Thames Tideway Tunnel
Thames Water Utilities Limited

Development Consent Order

Application Reference Number: WWO10001

Documents for Certification
September 2014

We, Lindsay Speed and Sarah Fairbrother hereby certify that this is a true copy of the environmental statement referred to in Article 61 (1) (f) of the Thames Water Utilities Limited (Thames Tideway Tunnel) Order 2014.

Lindsay Speed

Sarah Fairbrother

September 2014

Thames Tideway Tunnel

Creating a cleaner, healthier River Thames

Thames Tideway Tunnel
Thames Water Utilities Limited

Application for Development Consent

Application Reference Number: WWO10001

Environmental Statement

Doc Ref: **6.2.18**

Volume 18 Blackfriars Bridge Foreshore appendices

APFP Regulations 2009: Regulation **5(2)(a)**

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Appendix A: Introduction

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Appendix A: Introduction

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Appendix A: Introduction

A.1 Summary

A.1.1 This document presents the appendices that accompany the *Environmental Statement* Volume 18 Blackfriars Bridge Foreshore site assessment.

A.1.2 Figures associated with the appendices are provided within a separate volume of figures.

A.1.3 For consistency and ease of use Volumes 3 to 27 of the *Environmental Statement* all utilise the same appendices contents and labelling protocol. For these volumes the appendices are as follows:

a. Appendix A: Introduction
b. Appendix B: Air quality and odour
c. Appendix C: Ecology – aquatic
d. Appendix D: Ecology – terrestrial
e. Appendix E: Historic environment
f. Appendix F: Land quality
g. Appendix G: Noise and vibration
h. Appendix H: Socio-economics
i. Appendix I: Townscape and visual
j. Appendix J: Transport
k. Appendix K: Water resources – groundwater
l. Appendix L: Water resources – surface water
m. Appendix M: Water resources – flood risk
n. Appendix N: Development schedule.

A.1.4 Where a topic has not been assessed the associated appendix does not include any supporting information. Also, if a topic has been assessed but does not need to present any supporting information then the appendix is intentionally empty.

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Appendix B: Air quality and odour

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Appendix B: Air quality and odour

B.1 Model verification

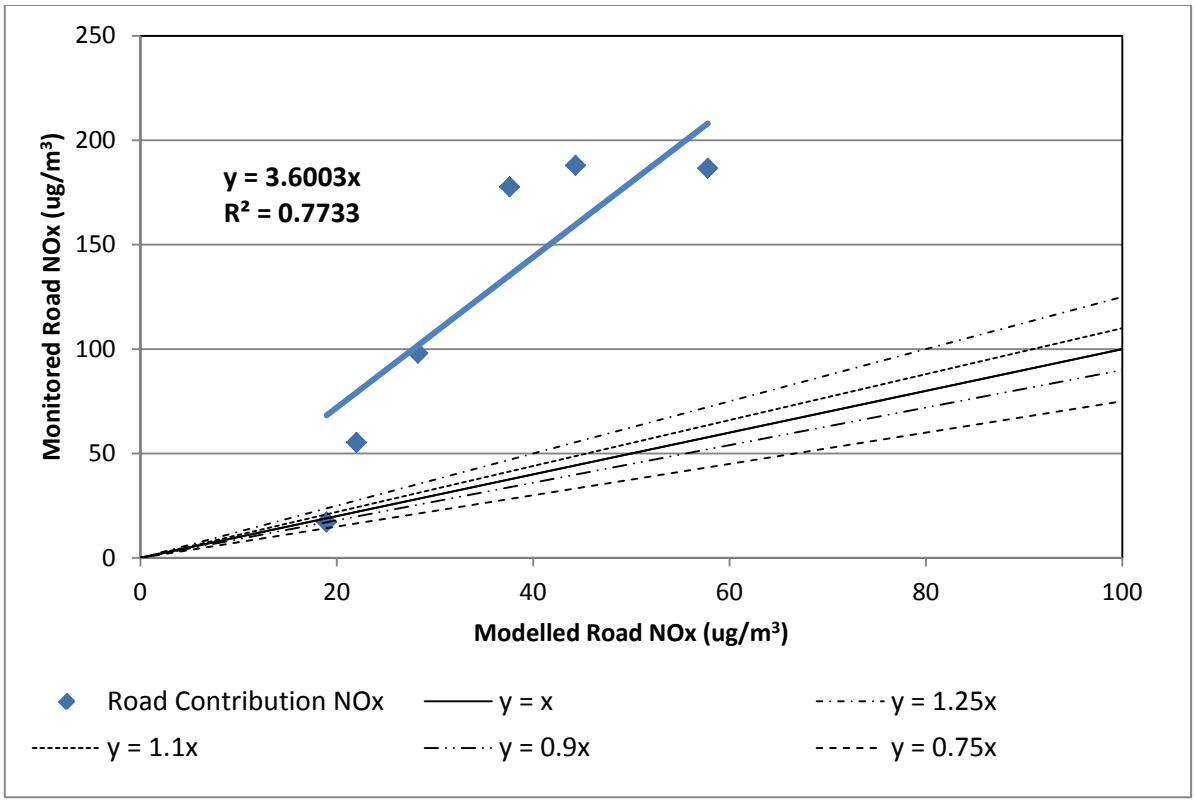
B.1.1 Modelled NO_2 concentrations have been plotted against monitored concentrations at the five diffusion tube (BBFM1-BBFM4, CL38) and one continuous analyser (CT1) sites shown in Vol 18 Figure 4.4.1 (see separate volume of figures).

B.1.2 This showed that the modelled results underestimated NO_2 concentrations by between -3% and 37%. As the model has been optimised and no further improvement of the model was considered feasible (such as reducing vehicle speeds or using different pollutant backgrounds, etc), a model adjustment factor was therefore deemed necessary.

