as welding / 'hot works') and records do not show these activities historically occurring on site. In the environment Chromium is normally encountered in the Trivalent form. Therefore, this result is not considered further.

Conclusion

3.2.10 The existing site consists predominantly of the Thames foreshore. Therefore onsite testing is limited to one foreshore borehole (SR2068) and three offsite foreshore samples. No testing is available on the terrestrial portion of the site.

3.2.11 The available testing from the foreshore borehole and grab samples does not record any exceedances against the Tideway Human Health Generic Assessment Criteria and S4ULs (notwithstanding the Chromium discussion in section 3.2.9).

3.2.12 On the basis of the available results, there do not appear to be any concentrations of contaminants which would pose a risk to long term human health, and by virtue acute risks to construction workers are assumed to be negligible.

3.3 Controlled Waters Risk Assessment

Screening criteria

3.3.1 The results of the groundwater testing have been compared to the Tideway Water Resources Generic Assessment Criteria (WRGAC).

3.3.2 The results of the sediment testing from ground level to 1m (i.e. shallow river sediments) have been compared to the Canadian Sediment Quality Guidelines (CCEM, 2001) Threshold Effect Levels (TEL) and Probable Effect Levels (PEL) to assess potential risk to aquatic life as endorsed by the Port of London Authority (PLA).

3.3.3 The results of the analysis shows Arsenic, Chromium, Copper, Mercury and Zinc exceedances against the TEL with additional PEL exceedances for Mercury and Lead in the PLA foreshore samples. However, the natural, and presumed uncontaminated sample at 38.6mbgl also shows exceedances for Arsenic, Cadmium, Chromium, Copper and Zinc which would indicate the possibility of naturally occuring elevated concentrations of metals. An additional Phenanthrene (a polyaromatic hydrocarbon compound) exceedance has also been noted from the natural sediments. A number of PAH compounds are noted as TEL and PEL exceedances within CBC02 and predominantly CBC04 (foreshore sediment samples) (see Table C.2, Appendix C, Preliminary Risk Assessment Report, 4602-FLOJV-CHEEF-490-NZ-RG-010001-P03).

Results

3.3.4 No groundwater quality data is available from onsite.

3.3.5 Reference has been made to available offsite groundwater quality testing in the vicinity of the site as shown in Figure 2 (blue boxes) and summarised in Table 3.2.

3. Generic Quantitative Risk Assessment

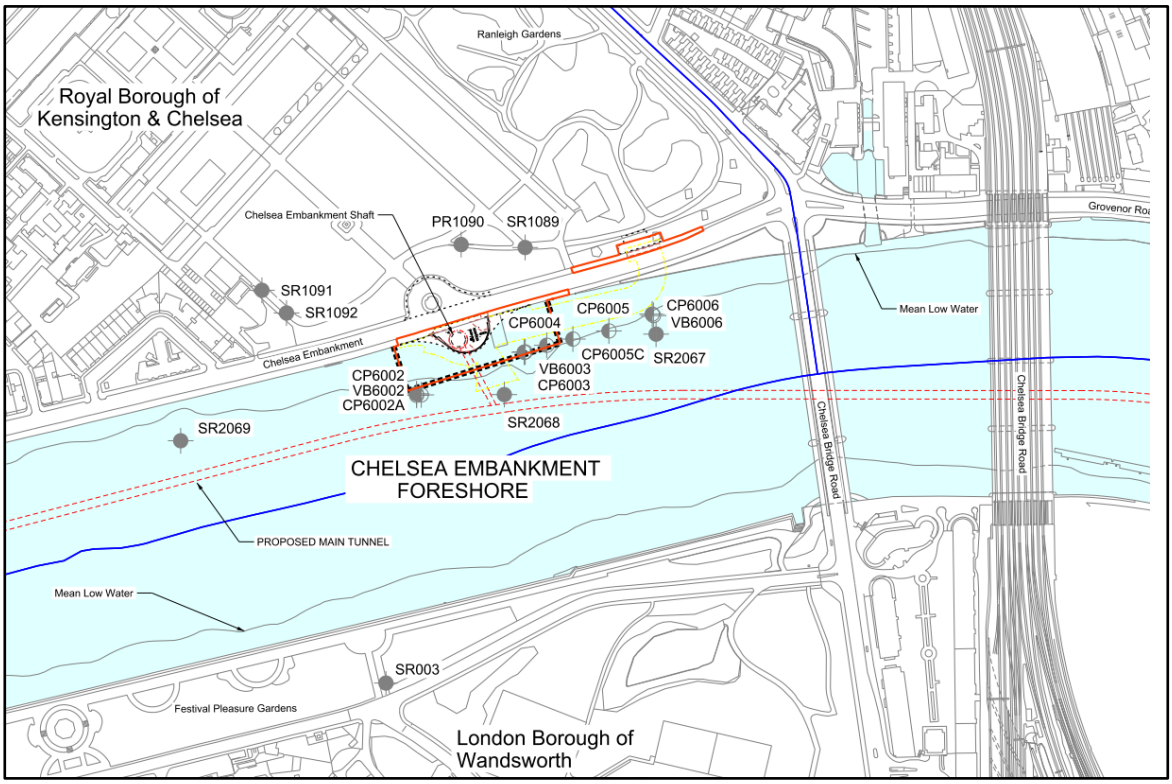

Figure 2 Installations

Table 3.2 – Summary of offsite groundwater testing

BH ID	Strata	Depth of groundwater sample (m bgl)	No. of rounds	Date of testing
PR1090	Lambeth Group	54.0	1	13th July 2009
	Thanet Sand	64.0	1	13th July 2009
SR1089	Lambeth Group	44.9	1	7th August 2009
	Thanet Formation	66.0	13	7th August 2009 18th November 2011 18th January 2012 19th March 2012 6th September 2012 26th September 2013 26th February 2015 10th September 2015 27th January 2016 13th July 2016 22nd July 2016 20th October 2016 11th April 2017

BH ID	Strata	Depth of groundwater sample (m bgl)	No. of rounds	Date of testing
SR1091	River Terrace Deposits	6.5	10	24th July 2009 26th September 2013 26th February 2015 10th September 2015 28th January 2016 13th July 2016 22th July 2016 19th October 2016 18th January 2017 10th April 2017
	Lambeth Group	51.3	1	24th July 2009
SR1092	London Clay Formation	23.55	1	7th August 2009
	London Clay Formation to Lambeth Group	45.0	1	7th August 2009

Analysis

3.3.6 A review of the results indicate impact within the River Terrace Deposits from SR1091 comprising of Chromium, PAH compounds, TPH (total), Chloride and Alkalinity. SR1091 has been monitored on 6 occasions. The most prevalent exceedance appears to be Chromium, detected on four occasions; however the maximum recorded concentration was 15ug/l against a WRGAC of 10ug/l which is not considered to be a significant exceedance. Exceedances are summarised in Table 3.3.

Table 3.3 – SR1091 – RTD exceedances and trends

Determinand	No of tests	No. of exceedances	WRGAC (ug/l)	Max Concentration (ug/l)	Comments
PolyAromatic Hydrocarbon (PAH) compounds					
Acenapthene	4	1	0.01	0.15	One exceedance in Sept 2013, next two visits <LOD.
Benzo[a]Anthracene	4	1	0.01	0.04	Marginal exceedance in Feb 2015 only
Benzo[a]Pyrene	4	1	0.01	0.014	Marginal exceedance in Feb 2015 only
Benzo[b]Fluoranthene	4	1	0.015	0.05	Marginal exceedance in Feb 2015 only
Benzo[g,h,i]Perylene	4	1	0.001	0.03	Marginal exceedance in Feb 2015 only
Benzo[k]Fluoranthene	4	1	0.015	0.03	Marginal exceedance in Feb 2015 only
Chrysene	4	1	0.01	0.04	Marginal exceedance in Feb 2015 only

Determinand	No of tests	No. of exceedances	WRGAC (ug/l)	Max Concentration (ug/l)	Comments
Fluoranthene	4	1	0.1	0.11	Marginal exceedance in Feb 2015 only
Fluorene	4	1	0.01	0.07	Marginal exceedance in Sept 2013 only
Indeno-[1,2,3-Cd]-Pyrene	4	1	0.01	0.03	Marginal exceedance in Feb 2015 only
Phenanthracene	4	3	0.01	0.05	Marginal exceedances in most rounds
Pyrene	4	2	0.01	0.1	Exceedances in last 2 rounds
Total Petroleum Hydrocarbons (TPH) fractions					
TPH Aliphatic	1	1	10	810	Single exceedance
TPH Aromatic	1	1	10	120	Single exceedance
TPH	5	1	10	20.7	Single exceedance
Metals					
Chromium	10	4	10	14.7	Marginal exceedances noted but reduced to under WRGAC in last 5 monitoring rounds.
Mercury	10	1	0.05	0.113	Exceedance noted in last monitoring round
Indicator properties					
Alkalinity	10	10	30	332	Exceedances in all rounds
Ammoniacal Nitrogen	10	1	500	4300	Exceedance in first round then not repeated
Chloride	10	2	250000	437000	2 isolated exceedances
Electrical Conductivity	7	3	1000 uS/cm	2970	Exceedances in last 3 rounds
Turbidity	4	3	1 FTU	1.29	Marginal exceedances
Potassium	9	1	12000	12900	Exceedances in single round

3.3.7 Additionally, a limited number of determinands without WRGAC were detected above LOD. These are 3-Methylphenol (0.24ug/l), 4-Methylphenol (0.9ug/l), Benomyl (0.005ug/l), Bromodichloromethane (1.29ug/l), Carbenzium (0.008ug/l), Carbetamide (0.002ug/l), Chlorodibromomethane (0.94ug/l), Chloroform (1.17ug/l), Cypermethrin ID (0.011ug/l), Diuron (0.0011ug/l) and Total Phenols (9.2ug/l).

3.3.8 Limited testing is available from within the London Clay Formation and top of Lambeth Group from two installations from SR1092 as this installation was only sampled on one occasion soon after drilling in 2009. Exceedances include TPH, Phenanthracene, Alkalinity, Ammoniacal Nitrogen and Electrical Conductivity however the validity of these results is questionable as the well may not have had time to equilibrate. Exceedances are summarised in Table 3.4.