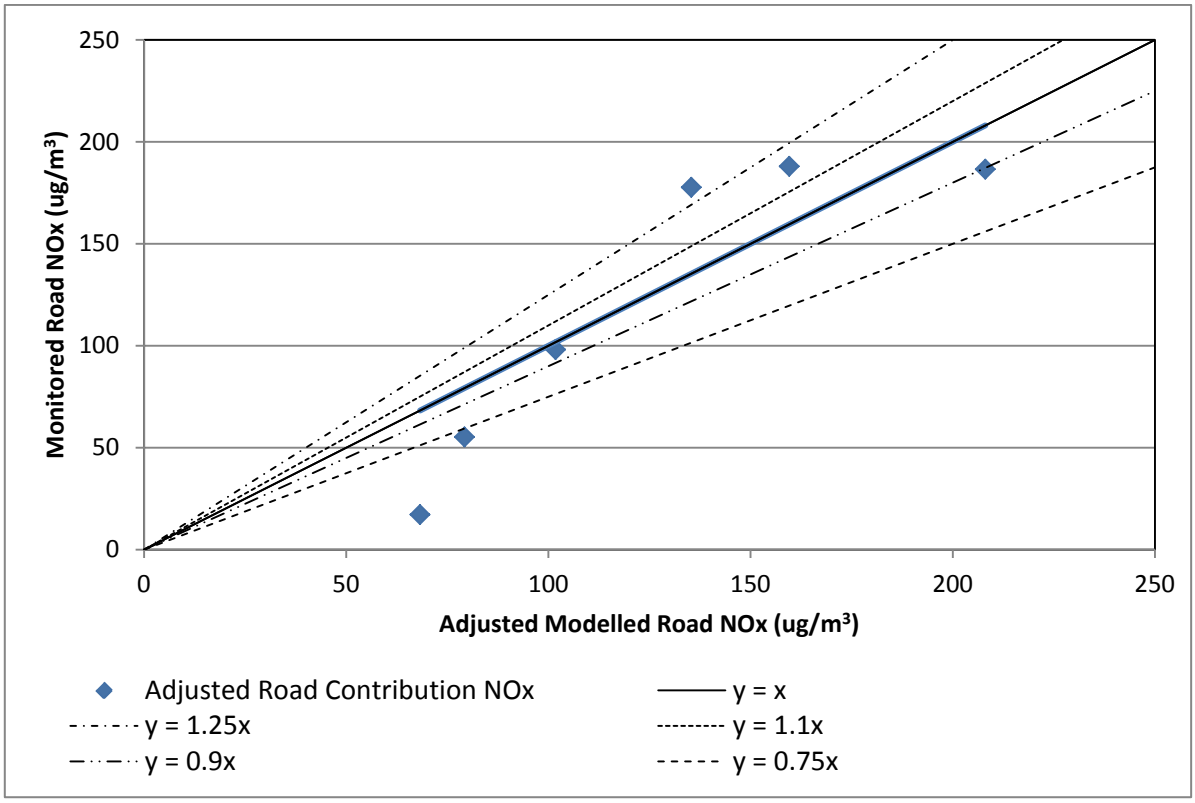
B.1.3 To derive the adjustment factor, modelled road NO_X concentrations were plotted against calculated monitored road NO_X concentrations - see Vol 18 Plate B.1 below. An adjustment factor of 3.60 was calculated to adjust modelled roadside NO_X concentrations, in accordance with LAQM.TG(09)[1] and was subsequently applied – see Vol 18 Plate B.1. This factor was also applied to the PM_{10} results as the PM_{10} monitoring sites were more than 1km away from the site and traffic data were not available, so model verification could not be carried out.

B.1.4 Applying the NO_X adjustment factor and then calculating NO_2 concentrations, as shown in Vol 18 Plate B.2, provides better overall agreement between actual and predicted data. The subsequent linear regression calculation for monitored versus modelled total NO_2, as shown in Vol 18 Plate B.3, indicated that four of the six modelled concentrations were within 10% of the measured value and that the other one was within 25% of the modelled value.

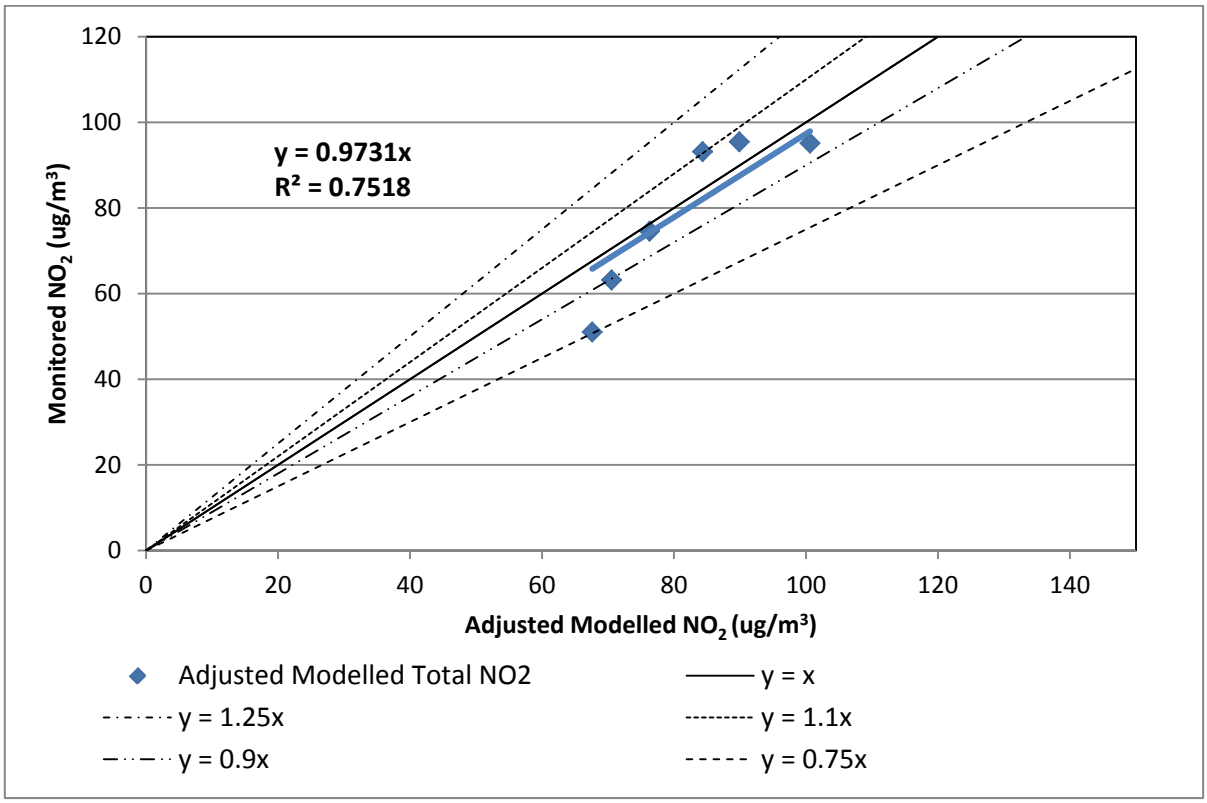
Vol 18 Plate B.1 Air quality - monitored road NO_X vs. modelled road NO_X