Table 3.4 – SR1092 – LC exceedances

Determinand	No of tests	No. of exceedances	WRGAC	Max Concentration (ug/l)
Alkalinity	2	2	30000	230000
Ammoniacal Nitrogen	2	2	500	1700
Electrical Conductivity	2	2	1000 uS/cm	1320
Phenanthracene	2	1	0.01	0.04
TPH Aliphatic	2	2	10	120
TPH Aromatic	2	2	10	42

3.3.9 Limited testing from the Lambeth Group (SR1089, PR1090 and SR1091) on one occasion each in 2009 indicates exceedances of TPH, Phenenthracene, Pyrene, Ammoniacal Nitrogen, Chemical Oxygen Demand, Chromium, Sulphide, Electrical Conductivity and Alkalinity. However, the date of the testing and the single sampling event means that these results are subject to the same issues as above. Exceedances are summarised in Table 3.5.

Table 3.5 – SR1089, PR1090 and SR1091 – LG exceedances

Determinand	No of tests	No. of exceedances	WRGAC	Max Concentration (ug/l)	Comments
Poly Aromatic Hydrocarbon (PAH) compounds					
Phenanthracene	4	3	0.01	0.07	Marginal exceedances
Pyrene	3	1	0.01	0.06	Marginal exceedance
Total Petroleum Hydrocarbon (TPH) fractions					
TPH Aliphatic	3	3	10	1200	
TPH Aromatic	3	3	10	110	
Metals					
Chromium	3	1	10	11	Marginal exceedance
Indicator properties					
Alkalinity	5	5	30000	260000	Exceedances all rounds
Ammoniacal Nitrogen	4	3	500	3300	
Chemical Oxygen Demand	4	1	125000	350000	
Electrical Conductivity	3	1	1000 uS/cm	1170	
Sulphide	2	1	0.25	600	

3.3.10 Testing of the Thanet Formation is available from one sample from PR1090 from 2009 (subject to the same issues as above) which shows exceedances of TPH,

Ammonia, Alkalinity and Electrical Conductivity. However additional testing from the Thanet Formation is available from SR1089 from 13 occasions from 2009 to 2016. This well demonstrates exceedances of Arsenic, Chromium, Copper, Lead, PAH Compounds, Chloride, Alkalinity, Ammoniacal Nitrogen, Electrical Conductivity, Magnesium, Turbidity, Potassium, Sodium and Sulphate. It should be considered that some of the elevated metal concentrations analysed could be a result of the natural geological composition of the strata. This is a common occurrence in groundwater from the Palaeogene strata of the Thames Basin (BGS, 2010). Exceedances are summarised in Table 3.6.

Table 3.6 – PR1090 and SR1089 – TF Exceedances and trends

Determinand	No of tests	No. of exceedances	WRGAC	Max Concentration (ug/l)
Polyaromatic hydrocarbon compounds				
Benzo[a]Anthracene	7	2	0.01	0.046
Benzo[a]Pyrene	14	8	0.01	0.065
Benzo[b]Fluoranthene	7	2	0.015	0.058
Benzo[g,h,i]Perylene	7	2	0.001	0.04
Benzo[k]Fluoranthene	7	2	0.015	0.03
Chrysene	7	2	0.01	0.043
Fluoranthene	7	1	0.1	0.11
Fluorene	7	1	0.01	0.04
Indeno-[1,2,3-Cd]-Pyrene	7	2	0.01	0.03
Phenanthracene	7	2	0.01	0.06
Pyrene	7	2	0.01	0.1
TPH fractions				
TPH Aliphatic	2	2	10	95
TPH Aromatic	2	2	10	52
TPH	2	2	10	41
Metals				
Arsenic	13	1	10	75.1
Chromium	14	6	10	19
Copper	13	2	6	21
Lead	11	2	7.2	41
Indicator properties				
Alkalinity	14	14	30000	320000
Ammoniacal nitrogen	13	2	500	1400
Chloride	13	6	250000	1300000
Magnesium	14	1	50	57
Sodium	13	6	170000	590000
Sulphate	13	1	250000	262000
Turbidity	8	7	1 FTU	288

Determinand	No of tests	No. of exceedances	WRGAC	Max Concentration (ug/l)
Potassium	12	7	12000	32000
Electrical Conductivity	11	9	1000 uS/cm	3231.9

3.3.11 Additionally, a limited number of determinands without WRGAC were detected above LOD. These are Benomyl (0.031ug/l), Bentazone (0.022ug/l), Carbenzium (0.008ug/l), Carbetamide (0.028ug/l), Clopyralid (0.042ug/l), Coumaphos (0.011ug/l), Cypermethrin ID (0.0064ug/l), Dichlorprop DCPP (0.015ug/l), Diuron (0.029ug/l), Glyphosate (0.003ug/l), Pentachlorophenol (0.088ug/l), Terbutryn (0.005ug/l) and Tetrachloroethene (0.42ug/l).

Conclusion

3.3.12 Generally speaking, there are low levels of Total Petroleum Hydrocarbons in all wells with the exception of SR1091 (LG - LMB) which showed higher concentrations of mid-range aliphatic fractions. The maximum concentration was 1100ug/l for the aliphatic range of C12-C16. However, because there is only a single result collected soon after drilling, it is difficult to provide any further commentary on this result except that the sample may have been adversely affected by drill waters.

3.3.13 Low level PAH impact is noted across all of the sampled boreholes, and from all strata. The maximum concentration, which is considered as an exceedance, is for Acenaphthalene at 0.15ug/l vs. the WRGAC of 0.01ug/l from SR1091 (RTD).

3.3.14 Based on the results, the groundwater (RTD, LG and TF) at the CHEEF site is not identified as significantly contaminated and so no groundwater remediation is identified.

3.4 Ground Gas Risk Assessment

Methodology

3.4.1 There are considered to be two scenarios where ground gas risks need consideration as follows:

a) Risks to construction workers (and potentially adjacent site receptors) during the construction period.

b) Risks to future site users and maintenance workers in the final design.

3.4.2 Gas risk during construction will be dealt with via the control measures outlined in Section 5.

3.4.3 The proposed development will comprise a new foreshore structure which will house the tunnel operational and maintenance infrastructure and also provide an amenity area for members of the public. The finished worksite will be a mix of hardstanding and soft landscaping. The soft landscaping design will also extend

to an area on land known as the Bull Ring so that the landscaping design creates a symmetrical feature.

3.4.4 The commonly accepted gas risk assessment methodology (Wilson and Card Methodology and the National House Building Council (NHBC) Guidance Document (traffic light system)) are not easily applicable in this circumstance.

Results

3.4.5 There is no ground gas data available for the site (which is limited to the terrestrial portion) but the gas generation potential for Made Ground or natural soil (Alluvium) with a low degradable organic content may be anticipated to be very low, based on ground conditions. The level of risk for on site development is very low. Offsite gas results are not considered appropriate to characterise conditions at the site. However ground gas concentrations of offsite wells are reported in Table 3.7 as an indication of the ground gas conditions prevailing in the surrounding area.

Table 3.7 – Ground gas in nearby offsite wells

BH ID	Date	Methane (CH_4) Max	Oxygen (O_2) Max	Carbon dioxide (CO_2) Max	Hydrogen sulphide (H_2S)	Carbon Monoxide (CO)	Flow rate
		(%v/v)	(%v/v)	(%v/v)	(ppm)	(ppm)	(l/hr)
SR1091	**19/08/2009**	1.8	11.9	3.3	1 to <1	4 to <1	-0.1
SR1091	**22/09/2009**	<2	20.7	<0.1	<1	<1	0.1
PR1088A	**02/07/2009**	<0.1	20.8	<0.1	<1	4	0.0
PR1088A	**18/08/2009**	<0.1	21.3	<0.1	<1	3 to <1	0.1
PR1088A	**06/10/2009**	<0.1	20.8	0.1	<1	<1	-0.1

% v/v – percentage volume;
ppm – parts per million;
l/hr – litre/hour

Ground gas measurements for both wells were taken from the shallower (River Terrace Deposits) installations. SR1091 is located less than 100m north west from the site boundary and PR1088A is located approximately 200m north. The ground gas concentrations indicate occurrences of elevated methane (maximum methane reading 1.8%v/v) and slightly elevated concentrations of carbon dioxide, typically less than 5%v/v. Gas flow concentrations are very low or negligible. There are not considered to be significant potential sources of ground gas in the vicinity of the site and the principal source of gas is limited to organic matter within Made Ground and/or Alluvium. It is considered that there is limited opportunity to undertake pre-construction ground gas monitoring simply because the site has yet to be built and it is not feasible to monitor the foreshore. Boreholes are planned to be installed on the embankment and within the cofferdam, but this will be during construction. Gas monitoring may be feasible dependent on the installation requirements and access constraints but the timing and availability of this data cannot be confirmed. It is likely that design requirements in accordance with BS8485:2015 will be adopted with reference to

the CSM and any future data that is able to be collected will be used to confirm the design requirements. It should be noted that potential ground gas receptors are limited to electrical kiosks which will be sited on the new cofferdam portion of the worksite and the cofferdam will be constructed of verified 'clean' materials and so will not represent a ground gas source.

Statistical analysis

3.4.6 Ground gas monitoring was not undertaken at the site.

Conclusion

3.4.7 Ground gas monitoring cannot be undertaken on site due to its foreshore location and site access constraints.

3.4.8 There is no significant ground gas source identified at the site at shallow depth based upon current or historical onsite and surrounding land uses. The risk arising from ground gas is considered very low based on the conceptual model indicating the only significant shallow gas source in the area to be limited to Made Ground and Alluvium with typically low degradable organic matter content. The residual risk of ground gases is expected to be limited to marginally elevated concentrations of methane and carbon dioxide; however the generation potential and hence flow is anticipated to be very low, given the nature of the source. This appears to be consistent with the findings in the offsite ground gas monitoring boreholes as presented in the Preliminary Risk Assessment Report (4602-FLOJV-CHEEF-490-NZ-RG-010001-P03).

3.4.9 It should be noted that potential ground gas receptors are limited to electrical kiosks which will be sited on the new cofferdam portion of the worksite and the cofferdam will be constructed of verified 'clean' materials and so will not represent a ground gas source.