Vol 18 Plate B.2 Air quality – monitored road NO_X vs. adjusted modelled road NO_X



Vol 18 Plate B.3 Air quality – total monitored NO_2 vs. total adjusted modelled NO_2



B.2 Traffic data

B.2.1 The traffic data used in the air quality modelling for the Blackfriars Bridge Foreshore site are shown in Vol 18 Table B.1.

Vol 18 Table B.1 Air quality - traffic data used model inputs

Source	Road link	2010 baseline AADT*	Baseline % HGV >3.5t	Speed limit (mph)	Model input speed (mph)	Growth factor % (2009 - 2018)	Peak const-ruction year AADT	Peak construction year AADT scheme construction HGV (HGV >3.5t)	Peak construction year development case (total AADT)	Peak construct-ion year develop-ment case AADT % HGV (>3.5t)
ATC** 'Indirect'	Victoria Embankment West	101544	5.6	30	27.0	8.0	109665	24	109689	5.7
ATC** 'Indirect'	Victoria Embankment Central	37910	8.3	30	27.0	8.0	40942	24	40970	8.4
ATC** 'direct'	Victoria Embankment East	8065	15.0	30	27.0	8.0	8710	0	8710	15.0
ATC** 'direct'	Victoria Embankment Northeast	7700	14.4	30	24.4	8.0	8316	0	8316	14.4
ATC** 'Indirect'	Upper Thames Street West	37910	8.3	30	27.0	8.0	40942	24	40970	8.4
TfL Model	White Lion Hill	7320	5.0	30	17.1	8.0	7905	0	7905	5.0

Source	Road link	2010 baseline AADT*	Baseline % HGV >3.5t	Speed limit (mph)	Model input speed (mph)	Growth factor % (2009 - 2018)	Peak const-ruction year AADT	Peak construction year AADT scheme construction HGV (HGV >3.5t)	Peak construction year development case (total AADT)	Peak construct-ion year develop-ment case AADT % HGV (>3.5t)
TfL Model	New Bridge Street	50874	5.8	30	13.0	8.0	54943	2	54949	5.8
TfL Model	New Bridge Street North	52642	5.8	30	13.7	8.0	56852	2	56865	5.8
TfL Model	Puddle Dock	19336	7.1	30	16.2	8.0	20883	0	20883	7.1
ATC** 'Indirect'	Upper Thames Street East	37605	9.4	30	27.0	8.0	40612	24	40640	9.4
TfL Model	Blackfriars Bridge	39792	8.2	30	9.5	8.0	42975	2	42980	8.2
TfL Model	A201 West	45289	9.8	30	13.8	8.0	48911	2	48917	9.8
TfL Model	A201 North	11945	11.4	30	16.7	8.0	12901	0	12901	11.4

** AADT – annual average daily traffic. ATC – automatic traffic counter.*

B.3 River tug emission factors

B.3.1 Emissions of NO_X and PM_{10} from tugs pulling the barges were calculated using the data shown in Vol 18 Table B.2 for the Blackfriars Bridge Foreshore site.

Vol 18 Table B.2 Air quality - tug assessment model inputs

Parameter	Value	Units
Total tugs	48	Tugs/year
Time per tug*	20	minutes
NO_X base emission factor	10.2	g/kWhr
PM_{10} base emission factor	0.9	g/kWhr
Average tug engine size	984	kW
Manoeuvring and hotelling** load factor	0.2	No units
Total tug area***	3000	m^2
NO_X emissions per tug	1.9×10^{-04}	$g/s/m^2$
PM_{10} emissions per tug	1.6×10^{-05}	$g/s/m^2$

* Time that tug is at the site.
** Hotelling refers to when the tug is securely moored or anchored.
*** Area of the mooring and manoeuvring of tugs.

B.4 Construction plant emission factors

B.4.1 For the purpose of the assessment, the following listed equipment in Vol 18 Table B.3 has been modelled for the peak construction year at the Blackfriars Bridge Foreshore site.

Vol 18 Table B.3 Air quality - construction plant assessment model inputs

Construction activity	Typical location	Typical plant	Unit No(s)	% on-time	Power (kW)	NO_X emission rate ($g/s/m^2$)	PM_{10} emission rate ($g/s/m^2$)
Site set up and general site	Ground level behind hoarding	Compressor 250cfm*	1	50	104	9.5×10^{-08}	5.9×10^{-09}
	Ground level behind hoarding	Generator - 200kVA	1	100	160	2.9×10^{-07}	1.8×10^{-08}
	Ground level behind hoarding	JCB with hydraulic breaker	1	50	67	6.1×10^{-08}	3.8×10^{-09}
	Ground level behind hoarding	Cutting equipment (diamond saw)	2	10	2.3	2.1×10^{-09}	4.6×10^{-09}
	Ground level behind hoarding	Telescopic handler / FLT**	1	30	60	3.3×10^{-08}	2.0×10^{-09}
	Ground level behind hoarding	Hiab*** lorry/crane	1	5	56	5.1×10^{-09}	3.2×10^{-10}
Demolition	Ground level behind hoarding	Service crane 25t mobile crane	1	30	275	1.5×10^{-07}	9.4×10^{-09}
	Ground level behind hoarding	22t excavator with hydraulic hammer	1	30	122	6.7×10^{-08}	4.2×10^{-09}
	Ground level behind hoarding	Site dumper	1	30	81	4.4×10^{-08}	2.8×10^{-09}