3.4.10 There is a notable ground gas source within the deeper geology within the Lambeth Group (Upnor Formation) which can lead to depleted oxygen levels which poses a risk to tunnelling operations. The Contractor must take special precautions when designing and undertaking excavations within these strata. It is assumed that the pathway created into the deeper geology and therefore the depleted oxygen environment will be temporary during construction and that the shaft construction will effectively seal the pathway, meaning that ground gas receptors at surface will not be at risk.

4 Updated conceptual site model

4.1 Introduction to Conceptual Site Model

4.1.1 A conceptual site model (CSM) describes the interaction between potential contamination sources and relevant environmental features using contaminant linkages. In order for a contaminant linkage to exist, the following must be present:

a. Sources (S) are potential or known contaminant sources e.g. a former fuel storage area.

b. Pathways (P) are environmental systems thorough which a contaminant could migrate, e.g. air, groundwater.

c. Receptors (R) are sensitive environmental receptors that could be adversely affected by a contaminant e.g. site occupiers, groundwater resources.

4.1.2 A CSM was developed as part of the Contaminated Land Risk Assessment report and a copy of the CSM is presented in Table 4.1 at the end of this section. The CSM has been updated to include a series of mitigation measures to break the potential contaminant linkages. Brief descriptions of the mitigation measures are provided in the CSM table and are cross referenced by an ID number to Section 5 where further information is given. Finally, the potential contaminant linkage risk has been reassessed following the adoption of the recommended mitigation measures.

4.1.3 The following sections provide a summary of the potential sources, pathways and receptors.

4.2 Sources

4.2.1 A broad range of contaminants could be associated with the soil and groundwater conditions at the site. Potential contaminants could include heavy metals, PAH, BTEX (benzene, toluene, ethylbenzene and xylenes), TPH, herbicides, insecticides, sulphates, asbestos, soil gas generation and UXO. However, the CHEEF worksite has long remained as part of the River Thames Foreshore with a section on the landward Chelsea Embankment and a small part of Ranelagh Gardens. Sources of contamination are likely to be limited to contaminants within the Made Ground and deposition along the foreshore via the River Thames.

Made Ground

4.2.2 Made Ground was encountered only in the land-based boreholes to a maximum thickness of 3.25m where proven. The description of the Made Ground is fairly typical of fill with some evidence of construction and historical wastes (brick, concrete, pottery, ash, coal etc.).

Alluvium and River Terrace Deposits

4.2.3 Alluvium deposits were encountered in all (five) of the land-based exploratory holes and two (out of three) overwater boreholes. Organic odours are noted in some samples, but are assumed related to natural high organic deposits. Organic (sewage) contamination may be expected close to the outfall.

Lambeth Group

4.2.4 No evidence of contamination has been observed within the Lambeth Group however there has been evidence of pressurised gases and depleted oxygen conditions. It is suspected that the gas predominantly comprises nitrogen formed via oxidation processes in the Upnor Formation. The depleted oxygen conditions in the Lambeth Group are noted to create potentially hazardous conditions for tunnelling.

Groundwater sources

4.2.5 Perched groundwater may be present within the Made Ground but it was not observed.

4.2.6 The shallow aquifer (RTD) is present at an elevation of approximately 99.27 to 100.58mATD. Available chemical testing from SA1091 within the RTD infers some marginal exceedances of a limited number of metals, PAH and TPH compounds in addition to some indicator parameters. On the basis of the available site testing, no significant impact is observed.

4.2.1 The deep aquifer (Thanet Formation) is present at a level of approximately 68.28 to 84.32mATD. Available chemical testing from PR1090 and SR1089 within the TF infers some marginal exceedances of a limited number of metals, PAH and TPH compounds in addition to some indicator parameters. On the basis of the available site testing, no significant impact is observed.

Gas sources

4.2.2 Gas monitoring data is not available for the site due to the access constraints and unique situation whereby the site will be constructed as a new structure within the foreshore of the River Thames.

4.2.3 There are not considered to be significant potential sources of ground gas in the vicinity of the site. The residual risk of ground gases is expected to be limited to marginally elevated concentrations of methane and carbon dioxide; however the generation potential and hence flow is anticipated to be very low given the nature of the source.

4.2.4 Ground gas sources could be associated with Made Ground and fill and these would be assumed to be a residual and degrading source.

4.2.5 Ground gas sources could be associated with organic materials degrading within the Alluvium and River Terrace Deposits with typically low degradable organic matter content.

4.2.6 Ground gas sources could also be associated with chemical conditions at depth within the Lambeth Group.

4.3 Pathways

4.3.1 The following potential pathways have been identified at the CHEEF worksite:

P1_a: On-site human exposure – dermal contact with soils,

P1_b: On-site human exposure – ingestion of soils,

P1_c: On-site human exposure – inhalation of soil dust,

P1_d: On-site human exposure – inhalation of gases,

P1_e: On-site human exposure – inhalation of vapours,

P2a: Off-site migration of soil gases,

P2b: Off-site migration of soil vapours,

P2c: Off-site migration of dust generated by construction activity, for example via windblown dusts or vehicle movements.

P3: Leachate generated from uncovered soil followed by entry into the Upper Aquifer.

P4: Migration of contaminated perched water and groundwater through preferential pathways created by construction activity (including dewatering in the Lambeth Group).

P5: Horizontal and vertical migration of contaminated groundwater via permeable strata.

P6: Construction materials in direct contact with contaminated soil or groundwater.

P7: Detonation of an UXO device.

P8: Soil gases and/or vapour migration via permeable strata and preferential pathways created by construction activity followed by accumulation in confined spaces.

P9: Effluent discharge from construction dewatering.

4.4 Receptors

4.4.1 The following potential receptors have been identified at the CHEEF worksite:

R1: Groundworkers and construction workers associated with the Tideway scheme.

R2a: Adjacent site users – Residents of 23 Embankment Gardens

R2b: Adjacent site users – Residents of Chelsea Court

R2c: Adjacent site users – Public Open Space Users

R3: Future site users (Maintenance workers associated with the Tideway scheme and members of the public).

R4: Groundwater in the Upper Aquifer (Secondary A aquifer).

R5: Surface water in the River Thames.

R6: Groundwater in the Intermediate Aquifer (Secondary A aquifer).

R7: Built environment.

4.5 Potential contaminant linkages

4.5.1 The conceptual site model table below is reproduced from the Contaminated Land Risk Assessment report and has been supplemented with proposed mitigation measures to break the potential linkages and subsequent risk assessment following adoption of these measures. These mitigation measures are further described in Section 5.

4. Updated conceptual site model

Table 4.1 – Conceptual Site Model and Risk Assessment

Source	Pathway	Receptor	Risk before mitigation			Proposed Mitigation	Risk after mitigation		
			Probability	Consequence	Risk		Probability	Consequence	Risk
S1: Contaminants from historical land-use and activity on the site/ S4:Contaminants from current land-use and activity on the site: *Potential contaminants in the Made Ground.*	P1_a: On-site human exposure – dermal contact with soils	R1: Groundworkers and construction workers	Low Likelihood	Medium	Moderate	**Ref. 01, 03, 15, 17, 23 & 26** Adoption of hierarchal health and safety precautions and watching brief as per COCP.	Unlikely	Medium	Low
	P1_b: On-site human exposure – ingestion of soils	R1: Groundworkers and construction workers	Low Likelihood	Medium	Moderate	**Ref. 01, 03, 15, 17, 23 & 26** Adoption of hierarchal health and safety precautions and watching brief as per COCP.	Unlikely	Medium	Low
	P1_c: On-site human exposure – inhalation of soil dust	R1: Groundworkers and construction workers	Low Likelihood	Medium	Moderate	**Ref. 01, 03, 15, 17, 23 & 26** Adoption of hierarchal health and safety precautions and watching brief as per COCP. **Ref. 01, 03, 23 & 26** Inhalation risks to construction workers need to be managed by monitoring and adoption of confined spaces entry and the contractor needs to understand the risk of deoxygenated conditions in deeper geology.	Unlikely	Medium	Low
	P1_d: On-site human exposure – inhalation of gases	R1: Groundworkers and construction workers	Low Likelihood	Medium	Moderate	**Ref. 01, 03, 15, 17, 23 & 26** Adoption of hierarchal health and safety precautions and watching brief as per COCP. **Ref. 01, 03, 23 & 26** Inhalation risks to construction workers need to be managed by monitoring and adoption of confined spaces entry and the contractor needs to understand the risk of deoxygenated conditions in deeper geology.	Unlikely	Medium	Low

4. Updated conceptual site model

	P1_e: On-site human exposure – inhalation of vapours	R1: Groundw orkers and construction w orkers	Low Likelihood	Medium	Moderate	**Ref. 01, 03, 15, 17, 23 & 26** Adoption of hierarchal health and safety precautions and w atching brief as per COCP. **Ref. 01, 03, 23 & 26** Inhalation risks to construction w orkers need to be managed by monitoring and adoption of confined spaces entry and the contractor needs to understand the risk of deoxygenated conditions in deeper geology.	Unlikely	Medium	Low
S1: Contaminants from historical land-use and activity on the site/ S4:Contaminants from current land-use and activity on the site: *Potential contaminants in the Made Ground.*	P1_a: On-site human exposure – dermal contact w ith soils	R3: Maintenance w orkers and future site users	Low Likelihood	Medium	Moderate	**Ref. 01, 03, 14, 18 & 19** In the final design, the development is an artificially created platform w ithin the cofferdam structure w hich w ill be formed of verified clean materials. The final design w ill comprise of hardcover, w hich severely restricts the pathw ay to underlying soils, and of verified imported soft landscaping.	Unlikely	Medium	Low
	P1_b: On-site human exposure – ingestion of soils	R3: Maintenance w orkers and future site users	Low Likelihood	Medium	Moderate	**Ref. 01, 03, 14, 18 & 19** In the final design, the development is an artificially created platform w ithin the cofferdam structure w hich w ill be formed of verified clean materials. The final design w ill comprise of hardcover, w hich severely restricts the pathw ay to underlying soils, and of verified imported soft landscaping.	Unlikely	Medium	Low
	P1_c: On-site human exposure – inhalation of soil dust	R3: Maintenance w orkers and future site users	Low Likelihood	Medium	Moderate	**Ref. 01, 03, 14, 18 & 19** In the final design, the development is an artificially created platform w ithin the cofferdam structure w hich w ill be formed of verified clean materials. The final design w ill comprise of hardcover, w hich severely restricts the pathw ay to underlying soils, and of verified imported soft landscaping.	Unlikely	Medium	Low