Construction activity	Typical location	Typical plant	Unit No(s)	% on-time	Power (kW)	NO_X emission rate ($g/s/m^2$)	PM_{10} emission rate ($g/s/m^2$)
	Ground level behind hoarding	Vibrating rollers	2	50	145	2.6×10^{-07}	1.6×10^{-08}
Cofferdam construction	Ground level behind hoarding	400cfm* compressor	2	50	104	1.6×10^{-07}	1.0×10^{-08}
	Ground level behind hoarding	150t crawler crane	1	60	240	1.8×10^{-07}	1.1×10^{-08}
	Ground level behind hoarding	Generator	1	100	28	2.8×10^{-09}	6.1×10^{-09}
	Ground level behind hoarding	Jack-up barge	1	100	104	2.6×10^{-07}	1.6×10^{-08}
	Ground level behind hoarding	Secant pile rig	1	60	150	8.2×10^{-07}	5.1×10^{-08}
	Ground level behind hoarding	25t excavator	1	80	125	8.2×10^{-07}	5.1×10^{-08}
	Ground level behind hoarding	Plate compactors	2	10	3	1.6×10^{-07}	1.0×10^{-08}
	Ground level behind hoarding	Vibrating rollers	2	50	145	1.8×10^{-07}	1.1×10^{-08}
Diaphragm wall	Ground level behind hoarding	Diaphragm wall rig (grab)	1	20	250	9.1×10^{-08}	5.7×10^{-09}
	Ground level behind hoarding	Diaphragm wall rig (hydrofraise)	1	80	250	3.6×10^{-07}	2.3×10^{-08}
	Ground level	Concrete deliveries	1	20	223	8.1×10^{-08}	5.1×10^{-09}

Construction activity	Typical location	Typical plant	Unit No(s)	% on-time	Power (kW)	NO_X emission rate ($g/s/m^2$)	PM_{10} emission rate ($g/s/m^2$)
	behind hoarding	(discharging)					
	Ground level behind hoarding	Concrete pump	1	20	223	8.1×10^{-08}	5.1×10^{-09}
	Ground level behind hoarding	Compressor 400cfm*	1	50	104	9.5×10^{-08}	5.9×10^{-09}
	Ground level behind hoarding	Dumper	1	50	81	7.4×10^{-08}	4.6×10^{-09}
	Ground level behind hoarding	150t crawler crane	2	50	240	4.4×10^{-07}	2.7×10^{-08}

*Note: For the purposes of this assessment, the above listed equipment has been modelled for the peak construction year. The data assumes a 10 hour working day. This schedule provides an illustration of typical plant that could be used in the construction of the Thames Tideway Tunnel at this site. The appointed Contractor must comply with section 6 of the CoCP but may vary the method and plant to be used. This schedule therefore represents the most reasonable assumption for the assessment that can be made at this stage. * cfm – cubic feet per minute. ** FLT – fork lift truck. ***Hiab – loader crane.*

References

[1] Defra, *Local Air Quality Management - Technical Guidance, LAQM.TG(09)* (2009).

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Appendix C: Ecology - aquatic

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Appendix C: Ecology - aquatic

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Appendix C: Ecology - aquatic

C.1 Introduction

C.1.1 Construction and operational effects assessments at this site for this topic do not require the provision of any supporting information, so this appendix is intentionally empty.

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Appendix D: Ecology - terrestrial

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Appendix D: Ecology - terrestrial

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Appendix D: Ecology - terrestrial

D.1 Introduction

D.1.1 Construction and operational effects assessments at this site have not been undertaken so this appendix contains no supporting information.

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Appendix E: Historic environment

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Appendix E: Historic environment

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Appendix E: Historic environment

E.1 Gazetteer of known heritage assets

E.1.1 Details of known heritage assets within the assessment area are provided in Vol 18 Table E.1 below, with their location shown on the historic environment features map (Vol 18 Figure 7.4.1, see separate volume of figures).

E.1.2 All known heritage assets within the assessment area are referred to by a historic environment assessment (HEA) number. Assets within the site are referred to (and labelled in the historic environment features map) with the prefix 1, eg, **HEA 1A**, **1B**, **1C**. References to assets outside the site but within the assessment area begin with **2** and continue onwards, eg, **HEA 3**, **4**, **5**.

Vol 18 Table E.1 Historic environment – gazetteer of known heritage assets within the site and assessment area

HEA Ref no.	Description	Site code/ GLHER ref/ List entry number
1A	Victoria Embankment Wall. Grade II listed. The wall is dated to the 19th century, with cast iron lamp standards.	199801
1B	Blackfriars Wreck 1, Blackfriars Underpass, Puddle Dock. During construction work carried out as part of the Blackfriars Bridgehead Improvement Scheme, in September 1962, substantial remains of a north-south aligned Roman ship wreck were exposed by a mechanical grab whilst holes were being dug into the foreshore for the construction of a temporary gantry. The wreck lay approximately mid-way between Blackfriars Road Bridge and the old railway bridge, c. 18m to the south of the old Embankment wall. Initially, two phases of excavation were carried out by the Guildhall Museum (GM) and the Corporation of London at low tide (October–November 1962). A section of the northern part of the wreck was exposed and recorded, In July 1963, a cofferdam, proposed as part of the construction works, was built across the southern section of the wreck (effectively cutting through it, with a small section of the bow left lying outside the cofferdam). Once the cofferdam had been constructed, it was possible to expose and record most of the southern part of the wreck. The wreck was discovered immediately to the east of the ancient mouth of the Fleet. The ship was carvel-built (ie, using wooden planks lying edge	GM182 040030