	P1_d: On-site human exposure – inhalation of gases	R3: Maintenance w orkers and future site users	Low Likelihood	Medium	Moderate	**Ref. 01, 03, 14, 18 & 19** In the final design, the development is an artificially created platform w ithin the cofferdam structure w hich w ill be formed of verified clean materials. The final design w ill comprise of hardcover, w hich severely restricts the pathw ay to underlying soils, and of verified imported soft landscaping.	Unlikely	Medium	Low
	P1_e: On-site human exposure – inhalation of vapours	R3: Maintenance w orkers and future site users	Low Likelihood	Medium	Moderate	**Ref. 01, 03, 14, 18 & 19** In the final design, the development is an artificially created platform w ithin the cofferdam structure w hich w ill be formed of verified clean materials. The final design w ill comprise of hardcover, w hich severely restricts the pathw ay to underlying soils, and of verified imported soft landscaping.	Unlikely	Medium	Low
S1: Contaminants from historical land-use and activity on the site/ S4:Contaminants from current land-use and activity on the site : *Potential contaminants in the Made Ground.*	P2a: Off-site migration of soil gases and/or vapours	R2: Adjacent site users	Low Likelihood	Medium	Moderate	**Ref. 01, 03, 04, 07, 12 & 17** Risks during the construction stage w ill be mitigated through the use of best industry practice e.g. environmental controls (dust and stockpile management).	Unlikely	Medium	Low
	P2b: Off-site migration of soil vapours	R2: Adjacent site users	Low Likelihood	Medium	Moderate	**Ref. 01, 03, 04, 07, 12 & 17** Risks during the construction stage w ill be mitigated through the use of best industry practice e.g. environmental controls (dust and stockpile management).	Unlikely	Medium	Low
	P2c: Off-site migration of dust generated by construction activity, for example via w indblow n dusts or vehicle	R2: Adjacent site users	Low Likelihood	Medium	Moderate	**Ref. 01, 03, 04, 07, 12 & 17** Risks during the construction stage w ill be mitigated through the use of best industry practice e.g. environmental controls (dust and stockpile management).	Unlikely	Medium	Low

	movements								
S1: Contaminants from historical land-use and activity on the site/ S4:Contaminants from current land-use and activity on the site : P*otential contaminants in the Made Ground.*	P4: Migration of contaminated perched w ater and groundw ater through preferential pathw ays created by construction activity	R5: Surface w ater in the River Thames	Low Likelihood	Medium	Moderate	**Ref. 01, 03, 08, 09, 10, 11 & 12** Surface w ater runoff w ill be controlled throughout construction by appropriate environmental management (bunding, stockpile management etc)	Unlikely	Medium	Low
S1: Contaminants from historical land-use and activity on the site/ S4:Contaminants from current land-use and activity on the site: P*otential contaminants in the Made Ground.*	P3: Leaching of soil contaminants into the Upper Aquifer	R4: Groundw ater in the Upper Aquifer	Low Likelihood	Medium	Moderate	**Ref. 01, 03, 08, 09, 10, 13, 14, 18, 19 & 26** Excavations w ill be of a temporary nature and limited in extent on the landw ard side. A w atching brief w ill be employed in the case that mobile contamination is discovered and suitable additional mitigation measures employed. The importation of fill material w ill require that material is verified as clean and suitable for use and so w ill not represent a new source of potential leachable contamination. This w ill be achieved by setting appropriate import leachate criteria and material testing.	Unlikely	Medium	Low
S1: Contaminants from historical land-use and activity on the site/ S4:Contaminants from current land-use and activity on the site: *Potential contaminants in the Made*	P4: Perched w ater and groundw ater migration created by construction	R4: Groundw ater in the Upper Aquifer	Likely to Low Likelihood	Medium	Moderate	**Ref. 06, 20, 21, 22 & 24** Groundw ater characterisation and groundw orks risk assessments follow ing standard EA guidelines should be undertaken to appropriately plan and manage groundw ork activities. The groundw orks risk assessments w ill be provided to the EA for information. The piling methodology should ensure that piling w ill limit the dow nw ard migration of potential contamination.	Unlikely	Medium	Low

Ground/mobile contaminants in the upper aquifer.									
S1: Contaminants from historical land-use and activity on the site/ S4:Contaminants from current land-use and activity on the site: *Potential contaminants in the Made Ground/mobile contaminants in the upper aquifer*	P4: Migration of contaminated groundwater	R5: Surface water in the River Thames	Low Likelihood	Medium	Moderate	**Ref. 01, 03, 06, 20, 21, 22 & 24** Construction works should incorporate mitigation measures detailed in the CoCP so as not to create additional pathways (e.g. P3 and P4) or influence contaminant migration in the Upper Aquifer.	Unlikely	Medium	Low
S1: Contaminants from historical land-use and activity on the site/ S4:Contaminants from current land-use and activity on the site: *Potential contaminants in the Made Ground/mobile contaminants in the upper aquifer*.	P6: Construction materials in direct contact with subsurface	R7: Built environment	Likely	Mild	Moderate	**Ref. 25** This risk will be mitigated by design. Appropriate characteristion of ground conditions and selection of suitable building materials in accordance with relevant specifications will greatly reduce the risk of deterioration of construction materials (e.g. buried concrete).	Unlikely	Medium	Very low
S1: Contaminants from historical land-use and activity on the site/ S4:Contaminants from current land-use and activity on the site: *Potential*	P9: Effluent discharge from construction dewatering (upper aquifer)	R5: Surface water in the River Thames	Likely	Medium	Moderate	**Ref. 20** Significant dewatering from the upper aquifer is not anticipated but some pumping out of the cofferdam may be required. The specialist dewatering contractor or principal contractor will apply for the appropriate discharge permit if water is to be discharged into the river and apply the necessary	Low Likelihood	Medium	Moderate

contaminants in the Made Ground/mobile contaminants in the upper aquifer.						processes and treatment if required in line with the permit rules. If the discharge cannot meet the agreed limits then alternative disposal will be required e.g. tankered offsite.			
S2a: Soil gases/ S2b: Soil vapours	P1_d: On-site human exposure – inhalation of gases	R3: Maintenance workers and future site users	Low Likelihood	Medium	Moderate	**Ref. 23** In the final development ground gas risk to permanent structures (electrical kiosk) will be reduced by design in accordance with relevant specifications. The shaft and tunnel infrastructure will incorporate ventilation due to the nature of the structure.	Unlikely	Medium	Low
	P1_e: On-site human exposure – inhalation of vapours	R3: Maintenance workers and future site users	Low Likelihood	Medium	Moderate	**Ref. 23** In the final development ground gas risk to permanent structures (electrical kiosk) will be reduced by design in accordance with relevant specifications. The shaft and tunnel infrastructure will incorporate ventilation due to the nature of the structure.	Unlikely	Medium	Low
S2a: Soil gases/ S2b: Soil vapours	P8: Soil vapour and gas migration and accumulation	R2a: Adjacent site users – residents of 23 Embankment Gardens	Low Likelihood	Severe	Moderate	**Ref. 23** In the final development ground gas risk to permanent structures (electrical kiosk) will be reduced by design in accordance with relevant specifications. The shaft and tunnel infrastructure will incorporate ventilation due to the nature of the structure.	Unlikely	Medium	Low
	P8: Soil vapour and gas migration and accumulation	R2b: Adjacent site users – Residents of Chelsea Court	Low Likelihood	Severe	Moderate	**Ref. 23** In the final development ground gas risk to permanent structures (electrical kiosk) will be reduced by design in accordance with relevant specifications. The shaft and tunnel infrastructure will incorporate ventilation due to the nature of the structure.	Unlikely	Medium	Low

	P8: Soil vapour and gas migration and accumulation	R2c: Adjacent site users – Public Open Space Users	Low Likelihood	Severe	Moderate	**Ref. 23** In the final development ground gas risk to permanent structures (electrical kiosk) will be reduced by design in accordance with relevant specifications. The shaft and tunnel infrastructure will incorporate ventilation due to the nature of the structure.	Unlikely	Medium	Low
	P8: Soil vapour and gas migration and accumulation	R7: Built environment	Low Likelihood	Severe	Moderate	**Ref. 23** In the final development ground gas risk to permanent structures (electrical kiosk) will be reduced by design in accordance with relevant specifications. The shaft and tunnel infrastructure will incorporate ventilation due to the nature of the structure.	Unlikely	Severe	Low
S3: Contaminants from historical land-use and activity off-site/ S5: Contaminants from current land-use and activity off-site	P1_a: On-site human exposure – dermal contact with soils	R1: Groundworkers and construction workers	Low Likelihood	Medium	Moderate	**Ref. 01, 03 & 26** There is considered to be little dermal exposure of groundworkers during construction to potentially impacted soil as Personal Protective Equipment will be wore at all time. However the discovery and management of unexpected potentially impacted soils will be dealt with on a case-by-case basis in order to address the specific nature of the ground conditions uncovered.	Unlikely	Medium	Low
	P1_b: On-site human exposure – ingestion of soils	R1: Groundworkers and construction workers	Low Likelihood	Medium	Moderate	**Ref. 01, 03 & 26** There is considered to be little soil ingestion exposure of groundworkers during construction. However the discovery and management of unexpected potentially impacted soils will be dealt with on a case-by-case basis in order to address the specific nature of the ground conditions uncovered.	Unlikely	Medium	Low

	P1_c: On-site human exposure – inhalation of soil dust	R1: Groundw orkers and construction w orkers	Low Likelihood	Medium	Moderate	**Ref. 01, 03, 07 & 26** Risks during construction stage w ill be mitigated through the use of best industry practice e.g. dust monitoring, dust suppression controls etc. w ill be in place to minimize the risk.	Unlikely	Medium	Low
	P1_d: On-site human exposure – inhalation of gases	R1: Groundw orkers and construction w orkers	Low Likelihood	Medium	Moderate	**Ref. 01, 03, 07, 23 & 26** Risks during construction stage w ill be mitigated through the use of best industry practice e.g. air management plan, gas monitoring, etc.	Unlikely	Medium	Low
	P1_e: On-site human – inhalation of vapours	R1: Groundw orkers and construction w orkers	Low Likelihood	Medium	Moderate	**Ref. 01, 03, 21, 22, & 26** Risks during construction stage w ill be mitigated through the use of best industry practice e.g. air management plan, gas monitoring, etc. There is considered to be little exposure of groundw orkers during construction to groundw ater during dew atering activities assuming the groundw ater is mechanically pumped, stored and discharged. Groundw orkers could come into contact w ith shallow groundw ater during river w all or sew er breakout w orks on the landw ard side. This should be mitigated against by assessing the groundw ater quality for acute risks to w orkers (e.g. vapours) and providing appropriate health and safety mitigation, in addition to efficient groundw ater control to limit exposure times.	Unlikely	Medium	Low
S3: Contaminants from historical land-use and activity off-site/ S5: Contaminants from current land-	P1_a: On-site human exposure – dermal contact w ith soils	R3: Maintenance w orkers and future site users	Low Likelihood	Medium	Moderate	**Ref. 01, 03, 14, 18 & 19** In the final design, the development is an artificially created platform w ithin the cofferdam structure w hich w ill be formed of verified clean materials. The final design w ill comprise of hardcover,	Unlikely	Medium	Low

use and activity off-site						which severely restricts the pathway to underlying soils, and of verified imported soft landscaping.			
	P1_b: On-site human exposure – ingestion of soils	R3: Maintenance workers and future site users	Low Likelihood	Medium	Moderate	**Ref. 01, 03, 14, 18 & 19** In the final design, the development is an artificially created platform within the cofferdam structure which will be formed of verified clean materials. The final design will comprise of hardcover, which severely restricts the pathway to underlying soils, and of verified imported soft landscaping.	Unlikely	Medium	Low
	P1_c: On-site human exposure – inhalation of soil dust	R3: Maintenance workers and future site users	Low Likelihood	Medium	Moderate	**Ref. 01, 03, 14, 18 & 19** In the final design, the development is an artificially created platform within the cofferdam structure which will be formed of verified clean materials. The final design will comprise of hardcover, which severely restricts the pathway to underlying soils, and of verified imported soft landscaping.	Unlikely	Medium	Low
	P1_d: On-site human exposure – inhalation of gases	R3: Maintenance workers and future site users	Low Likelihood	Medium	Moderate	**Ref. 01, 03, 14, 18 & 19** In the final design, the development is an artificially created platform within the cofferdam structure which will be formed of verified clean materials. The final design will comprise of hardcover, which severely restricts the pathway to underlying soils, and of verified imported soft landscaping.	Unlikely	Medium	Low
	P1_e: On-site human – inhalation of vapours	R3: Maintenance workers and future site users	Low Likelihood	Medium	Moderate	**Ref. 01, 03, 14, 18 & 19** In the final design, the development is an artificially created platform within the cofferdam structure which will be formed of verified clean materials. The final design will comprise of hardcover, which severely restricts the pathway to underlying soils, and of verified	Unlikely	Medium	Low

						imported soft landscaping.			
S3: Contaminants from historical land-use and activity off-site/ S5: Contaminants from current land-use and activity off-site	P4: Perched water and groundwater migration created by construction	R6: Groundwater in the Intermediate Aquifer	Low Likelihood	Medium	Moderate	**Ref. 06, 20, 21 & 22** Dewatering operations will be adequately designed and controlled, and agreed in advance with the Environment Agency in line with GEMDMS and PW13. Baseline groundwater quality will be defined and monitored during the works to record any changes in groundwater quality. The construction works will not penetrate into the Lower Aquifer.	Unlikely	Medium	Low
S3: Contaminants from historical land-use and activity off-site/ S5: Contaminants from current land-use and activity off-site	P5: Migration of contaminated groundwater	R4: Groundwater in the Upper Aquifer	Likely to Low Likelihood	Medium	Moderate	**Ref. 20 & 26** Natural causes such as tidal influences in the Upper Aquifer or external pumping causing groundwater migration could lead to migration of potential contamination from off-site. If occurring, these would be pre-existing pathways that represent the current baseline of the site. It would be outside the scope of the works to remediate potential off-site sources of contamination but risks to construction workers or other receptors will need to be appropriately considered.	Low Likelihood	Medium	Moderate
S3: Contaminants from historical land-use and activity off-site/ S5: Contaminants from current land-use and activity off-site	P5: Migration of contaminated groundwater	R6: Groundwater in the Intermediate Aquifer	Low Likelihood	Medium	Moderate	**Ref. 20 & 26** Natural causes such as tidal influences in the Upper Aquifer or external pumping causing groundwater migration could lead to migration of potential contamination from off-site. If occurring, these would be pre-existing pathways that represent the current baseline of the site. It would be outside the scope of the works to remediate potential off-site sources of contamination but risks to construction workers or other receptors will need to	Low Likelihood	Medium	Moderate

						be appropriately considered.			
S3: Contaminants from historical land-use and activity off-site/ S5: Contaminants from current land-use and activity off-site	P9: Effluent discharge from construction dewatering	R5: Surface water in the River Thames	Low Likelihood	Medium	Moderate	**Ref. 20** Significant dewatering from the Lambeth Group is not anticipated but some depressurisation may be required. The specialist dewatering contractor or principal contractor will apply for the appropriate discharge permit if water is to be discharged into the river and apply the necessary processes and treatment if required in line with the permit rules. If the discharge cannot meet the agreed limits then alternative disposal will be required e.g. tankered offsite.	Low Likelihood	Medium	Moderate
S6: UXO	P7: Detonation of an UXO device	R1: Groundworkers and construction workers	Likely	Severe	High	**Ref. 16** Potential risks to be mitigated in accordance with specialist advice during all groundworks.	Unlikely	Severe	Low
S6: UXO	P7: Detonation of an UXO device	R2: Adjacent site users	Likely	Severe	High	**Ref. 16** Potential risks to be mitigated in accordance with specialist advice during all groundworks.	Unlikely	Severe	Low
S6: UXO	P7: Detonation of an UXO device	R7: Built environment	Likely	Severe	High	**Ref. 16** Potential risks to be mitigated in accordance with specialist advice during all groundworks.	Unlikely	Severe	Low

Notes:

Reference numbers relate to mitigation measures described in Section 6.

5 Proposed Mitigation Measures

5.1 Remedial approach

5.1.1 On the basis of the preliminary risk assessment, ground investigation results and the nature of the proposed development, no specific pre-construction remedial activities are identified. The risks identified in the CSM can be managed via design measures and controls to be implemented prior to-, during- and post-construction. Therefore it is concluded that a remedial options appraisal is not warranted. Mitigation measures are presented below divided into embedded mitigation measures which are a requirement of the project, as stipulated by planning, and a series of site specific mitigation measures.

5.2 Embedded mitigation measures

5.2.1 The land quality assessment framework for the Tideway project is outlined in section 9 of COCP Part A. It states that where ground investigations reveal the presence of contamination, an appropriate remedial strategy will be developed to identify the most appropriate option for dealing with the presence of contamination (this document).

5.2.2 Land contamination controls in the COCP Part A are listed, and are therefore an inherent part in the delivery of the project and therefore the CHEEF worksite. In accordance with the COCP Part A the Contractor shall provide the following, where appropriate:

- Routine contamination monitoring during site works e.g. odours, unusual staining, oily, tarry or fibrous materials;
- Specialist onsite watching brief for potentially high risk activities and an 'on call' watching brief for all other activities;
- Procedures for dealing with unexpected contamination (specific condition of the DCO);
- Site inductions to include a section on the potential for encountering contaminated materials and the risks posed to workers or others (including offsite receptors via dust generation). Training will be given on the identification of potentially hazardous materials and a clearly defined reporting procedure set up in the event that any suspect substances are encountered;
- All staff and visitors will be made aware of the requirement to adopt the appropriate personal protective equipment, eg, dust masks, respirators, gloves, etc., and also to observe good hygiene practices and avoid hand to mouth contact;
- All staff will be made aware of regulations governing storage, handling, treatment and disposal procedures for all wastes. In particular, material segregation and management of potentially hazardous/harmful materials;
- Occupational monitoring, such as gas or vapour monitoring (either personal or work area) and health surveillance;
- Dust and air/vapour monitoring to check that volatile contamination or construction dusts do not affect off-site receptors. Where appropriate, this will include a combination of onsite and boundary.

5.2.3 It is expected that the Contractor shall confirm the details of these requirements in the construction method statements and other documentation as appropriate and these shall be retained for verification purposes:

5.2.4 In addition, and to support the above requirements, the DCO and other regulations stipulate a number of embedded mitigation measures as summarised in the following table. In some instances the reference document is already available however the majority of these site specific documents are not yet in production due to the design programme having not advanced to the relevant stage. The regulators will have opportunity of viewing these supporting documents as part of either planning or consenting in due course.