HEA Ref no.	Description	Site code/ GLHER ref/ List entry number
	to edge) and its bottom was almost flat, indicating that it was probably a barge. Part of the ship's cargo of Kentish ragstone was discovered, along with a millstone, lying at the bottom of the ship. A bronze coin of Domitian (AD 81–96) was discovered in the recess of the mast-step, placed beneath the mast, to bring good luck to the vessel, and so dates its construction. The barge is believed to have sunk whilst carrying a cargo of Kentish ragstone stone quarried near Maidstone to London via the Medway in c. AD 150. Almost all stone buildings in Roman London were constructed of Kentish ragstone.	
1C	The President ship, Thames Channel. Built in 1917. Served as a Royal Navy convoy escort vessel in the First World War disguised as a merchant ship, with hidden anti-U boat weapons. It has been moored at the Victoria Embankment since 1922.	National Historic Ship Cert. No. 494
1D	Thames Channel, opposite Victoria Embankment. The remains of a post-medieval timber and iron jetty identified as part of a TDP survey in the 1990s. This was subsequently removed to allow for the construction of the Millennium Pier in 2000.	FCY05
1E	Thames Channel, opposite Victoria Embankment. The remains of a post-medieval hand crane attached to a jetty (**HEA 1D**) identified as part of a TDP survey in the 1990s. This was subsequently removed to allow for the construction of the Millennium Pier in 2000.	FCY05
1F	Site of the Fleet Canal, Farringdon Street. The site of the former Fleet Canal where it joined the Thames, dating to the later 17th century. Cast Iron outfall gates which are probably contemporary with Bazalgette's Blackfriars Bridge are located beneath the bridgehead.	041670 MLO 22550
1G	Thames Channel 20th century brick built building at the eastern end of the Millennium Pier. Former fire pump house used during World War II.	---
1H	Thames foreshore Findspot of a late Neolithic-Bronze Age sword, found by chance in the mid 20th century, possibly earlier.	MLO100193
1I	Blackfriars Bridge. Grade II listed. Bridge built in 1869, by James Cubitt. It comprises five shallow, segmental arches of cast iron with abutments of grey	1064717

HEA Ref no.	Description	Site code/ GLHER ref/ List entry number
	granite and piers with squat engaged columns, the caps and bases of carved Portland stone. Gothic balustrade of gray granite.	
1J	Bazalgette's No.1 Low level sewer. Sewer of mid 19th century date.	---
1K	Thames Channel, adjacent to the Victoria Embankment wall. Round timbers were observed during the Museum of London Archaeology (MOLA) Thames Tideway Tunnel project site visit in 2011. Possibly the remains of a post-medieval cofferdam, mooring posts, jetty or slipway.	---
1L	Thames Channel, adjacent to the Victoria Embankment wall A pontoon dated to the early 20th century.	---
1M	Thames Channel, adjacent to the Victoria Embankment wall A pontoon dated to the early 20th century. The Grade II listed President ship (see **HEA 1C**) is currently moored to it.	---
2	Barge House Street. Site of the King's bargehouse. Noted on the GLHER.	090076
3	Bridge House, 181 Queen Victoria Street. A Museum of London Archaeological Service (MoLAS, now MOLA) evaluation in 2006 revealed substantial structural remains associated with either the 1769 Blackfriars Bridge or Chatham Place, a contemporary square to the north of the bridgehead. Victorian and modern made ground was recorded and a single auger hole indicated post-medieval tidal deposits.	QVI06
4	Unilever House, Victoria Embankment. A MoLAS evaluation and watching brief in 2004 revealed an oak and elm timber revetment or dock, overlaid by medieval dumping and reclamation deposits. Dumping dated to the 16th–17th century dumps and a later chalk and ragstone cellar were also recorded. Boreholes analysis revealed a possible sand and gravel bar or bank formed at the mouth of the River Fleet. A radiocarbon sample gave a date of 11,140–11,080 BC (Middle Bronze Age) towards the base of the alluvial sequence.	UNH04 MLO 98000 98001 98002
5	Thameslink Blackfriars Station, New Bridge Street, Queen Victoria Street. An archaeological evaluation, involving the monitoring of observation pits and geotechnical boreholes was carried out at Blackfriars Station as part of proposed works for Thameslink on both the northern (City) and southern (Southwark) sides of the Blackfriars Railway Bridge. These investigations followed	THB09

HEA Ref no.	Description	Site code/ GLHER ref/ List entry number
	on from a previous watching brief which monitored an earlier phase of geotechnical site investigations at Blackfriars in 2000 (QUA00; **HEA 59**) at Blackfriars Station.	
6	167–179 Queen Victoria Street. An excavation by the Museum of London Department of Urban Archaeology (DUA) in 1985 revealed a substantial late 13th–early 14th century east-west river wall, river stairs, and reclamation dumping. At the front of the wall, compacted gravel and several mooring timbers were found. Further reclamation from the second half of the 17th century, following the Great Fire of London, was also recorded. A sequence of brick cellars was constructed on this reclaimed land dated to the mid to late–18th century. Modern activity truncated the sequence on both sides of the wall.	QVS85 042894-9042894-9
7	Blackfriars House, 19 New Bridge Street. An AOC Archaeology (AOC) excavation in 1998 recorded timber revetments and reclamation dumping dating to the medieval and post-medieval periods and successive foreshore deposits of the confluence of the Thames and Fleet rivers. An iron auger or drill bit was found in the vicinity of one timber structure and an extensive timber-lined pit contained a complete jug and decorated plate dating to the late 16th or early 17th century. Burials dating from 1608 and associated with the nearby Bridewell Palace (which became a workhouse for the poor) were recorded, and confirmed a contemporary account of densely packed burials. The late 17th century Fleet Wall crossed the southeastern corner of the site; 18th century structures were also identified, including a large circular brick-lined pit, probably used for cold storage.	NBR98
8	1–11 Tudor Street. A watching brief carried out by the DUA in 1978, recovered palaeoenvironmental evidence of the Fleet Valley in Pleistocene and prehistoric times; medieval reclamation and revetments on the west side of the valley, and fragmentary brick arched foundations of the gallery of the medieval Bridewell Palace (c.1515–1523).	TUD78
9	1 Tudor Street. A MoLAS evaluation in 2008 revealed modern disturbed ground beneath an existing basement slab. No archaeological deposits survived.	TUS08
10	1–3 Tudor Street. A MoLAS watching brief in 1996 revealed truncated natural	TOR96 044779