Table 5.1 – Embedded Mitigation Measures

Ref.	Document	Summary
01	COCP Part A Doc Ref: **APP205.01** *As per Schedule 3, CHEEF1.*	Project wide health and safety practices are set out including undertaking of a site induction for construction workers that will include a section on the potential for encountering contaminated materials and the associated risks. Training will be given on the identification of potentially hazardous materials and a clearly defined reporting procedure set up in the event that any suspect substances are encountered. All staff and visitors will be instructed to comply with the site health, safety and environmental management plans which will include the consideration of the established hierarchal approach to risk management whereby steps should initially made to determine the feasibility of preventing direct exposure, before otherwise defining a safe system of work etc. Additionally, all construction workers will be required to wear suitable Personal Protective Equipment (PPE) and adopt good site hygiene procedures.
02	COCP B Doc Ref: **APP178.29** *As per Schedule 3, CHEEF1*	Site specific requirements in addition to the COCP Part B. (Nothing additional identified for land contamination.)
03	Construction Environmental Management Plan Doc Ref: **TBC** *As per Schedule 15, Part 2 9) and Schedule 16, Part 3 11) of the DCO and the COCP Part A*	FLO will implement environmental management procedures as documented in the CEMP. The plan includes overarching and site specific management plans. The CEMP will include: - Pollution Incident Response Plan - Air Quality Management Plan - Water Management Plan - Land Quality - Site Waste Management Plan
04	Excavated Materials Plan and Site Waste Management Plan (EMPSWMP) Doc Ref: **TBC**	FLO will produce a Site Waste Management Plan in accordance with the overarching project plan produced by the Employer and waste management policies. The SWMP will document the approach taken to waste hierarchy, handling and storage protocols, waste records, disposal options, waste carrier details and other Duty of

5. Proposed Mitigation Measures

Ref.	Document	Summary
	As per Schedule 3, PW12	Care requirements.
05	Groundwater monitoring for shaft construction Doc Ref: **TBC** *As per Schedule 3, PW13.*	Groundwater and dewatering monitoring and management shall be carried out in accordance with the Groundwater Environmental Management – Dewatering and Monitoring Strategy (GEMDMS-document reference APP141). Any alterations to the strategy shall be submitted to, and agreed by, the Environment Agency.
06	Control of pollution to groundwater/boreholes Doc Ref: **TBC**	Managed as part of CEMP, included within the pollution incident control plan and in accordance with the Environmental Permitting Regulations 2010.
07	Dust and Odour Control Doc Ref: **TBC** *As per Schedule 3, PW7.*	An air management plan, plus supporting site specific plans will be included in the CEMP to cover vehicle and plant emissions, dust emissions, dust control, odours and dust and particulate monitoring requirements.
08	Storage and disposal of excavated material Doc Ref: **TBC**	Managed as part of the SWMP and in accordance with Duty of Care.
09	Spill and leaks Doc Ref: **TBC**	Managed as part of the CEMP as part of the pollution incident control plan. Also required under Part 2 12) of the DCO.
10	Site drainage Doc Ref: **TBC**	Managed as part of the CEMP as part of the pollution incident control plan, control of site drainage during construction and appropriate discharge permits.
11	Protection of watercourses and control of pollution to watercourses Doc Ref: **TBC**	Managed as part of CEMP in association with the Deemed Marine Licence conditions and EA requirements of the DCO.
12	Exporting materials via road/river Doc Ref: **TBC**	Managed by traffic management and control plan in CEMP to contain hazardous materials from affecting offsite receptors.
13	Imported materials Doc Ref: **TBC**	Managed by appropriate sourcing of materials and materials tracking procedures.
14	Landscaping Doc Ref: **TBC** *As per Schedule 3, CHEEF8*	Landscaping proposals will be confirmed with the relevant planning authority prior to the construction of the permanent above-ground structures which will document location, quantity and density of planting, importation of materials, hard surfacing materials and details of existing trees.
15	Unexpected contamination Doc Ref: this document – see Ref. 25. *As per Schedule 3, CHEEF10*	If, in carrying out any works on this site, contamination not previously identified is found to be present, then unless otherwise agreed by the relevant planning authority, no further development or works shall be carried out in the part of the site in which the contamination is identified until a remediation strategy is submitted to and approved by the relevant planning authority in consultation with the Environment Agency. The authorised development shall

Ref.	Document	Summary
		be carried out in accordance with the approved details, unless otherwise approved by the relevant planning authority.
16	UXO Doc Ref: **4000-FLOJV-TTCEN-000-ZA-PQ-100002**	Procedures for UXO mitigation will be documented in the CEMP and a watching brief will be provided as required by the COCP Part A. If recommended by the UXO specialist further mitigation measures will be implemented.

5.3 Site specific mitigation measures

5.3.1 The following sections detail a series of site specific mitigation measures required to address potential contaminant linkages.

Ref. 17 - asbestos mitigation measures

5.3.2 Asbestos has not been detected to date in available testing, however it is a common brownfield contaminant which could be encountered during excavations within Made Ground.

5.3.3 The Contractor is referred to the following guidance documents in relation to works impacted by asbestos:

a. Control of Asbestos Regulations 2012 (SI 2012/2675)
b. Asbestos (Licensing) Regulations 1983 (SI 1983/1649), as amended in 1998 (SI 1998/3233)
c. Asbestos: Exposure Limits and Measurement of Airborne Dust Concentrations (EH10 and MDHS 39/4), 1996. Health and Safety Executive.
d. Asbestos: The survey guide (HSG 264), 2010. Health and Safety Executive
e. CIRIA C765: Asbestos in soil and made ground good practice site guide, 2017. CIRIA.

5.3.4 The Contractor shall employ a watching brief by a suitably qualified person(s) to oversee higher risk activities (such as shallow excavations through Made Ground on the land and foreshore). Risks associated with excavating asbestos impacted soils will be included in the Contractors Risk Assessments and Method Statements.

5.3.5 If asbestos is identified a procedure for dealing with potentially suspect materials exposed requiring sampling and analysis will be produced.

5.3.6 The contractor will undertake specific precautions if materials containing asbestos are present or encountered during works, in order to comply with the Control of Asbestos Regulations 2012, and adhering to relevant guidance, including Asbestos: Exposure Limits and Measurement of Airborne Dust Concentrations (EH10 and MDHS 39/4) and Managing Asbestos in Workplace Buildings 1988.

5.3.7 Specialist measures may be required such as dampening down of excavations, adoption of specialist PPE and RPE, air monitoring, waste segregation and labelling and specialist waste disposal. Works may need to be undertaken by a specialist licenced asbestos contractor if significant quantities of fibrous materials are encountered.

5.3.8 The Contractor must ensure that the HSE is informed if the asbestos is classified as notifiable.

5.3.9 Transport of asbestos containing materials will be undertaken in accordance with Carriage of Dangerous Goods and Use of Transportable Pressure Equipment Regulations 2009 (SI 2009/1348). Disposal of asbestos containing materials to licensed waste sites in accordance with Hazardous Waste (England and Wales) Regulations 2005, as amended (SI 2005/894).

5.3.10 All records to be kept by the Contractor for verification purposes.

Ref. 18 - importation of materials

5.3.11 Before importing materials onto the worksite for temporary or permanent works, the contractor must ensure that the materials do not have the potential to introduce contamination. The materials must also be geotechnically suitable and the specification for geotechnical suitability will be provided elsewhere.

5.3.12 The geo-chemical requirements for imported materials are as follows:

Table 5.2 – Importation Testing Summary

Material	Requirements	Testing Suite	Testing Frequency
General Fill	Non-hazardous by determination in accordance with WM3	See Appendix B	Three samples per new source then one sample every 1000m^3 thereafter
Topsoil	Inert WAC (Total) BS3882:2015 HHSC Open Space	See Appendix B	Three samples per new source then one sample every 20m^3 thereafter

5.3.13 Material should be tested prior to importation by independent testing undertaken by the Contractor and the material tested should be representative of what will be imported. It is not sufficient to rely upon supplier certificates.

5.3.14 Virgin quarried materials may be excluded from chemical testing on the basis that the material is inert but this must be confirmed with the Local Planning Authority.

5.3.15 Imported, recycled aggregates should have proof of origin under the WRAP scheme or similar. Concrete or large grade materials which are not suitable for geo-chemical testing by virtue of their grading size should be visually inspected and be free of contamination (foreign objects, staining etc.) and undergo asbestos screening and PID screening at a suitable frequency dependent upon importation volume and source of material.

5.3.16 Materials laid in the temporary work may be chosen to be re-used in the permanent works. In this case, it should be demonstrated that the materials have not been subject to contamination as a results of the works.

5.3.17 Testing suites and frequencies are to be confirmed prior to construction as the length of the construction period and lag to importation means that statutory requirements may have changed in the interim. Alterations to Import Criteria will be confirmed with the EHO in advance.

5.3.18 If the imported materials are sourced from within London then the Import Criteria could be altered to consider the urban source of the soil and typical background concentrations.

5.3.19 For the interidal terraces, the fill material will need to be more stringent than the general cofferdam fill because this material will be in direct contact with the water environment and so must meet environmental standards protective to aquatic life. Acceptance criteria must be generated and agreed with the EHO in advance of importing material to site for the terraces. Statutory standards are subject to change and so values have not been quoted in this report but should be confirmed at the actual time of import (which could be several years in the future). It is thought likely that the acceptance criteria to be adopted should be the Environmental Quality Standards (EQS) for saltwater.

Ref. 19 - landscaping and capping layer

5.3.20 In the final development there will be a new area of public realm as part of the cofferdam within the river.

5.3.21 Landscaping details will be finalised as the design progresses. Although the cofferdam will be constructed of verified imported fill it is recommended to construct a capping layer in any areas of soft landscaping as an additional barrier.

5.3.22 The capping layer details shall be provided to the EHO for approval at the appropriate design stage. It is expected that the capping layer will comprise of a suitable thickness of topsoil (nominal thickness 300mm), underlain by a geo-membrane and a sub soil layer. The components of the capping layer will be chemically tested to confirm suitability and suitable screening criteria shall be devised prior to importation and agreed with the EHO.

5.3.23 The intertidal terraces are not thought likely to require a capping layer as these areas will not be reached by the public, however this will be confirmed as the design is finalised. Further, the terraces will be inundated by the tide on a daily basis and so a capping layer will not function as intented on these areas of the

cofferdam. Ensuring that the terraces are constructed of 'clean' suitable for use fill is considered to be the most appropriate form of mitigation.

Ref. 20 - licences and consents

5.3.24 The Contractor will be required to apply for various licences and consents to complete the works such as discharge permits and abstraction licences for dewatering.

5.3.25 The specific requirements will be set out by the regulator responsible for granting the licence(s).

5.3.26 The Contractor will provide all necessary risk assessments and documentation to support the applications and shall keep the documents and approvals for verification purposes. Remedial criteria for treated waters or discharge parameters will be provided in these supporting documents.

Ref. 21 – GEMDMS groundwater monitoring

5.3.27 In accordance with the GEMDMS the following boreholes shall be monitored prior to and during construction:

Table 5.3 – GEMDMS Monitoring Summary

BH ID	Strata	Response zone depth (mbgl)	BH Location	Pre-construction monitoring visits to date
SR1091	RTD – sand and gravel	4.00 – 7.10	Off site, on land, in Ranelagh Gardens	10
SR1089	TSF	64.0 – 70.00	Off site, on land, in Ranelagh Gardens	13

5.3.28 No further boreholes are available for monitoring.

5.3.29 The frequency of monitoring is currently on a quarterly basis and will be altered to monthly monitoring in the lead up to construction. Monitoring of groundwater quality is being undertaken using the parameters identified in Table 10 of the GEMDMS Report (developed in consultation with the Environment Agency).