HEA Ref no.	Description	Site code/ GLHER ref/ List entry number
	gravel and undated crushed brick. No significant archaeological remains were recorded.	MLO 71173
11	Tunnel, Kingscote Street. A DUA watching brief in 1977 revealed two undated timber base-plates on piles, driven into waterlain gravels, aligned north-south; above this lay ragstone rubble.	KSC77 044460
12	City of London Boy's School (formerly), 60 Victoria Embankment, 5–11 Tudor Street. A DUA excavation in 1986 recorded alluvium and a gravel bank. Roman tile and pottery fragments, 12th century dump material, a mid-14th century chalk river wall and extensive reclamation dumping (over 50m) were recorded. The riverwall construction used a shallow foundation trench shored with a large wattle fence. The dumped deposits were sealed by a fire horizon of late 17th century date (the Great Fire). Further reclamation with a timber revetment probably represents construction of new quays during post-Fire rebuilding. The reclamation included over 700 timber piles, reused from 17th–18th century vessels. A series of post-medieval brick walls, foundations and cellar floors were recorded. During the early 19th century the City Gas Works was constructed on the site and later a WWII public air-raid shelter. Waterfront dumps produced medieval imported pottery, organic material, including shoes, scabbards, a glove and decorated fragments of leather objects. Copper-alloy material from a later medieval workshop, and a pilgrim's badge of St Eloi.	BOY86 043988 MLO 65726 (Roman deposit) 043989 MLO 65727 (flood deposit) 043990 MLO 65729 (land reclamation) 043991 MLO 65730 (river wall) 043992 MLO 65731 (fire debris) 043993 MLO 65732 (revetment) 043994 (foundation)
13	Inner Temple Garden, Inner Temple Lane, Inner Temple. A Pre-Construct Archaeology (PCA) watching brief in 2001 revealed late 18th–19th century dumps. Natural strata were not reached.	INT01
14	11 King's Bench Walk. A MoLAS evaluation in 1992 revealed post-medieval construction, dumping, and demolition debris.	KBW92 MLO 65850
15	19-21 Tudor Street, Carmelite Street, Tallis Street, Temple	WFT99

HEA Ref no.	Description	Site code/ GLHER ref/ List entry number
	Avenue. A PCA evaluation in 1999 revealed alluvial deposits overlaid by medieval reclamation dumps containing residual Roman and Saxon (10th to mid-12th century) pottery. Timber stakes and stakeholes predating the late 14th century were recorded, a long with a stone river wall, known from documentary sources to have been constructed in 1396. This wall was part of an expansion of the gardens of the Carmelite precinct (Whitefriars, founded in c. 1241). A large quantity of high quality artefacts was recovered. The medieval deposits were sealed by post-medieval ground raising dumps and extensive 15th–19th century structural remains.	MLO 75798 MLO 76650 MLO 76651 MLO 77610
16	Inner Temple Garden, Victoria Embankment. Grade II registered gardens. The gardens have origin in the late 12th century when the Knights Templar moved to the area and it is likely that there were gardens associated with the monastery that they built there. By the mid 15th century the Temple buildings and gardens had been separated into the Middle and Inner Temple. During the 15th and 16th centuries the Inner Temple gardens were divided into various enclosures, which included the Great Garden and three smaller gardens or courts. By the early 19th century the gardens had been redesigned to the present (late 20th century) layout in the northern and central sections, with the terrace, a large expanse of lawn and planting around the perimeter. The construction of the Victoria Embankment in 1870 resulted in the garden being expanded to the south, and the planting and layout of this additional area dates from the late 19th century.	---
17	River Thames (King's Reach). The find spot of a Bronze Age spear.	MLO 26960
18	Blackfriars, to the west of Blackfriars Bridge. The findspot of an axe dating from the late Neolithic to the late Bronze Age.	104000 MLO 26958
19	Blackfriars, to the west of Blackfriars Bridge. The findspot of an axe dating to the Neolithic period.	114039 MLO 26914
20	Adjacent (to the east of) the Submarine War Memorial, Victoria Embankment. Grade II listed. Police public callbox. Cast iron and dated to c.1935.	1251871
21	New Bridge Street. Site of 13th century city wall.	041193 MLO 15587

HEA Ref no.	Description	Site code/ GLHER ref/ List entry number
22	1 Tudor Street. Site of medieval piling and land reclamation, dating to the 13th century.	041192 MLO 24919
23	Bridewell Palace. The site of a former royal palace, built in c. 1515–1520, for Henry VIII, on the banks of the River Fleet. It was named after a holy well nearby, dedicated to St. Bride. In 1553, Edward VI gave the palace to the City for the reception of vagrants and homeless children. In 1556 the City took possession and the palace was turned into a prison, hospital and workrooms. Most of the old buildings were destroyed in the Great Fire and rebuilt 1666–1667. A new prison section was built in 1797. In 1863–1864 the buildings were demolished apart from a gate, constructed in 1802. The rest of the site, to the south, was covered by the Keyser's Royal Hotel until 1931, followed by the Unilever building.	---
24	Bridewell burial ground. The site of a former burial ground for the use of the hospital and prison constructed on the site of the former Bridewell Place, in the 16th century. Disused by the mid19th century.	041191
25	Site of the City of London (Blackfriars) Gasworks, Tudor Street. The gasworks were constructed at the beginning of the 19th century, and closed in 1873. In 1880 the City of London school was built on part of the site.	MLO 21048
26	The site of Powell's (Whitefriars) Glassworks, 26 Tudor Street. The former glassworks were established in 1680. In 1834 the glassworks was purchased by James Powell and became known as 'James Powell & Sons'. The name reverted back to Whitefriars in 1963. The works was closed in 1980.	040223
27	Site of a former glasshouse belonging to the Whitefriar's Glassworks. Established in the 18th century.	MLO 77754
28	Junction of Watergate and Kingscote Street. The site of an unspecified, undated structure of archaeological interest. No further information on the Greater London Historic Environment Record (GLHER).	MLO 68667
29	West of Blackfriars Road, (Southwark side of the Thames). The site of a post-medieval windmill.	MLO 8783
30	Thames foreshore, Southwark. The findspot of an unspecified object. No further information on the GHLER	MLO 100245