5.3.30 The GEMDMS suite consists of approximately 80 substances (including field parameters, major and minor ions, metals, herbicides, pesticides, Poly-Aromatic Hydrocarbons (PAH), phenols, solvents, urons and pyrethroids). The suite may be altered once the construction materials have been identified (i.e. grouts, tail skins sealant). The project list is not definitive and will routinely be reviewed and updated.

5.3.31 The monitoring results summary shall be reported to the Environment Agency within two months for each round of monitoring.

5.3.32 Dewatering at CHEEF is expected to comprise of depressurisation of the Lambeth Group at an average rate of less than 200m3/d. Site specific

requirements will be confirmed by the specialised dewatering contractor in due course and the details shall be provided to the Environment Agency as part of a dewatering consent.

5.3.33 Any water pumped from the ground via dewatering systems would be discharged to the river or to a Thames Water sewer. Settlement and/or treatment will be applied where necessary. A permit to discharge dewatering water will be obtained in all cases from the Environment Agency. The discharge permit shall set out the testing frequency and discharge limits for abstracted groundwater. It is noted that weekly monitoring of discharge water is required as part of GEMDMS.

5.3.34 It should be noted that the GEMDMS monitoring may continue one year after the construction period has finished. Inclusion of this data in the verification report will depend on timings of construction and planning approvals and will need to confirmed in the future. It is possible that the GEMDMS monitoring data will be presented in a separate report on completion of monitoring.

Ref. 22 – land contamination groundwater monitoring

5.3.35 It is not considered feasible to install groundwater monitoring points on site due to the fact that the majority of the site is located within the River Thames and a small section on the Highway.

5.3.36 Off site there is one available upper aquifer monitoring point – SR1091. It is recognised that a single monitoring point is not ideal for land contamination monitoring purposes because it is difficult to assess variability in the aquifer. A further borehole is proposed by FLO, due to be drilled in mid-summer 2017. The borehole is proposed to be referenced as SR7502 and is proposed to include a shallow installation which can then be included in the groundwater monitoring array.

5.3.37 With respect to the CSM and construction proposals, it is considered that the construction of the cofferdam will create an isolated structure in which groundwater will be sealed. The piles for the cofferdam walls will extend into the London Clay and therefore sever the upper aquifer. In the temporary case groundwater may be able to flow in and out the structure from the landward site but that would mimic current conditions. In the permanent case the cofferdam will be sealed on all sides to allow construction to progress and the residual water inside pumped out and discharged under the conditions of the permit. Therefore the likelihood for the construction works to significantly alter the flow of the upper aquifer is considered to be limited because widescale upper aquifer dewatering is not required.

Ref. 23 - ground gas mitigation

5.3.38 There are no identified ground gas receptors in the final development with the exception of the above ground tunnel maintenance infrastructure.

5.3.39 Below ground tunnel infrastructure has been excluded from this assessment on the basis that ventilation is an embedded design measure associated with the tunnel and shaft.

5.3.40 The cofferdam itself is considered to be a self-ventilated structure and the importation of verified fill should not pose a ground gas risk.

5.3.41 The above ground tunnel maintenance infrastructure design has yet to be finalised however design commensurate to CIRIA C665 Characteristic Situation-2 is recommended and is likely to include a gas resistant membrane and a ventilation layer as a precautionary approach. CS-2 is deemed a suitable risk approach for made ground with a low degradable content (CL:AIRE Research Bulletin 17). Design must be in accordance with BS8485:2015. Design proposals will be sent to the LPA for approval at the appropriate stage of design.

5.3.42 Ground gas risk in the construction phase may come from excavations in the shallow deposits (Made Ground/Alluvium/RTD) and from deeper, deoxygenated deposits in the Lambeth Group. The Contractor must consider ground gas in the method statements and confined spaces entry is recommended. The adoption of suitable RPE may be required. The risk of encountering deoxygenated conditions during tunnelling and excavations in the deeper geology must not be overlooked and is recommended to form the basis of a specific method statement and risk assessment.

Ref. 24 – foundation works risk assessments

5.3.43 Various piling activities will be required as part of the construction. Piling activities include sheet piling for the cofferdam walls and piling for the installation of the permanent works (e.g. interception chamber etc.).

5.3.44 A Foundation Works Risk Assessment will be submitted to the Environment Agency for piling works to assess the risk from each type of activity and propose mitigation measures if required.

5.3.45 The mitigation measures will be documented and records kept for verification purposes.

Ref. 25 – material selection

5.3.46 The selection of construction materials needs to be commensurate with the ground conditions.

5.3.47 For example, it is possible that elevated concentrations of hydrocarbon compounds can react with certain organic compounds used in building materials and services. Corrosive or aggressive ground conditions can impact on buried concrete and plastic water supply pipes (if required). Extremes of pH represent a corrosive risk to materials and also act as an activator to other chemical reactions.

5.3.48 Therefore it is recommended that any new materials used on site be designed accordingly.

5.3.49 Design specifications will be produced in due course which will document the required product specifications. Verification records will be kept by the contractor to demonstrate that the correct materials have been used in construction.

Ref. 26 - unexpected contamination (discovery strategy)

5.3.50 In the case that unexpected contamination is identified then further risk assessments to receptors will be carried out as necessary and reported to the employer, the local authority and the EA. Should unacceptable risks be identified, the contractor shall submit to and agree a revised remediation method statement with the local authority, in consultation with the EA.

5.3.51 The discovery and management of potentially impacted soils should be dealt with on a case-by-case basis in order to address the specific nature of the ground conditions uncovered. A general approach to the discovery strategy is provided below. Visual and olfactory inspection shall be used to identify potentially impacted soils. Following agreement on a plan of action it is likely that a conventional delineation exercise will be used to segregate impacted soil from the surrounding material.

5.3.52 The following general sequence should be adopted for managing suspicious ground conditions (note: an alternative approach may be required for any overwater based contamination):

1) Suspicious ground conditions are identified by groundworker(s) and the affected works are halted;
2) Contractor assesses the requirement for any additional health and safety or environmental management control measures;
3) Control measures, if required, are implemented;
4) Contractor notifies the Contractor's Land Quality Specialist;
5) Contractor's suitably qualified person records the extent of 'contamination' and nature of stratigraphy;
6) Findings are discussed with the Contractor's Land Quality Specialist and a way forward is ascertained e.g. sampling and testing requirements, special measures required during excavation etc.;
7) Contractor's Land Quality Specialist suitably qualified person collects samples and schedules the agreed laboratory analysis;
8) Details of samples collected and tests scheduled are recorded;
9) Contractor's Land Quality Specialist notifies Local Planning Authority and provides a copy of the records;
10) Contractor provides the test results to the Contractor's Land Quality Specialist for review;
11) Remedial action, if necessary, and programming of the works are agreed with the Local Planning Authority;
12) Contractor is informed of the remedial action required;
13) Contractor prepares a Method Statement that details how the agreed remedial action will be carried out;
14) Method Statement is agreed by Contractor's Land Quality Specialist;
15) Works proceed and Contractor's Land Quality Specialist provides a copy of the Method Statement to the Local Planning Authority.
16) Evidence of work carried out is collated for inclusion in the Close Out Report.

5.3.53 The following sequence outlines the approach to be adopted for a conventional delineation exercise:

1) Strip the overlying soil that does not appear to be impacted ('clean') and stockpile separately.

2) Collect 1no. sample from the stockpile. Schedule for analyses to be advised by the Contractor's Land Quality Specialist.

3) Collect 1no. sample from the impacted soil horizon per 25m2 (or part there of). Schedule for analyses to be advised by the Contractor's Land Quality Specialist.

4) Continue the delineation exercise, appropriately separating the impacted soil from the 'clean' soil.

5) Upon exposing 'clean' soil at the extents of the excavation, halt the delineation.

6) From each side of the excavation collect 1no. sample within 1m above the impacted horizon, 1no. sample at the depth of the impacted horizon, and 1no. sample within 1m below depth of impacted horizon. Schedule for analyses to be advised by the Contractor's Land Quality Specialist

7) Across the base of the excavation collect 1no. sample per 25m2 (or part thereof). Schedule for analyses advised by the Contractor's Land Quality Specialist.

8) All results and evidence of the work carried out should be collated for inclusion in the Verification Report.

5.4 Responsibilities and Consultations

5.4.1 The contractor is responsible for collecting and maintaining all records of the remediation works and these will ultimately inform the verification report (Appendix A).

Appendices

Appendix A: Verification Plan

The following section sets out the expected requirements of the CHEEF verification plan. The verification plan is a document that sets out the requirements for gathering data to demonstrate that remediation meets the remediation objectives and remediation criteria and will ultimately inform the verification report at the end of works. This data is referred to as 'Lines of Evidence' and in accordance with CLR11, it includes sampling and testing criteria, and identifies all those records that should be retained to demonstrate compliance with the Remediation Strategy (e.g., field monitoring data, analytical data etc.).

The Lines of Evidence set out below are to be used as guidance only and their requirement will be dependent on actual site conditions encountered during the works.