HEA Ref no.	Description	Site code/ GLHER ref/ List entry number
31	2 Lamp Standards Outside Inner Temple Hall, Crown Office Row. Grade II listed.	1193114
32	Cattle trough outside Inner Temple garden. Grade II listed. Dated 1892. Grey granite. Long monolithic trough with 2 divisions standing on 3 rectangular piers. Inscriptions: - "Metropolitan Drinking Fountain and Cattle Trough Association" and "The Gift of J H Buxton 1892".	1079105
33	Five gate piers to Inner Temple Garden. Grade II listed. Late 19th century gates. Tall Portland stone piers of grouped flat pilasters with incised stylized floral motifs, angle shafts on acanthus leaf bases and surmounted by cast iron vases.	1079104
34	Hamilton House. Grade II listed. Includes No I Temple Avenue. Dated 1880. Ornamented, gabled building in Portland stone. 4 main storeys plus dormers. Doorway dated 1899. Returns to Temple Avenue and Inner Temple Garden.	1079106
35	Carmelite House. Grade II listed. Includes Nos. 1 to 5 (consecutive), Tallis Street. Late 19th century. Red brick with stone dressings and bands. 5 storeys, higher corner tower with octagonal slate roof with lantern cupola, and flagstaff.	1064727
36	9 Carmelite Street. Grade II listed. Office block. 1893-4 by H A Hunt and H T Steward (architects & surveyors) for the Board of Conservators of the River Thames. Built by George Trollope & Sons. Red brick with stone dressings in Tudor Gothic style. Slate roof with tall chimney stacks.	1252144
37	Sion College and attached railings. Grade II listed. College building. 1886 by Sir Arthur Blomfield. Ground floor extension 1965-6. Red brick with stone dressings. Tudor Gothic style. Irregular storeys and fenestration.	1079107
38	Main block of City of London School (main front block only). Grade II listed. 1881-2, by Davis and Emmanuel. Large scale, richly modelled Portland stone building in northern renaissance manner. 2 main storeys above basement.	1358920
39	Unilever House. Grade II listed. 1930-1 by J. Lomax-Simpson with Sir John Burnet, Tait and Lorne. Monumental quadrant shaped facade. Projecting, heavily rusticated ground floor, 3-storey base above which the	1079108

HEA Ref no.	Description	Site code/ GLHER ref/ List entry number
	3 upper floors are united by a giant colonnade in antis of 16 detached Ionic columns. To left and right of front, huge statues of draught horses with restraining male and female figures on 3 storey stepped bases, by Sir William Reid Dick	
40	Statue of Queen Victoria at approach to Blackfriars Bridge. Grade II listed. Dated 1893 and 1896, by C B Birch. Standing bronze figure on plinth of pink granite.	1358889
41	Surviving piers of former West Blackfriars and St. Paul's Rail Bridge.	---
42	12&13 King's Bench Walk. Grade II listed. Early/mid 19th century. 4 storeys plus basement. Plain, classical design in Bath stone with channelled ground storey and cornice below top floor.	1064651
43	Telephone House. Grade II listed Circa 1900. 4 main storeys plus dormers. Free classical style with gables. Central cupola, chimney stacks etc. Portland stone. Carved and moulded enrichment. Long frontage with 2 short returns	1079128
44	Former Argus Printing Company. Grade II listed	1375288
45	Former Guildhall School of Music. Grade II listed.	1079093
46	K2 Telephone. Grade II listed 1927, designed by Giles Gilbert Scott. Cast iron. Intact square kiosk of K2 type with domed roof, perforated crowns to top panels and glazing bays to windows and door. Drinking fountain on east side of road at north end of bridge. Grade II listed. 1861. Sculpted by Wills Bros and cast by Coalbrookdale Foundry. Circular granite bowl on baluster base, carrying bronze figure of woman of Samaria.	1251643 1262674
47	Thames foreshore, Southwark. The remains of a prehistoric peat deposit with rootlets identified by the Thames Discovery Programme (TDP) in 2010.	FSW10
48	Thames foreshore, Southwark. An artefact scatter, featuring 18th and 19th century pottery. Identified by the TDP in 2010.	FSW10
49	Thames foreshore, Southwark. An artefact scatter, featuring post-medieval nails; perhaps	FSW10

HEA Ref no.	Description	Site code/ GLHER ref/ List entry number
	ship-building debris. Identified by the TDP in 2010.	
50	Thames foreshore, Southwark. The remains of a post-medieval causeway constructed of timber and stone block (one surviving). Identified by the TDP in 2010.	FSW10
51	Thames foreshore, Southwark. The remains of two groups of wooden stakes; the eastern group may be a fish trap or mooring feature, consisting of two rounded stakes. The western group is a possible mooring feature, consisting of five angled stakes in two rows. Identified by the TDP in 2010.	FSW10
52	Thames foreshore, Southwark. The remains of a prehistoric peat and organic clay layer, exposed at low tide. Identified by the TDP in 2010.	FSW10
53	Thames foreshore, Southwark. The remains of a post-medieval consolidation dump. Identified by the TDP in 2010.	FSW10
54	Thames foreshore, Southwark. A scatter of post-medieval timbers, perhaps shipyard waste. Identified by the TDP in 2010.	FSW10
55	Thames foreshore, Southwark. The remains of a post-medieval timber-lined drain. Identified by the TDP in 2010.	FSW10
56	Thames foreshore, Southwark. The remains of a possible post-medieval consolidation dump layer, containing bone, organic and industrial waste. Identified by the TDP in 2010.	FSW10
57	Thames foreshore, Southwark. The remains of an unclassified post-medieval structure; possibly a jetty featuring one horizontal and five vertical large squared timbers. Identified by the TDP in 2010.	FSW10
58	Thames Channel. The location of an unspecified obstruction and/or foul ground. Identified by Seazone.	SZID FEAT CODE 8607
59	Thames Link 2000 Blackfriars Bridge Station Watching brief by MoLAS recorded concrete foundations above post-medieval deposits that may have been the remains of St Paul's Station, the original station on the northern bank of the Thames, having replaced, in 1886, Blackfriars Road	QUA00