Lines of Evidence
Ref. 01 – COCP A
Records of briefings/inductions given to staff (representative sample)
Method Statement /Risk Assessments for high risk work – adoption of PPE/RPE (representative sample)
Records of routine contamination monitoring (representative sample)
Record of watching brief – CV and site record of competent person
Ref. 02 - COCP B
- no records currently required
Ref. 03 - CEMP
Copy of CEMP and any alterations made during construction
Ref. 04 - EMPSWMP
Copy of EMPSWMP
A breakdown of all quantities of soils, brick, concrete, tarmac and similar removed from site then crossed referenced to the below
Site names and addresses for all disposal or treatment facilities that accepted waste soil and similar from the site and copies of their environmental permits
A selection and summary of waste consignment notes corresponding to the materials removed from site
Company names and addresses for the waste hauliers and copies of their registration
Chemical laboratory results certificates corresponding to chemical tests carried out on samples of the material removed from site – for waste characterisation purposes
Ref. 05 and 21 - GEMDMS
Copies of GEMDMS monitoring reports including chemical test results
Records of any mitigation measures if required
Records of consultation with regulators
Ref. 06 - Control of pollution to groundwater/boreholes
Copy of pollution incident control plan (in CEMP)
Site records showing implementation
Ref. 07 - Air management plan
Copy of air management plan
Site records of dust monitoring
Copies of interim reporting
Site records of any mitigation measures employed
Ref. 08 - Storage and disposal of excavated material
As per Ref. 04.
Photographs showing waste segregation, waste storage and waste disposal on site

Ref. 09 - Spills and leaks
See Ref. 01 and 06
Site photographs of spill kits, drip trays, plant nappy's etc.
Incident reporting of any spills and the measure undertaken to rectify the problem
Ref. 10 - Site drainage
- See Ref. 01 and 06
Site photographs showing protection of edges, drains, control of runoff
Ref. 11 - Protection of watercourses and control of pollution to watercourses
- See ref. 01
Ref. 12 - Exporting materials via road/river
Copy of traffic management and control plan
Site photographs showing waste consignments
Ref. 13 - Imported materials
- See Ref. 18
Ref 14 - Landscaping
- See Ref. 18 and 19
Ref 15 – Unexpected contamination
- See Ref. 26
Ref. 16 - UXO
CV and site attendance records for UXO supervisor engineer
Site records
Sign off/completion report of areas of the site or specific works
Ref. 17 - Asbestos
Records from the asbestos specialist to summarise control measures undertaken
Evidence to demonstrate that the Discovery Strategy was employed where asbestos was suspected
Evidence of dust suppression controls minimise risk of airborne fibres (photographs, records)
Air-borne asbestos monitoring results
Evidence that asbestos containing soils were appropriately segregated from other soils
Evidence that decontamination facilities made available on the site for personnel (if applicable)
Evidence of appropriate disposal of asbestos wastes to licenced facilities
Copy of method statement for works involving asbestos containing material and infrastructure
Ref. 18 - Importation of materials
Name(s) and address(es) of soil supplier(s)
Quantity of imported soil
Chemical laboratory results for chemical tests carried out on samples of the material imported to site – these should be those carried out by the contractor not the supplier
Waste provenance certificates e.g. WRAP or similar
Ref. 19 – landscaping and capping layer
Copy of landscaping proposals
Scaled photographs showing thickness and composition of capping layers
Chemical certificates to prove quality of imported materials

Ref 20. – licences and consents
Copies of granted licences/consents
Copies of monitoring/testing required to satisfy licences/consents
Records of consultation with regulators
Ref 21. – GEMDMS groundwater monitoring
See Ref 5.
Ref. 22 – land contamination groundwater monitoring
- no records currently required
Ref. 23 – Ground gas mitigation
Copies of design specification
EHO design approval
Records of the product used – e.g. delivery tickets, purchase orders etc.
Photographs taken during installation
Records of sign off by building control
Ref. 24 – foundation works risk assessment
Copies of accepted FWRA(s)
Monitoring associated with FWRA, if required
Records of consultation with regulators
Ref. 25 – material selection
Copy of the specification corresponding to buried concrete
Results of any sulphate testing undertaken to confirm BRE SD1
Evidence to demonstrate the concrete used conformed to the specification
Records of the product used – e.g. delivery tickets, purchase orders etc.
Ref. 26 - unexpected contamination (discovery strategy)
Name and address of the company employed to carry out the watching brief for contamination as part of the Inspection and Discovery Strategy (Section 5.6)
CV for the Engineer/Scientist that attended site
Copies of any reports prepared by that company in relation to soil contamination
Plan(s) showing the vertical and horizontal extent of the contamination
Laboratory test certificates corresponding to the material and extent of excavation
Plan showing the sampling location and sampling depth for each sample collected
Copies of Engineer's field notes and photographs of contamination encountered
Copy of Method Statement
General
Provide a completed record of soil tracker to demonstrate earthworks movements
Topographical plan of site before earthworks and after completion of earthworks
A sample of photographs showing the earthworks being carried out and areas completed
Completed record of soil tracking spreadsheet
Plan showing the location and extents of all buried obstructions encountered and then removed for the purpose of the development plus a sample of photographs showing them
Plan showing the delineation of the cut and fill exercise plus total quantity of cut and fill
Plan delineating soil derived from the site and soil imported to site
Topographical plan showing final ground levels
Plan showing all sampling locations, stockpile locations and sampling depths

Appendices

Misc.
Development layout drawing in .dwg (CAD) format
Copies of any correspondence with the Local Planning Authority or Environment Agency on managing land contamination or environmental protection
Copies of any discharge consents, permits or similar obtained in order to carry out the development
Plan showing the location and approximate extent of soil stockpiles – topsoil, subsoil, contaminated soil – plus any photographs
All photographs annotated and accompanied by site plans showing each vantage point
Quantities of all materials retained, removed and imported are recorded in cubic metres
All measurements are recorded in SI units with vertical extents of excavations recorded in “metres below original ground level” and “metres above Ordnance Datum”
All drawings have a north arrow and where possible are drawn to scale

Appendix B: Acceptance Criteria

Topsoil and materials placed between ground level and 1mbgl below finished surface level in permanent design*

Analyte	Threshold Concentration (mg/kg unless stated) [1]	Source
Metals		
Arsenic (Inorganic)	170	2
Beryllium	63	2
Boron	46000	2
Cadmium	530	2
Chromium III	33000	2
Chromium VI	220	2
Copper	44000	2
Lead	1300	3
Mercury	25	2
Nickel	800	2
Selenium	1800	2
Vanadium	5000	2
Zinc	170000	2
Petroleum Hydrocarbons (TPH)		
BTEX (Sum) [7]	6	4
TPH (Sum of C10-C40)	500	4
Polyaromatic Hydrocarbons (PAH)		
Benz[a]anthracene	61	2
Benzo[a]pyrene	4.8	2
Benzo[b]fluoranthene	17	2
Dibenz[ah]anthracene	1.4	2
Total PAH (Sum of 17) [8]	100	4
Phenols		
Phenol	620	2

Analyte	Threshold Concentration (mg/kg unless stated) [1]	Source
Others		
pH, pH units	5.5 to 8.5	5
Asbestos	Not detected	2
VOCs	Not detected	2
Total cyanide	Not detected	2
Sulphate (2:1 water/soil extract), mg/l	500	6
Topsoil Specific [9]		
Total nitrogen, % m/m	>0.15	5
Extractable phosphate, mg/l	16 to 140	5
Extractable potassium, mg/l	121 to 1500	5
Extractable magnesium, mg/l	51 to 600	5
Zinc (nitric acid extractable)	200	5
Copper (nitric acid extractable)	135	5
Nickel (nitric acid extractable)	75	5

1. Threshold concentrations for topsoil are based on a park-type public open space and a SOM content of 2.5% on the basis that the lower bound SOM content for multipurpose topsoil in BS 3882:2015 is 3%, unless otherwise stated.
2. Threshold concentrations derived by AECOM and are fully aligned with the "Suitable for Use" (S4UL) criteria issued by LQM/CIEH except a sandy soil rather than a less conservative sandy loam soil has been assumed.
3. Threshold concentrations for lead are the published Category 4 Screening Level (C4SL) published by Defra.
4. Threshold concentrations are Inert Waste Acceptance Criteria (WAC) taken from Council Decision annex 2003/33/EC.
5. Threshold concentrations are required characteristic for multipurpose topsoil taken from BS 3882:2015 and assume a soil pH in the range 6.0 to 7.0.
6. Threshold concentration is for Design Sulphate Class DS1 taken from BRE SD1.
7. BTEX (Sum) is the total of concentrations for benzene, toluene, ethyl benzene and xylenes (m-, o- and p-).
8. Total PAH (Sum of 17) is USEPA 16 PAH plus coronene.
9. Topsoil to be compliant with British Standard BS:3882:2015 Specification for Topsoil

*Topsoil acceptance criteria are given for guidance. Acceptance criteria are to be confirmed prior to importation, taking into consideration any changes to legislation between issue of this document and importation.

General Fill Acceptance Criteria

Materials used for general cofferdam fill must not possess any hazardous properties by way of assessment in accordance with WM3 (or the prevailing literature at the time of importation). In order for hazard characterisation to be undertaken the materials must be tested for the following list of determinands:

- arsenic, cadmium, chromium III, chromium VI, lead, mercury, selenium, vanadium, copper, nickel, zinc, antimony, barium, boron (water soluble), magnesium, beryllium, cyanide (total and free), sulphide (acid soluble), speciated polycyclic aromatic hydrocarbons (PAH), total petroleum hydrocarbons (TPHCWG (inc. BTEX)), organic matter, soluble sulphate, nitrate, speciated phenols, VOC, sVOC, PCBs and pH.
- Asbestos

The soil results are to be analysed by a recognised waste assessment tool and confirmed that the materials are non-hazardous. Therefore specific values have not been provided as acceptance thresholds could depend upon the interaction of different chemicals.

The following threshold limits must also not be exceeded:

Analyte	Threshold concentration (mg/kg unless otherwise stated)	Notes
BTEX	6	1
PCBs (7 cogeners)	1	1
TPH (C10-40)	500	1
PAH's	100	1
Asbestos	No Asbestos Containing Materials 0.001% w/w fibres	2
VOC and SVOC's	<Limit of Detection	3

Notes:
1. Threshold Concentrations compliant with solid inert WAC limits
2. Adopted human health threshold concentration for asbestos fibres
3. Materials shall not contain any volatile determinands

In addition, all imported materials must be visually inspected and verified that they do not contain any of the following:

- Fuel and oil contamination, including the presence of free phase hydrocarbon product;
- Tar and tarry wastes;
- Wastes that may pose an acute risk to construction workers and adjacent site users;
- Putrescible waste materials;
- Suspected ordnance;
- Ash, clinker, bricks and other indicators of made ground such as glass or other sharps;
- Asbestos containing materials (ACM); and
- Other visually or olfactory impacted material, including contaminated liquids or sludge.

Appendices

Additional acceptance criteria will be provided within the Geotechnical Earthworks Specification and must be complied with.