HEA Ref no.	Description	Site code/ GLHER ref/ List entry number
	Station, located on the southern bank. Boreholes showed made ground above foreshore and riverine deposits and in one of them was noted a substantial timber, which could be either a revetment timber on the foreshore or possibly from the eastern side of Puddle Dock.	
60	Mermaid Theatre Excavations by the GM between 1974 and 1979 revealed the Roman riverside wall immediately to the east of the Puddle Dock. A fragment of Roman masonry along with evidence of river erosion and a surface of Thames Street dated to the 12th century were discovered. The masonry is identified as part of the Roman riverside wall, dated to AD 255–70 on the adjacent Baynard's Castle site. Timber base-plates for a front- and back-braced timber revetment were found turning from the line of the Dock on the western side to form a frontage to the river, initially datable on carpentry joints to the late 13th or early 14th century but by dendrochronology to c. 1240. With this revetment were noted traces of buildings forming units of reclamation S of Thames Street.	MM74 042155−8 THE79 043502−3 GM189 044378
61	Upper Thames Street 223-225, City of London Boys School (St Peters) Excavation by DUA in 1990 and watching brief in 1991 uncovered four periods of medieval and post-medieval east-west river frontages. A DUA excavation in 1981 revealed late 2nd or early 3rd century terracing. On the lower terrace massive north-south and east-west foundations were constructed of oak piles, rammed chalk and limestone blocks. Evidence of a later Roman timber building with beaten earth floors was uncovered. Saxon activity survived only under St Peter's Hill and Upper Thames Street. Various related medieval properties were excavated. The west wall of St Peter's church, possibly of the 12th century, was examined in relation to various phases of street surfaces of Peter's Hill. A sequence of Great Fire deposits consisted of burnt brick cellars, the destruction of the church and subsequent substantial dumping over the whole area. A watching brief by DUA in 1984 recorded a length of wall and foundation of Baynard's Castle. The Roman riverside wall (MLO13871) was observed in one trial hole. Terraced ground dating to the Roman period (MLO65549) was also observed.	BEX90 042737 BYD81 043780−4 PET81 TIG84 MLO 13871 MLO 65549

HEA Ref no.	Description	Site code/ GLHER ref/ List entry number
	A series of Victorian brick vaults were recorded. A series of post-Great Fire dumps was recorded and possibly dark earth overlying Roman dumps.	
62	Upper Thames Street, Baynard's Castle, North Bank Development Area Excavation by the Guildhall Museum (GM) between 1972 and 1974 revealed two parallel east-west limestone walls which may be part of Baynard's Castle II (built from 1428 onwards). It found the foundations of the 15th century and Tudor Baynard's Castle, overlying earlier tenements and the East Watergate, a dock-like public watergate.	GM152 BC72 UT74 043859
63	Blackfriars, near Obelisk. Chance find of a Neolithic axe recorded on the GLHER.	041118
64	Baynard House. Chance find of an Early Medieval/Dark Age pot recorded on the GLHER.	042155
65	Post-medieval dump and made ground recorded on the GLHER.	042737
66	Roman to medieval flood defences and castle dock recorded on the GLHER.	043860−2
67	K2 Telephone Kiosk by Submarine Memorial, Victoria Embankment. Grade II listed. Telephone kiosk, 1927, designed by Giles Gilbert Scott.	1251782
68	Thames foreshore The location of a boat, of post-medieval date, recorded on the GLHER. It was also observed as part of a foreshore survey carried out by LARF in 1996. The boat was clinker-built, with an engine added; presumably 20th century.	FCY01 A102 MLO 70288 044659
69	Thames Foreshore. The location of boat (barge) remains, of post-medieval date, recorded on the GLHER. It was also observed as part of a foreshore survey carried out by LARF in 1996. Remains consisted of a fragment of a barge board from the leeward (port) side of the vessel.	FCY01 A104 MLO 70290 044661
70	Site of post-medieval cemetery recorded on the GLHER. As this is indicated as lying within the Thames foreshore it is likely to be a location error.	044696
71	Site of medieval tide mill and windmill recorded on the GLHER. As this is located in the Thames channel it is likely to be a	090735

HEA Ref no.	Description	Site code/ GLHER ref/ List entry number
	location error.	
72	Five benches on riverside pavement opposite Temple Gardens Victoria Embankment. Grade II listed. Late 19th century cast iron supports with figures of crouching camels. Wooden slats	1079110 199803
73	Thames foreshore, Blackfriars The findspot of a mid-7th century gold *tremissis* (Witmen type) coin found in 1848 and recorded on the GLHER, and also of a Saxon knife.	MLO 99344 MLO 99345
74	Submarine War Memorial attached to Embankment Wall Victoria Embankment. Grade II listed.	1079109 199802
75	Baynard's Castle. Scheduled Monument. Medieval castle surviving as buried archaeological remains below an area of modern development. Built in the 13th century, the castle was altered, part-rebuilt and enlarged several times.	LO135
76	5 Paper Buildings. Grade II listed.	1359179
77	9–11 King's Bench Walk. Grade II listed.	1359178
78	8 King's Bench Walk. Grade II* listed.	1193194
79	7 King's Bench Walk. Grade I listed.	1064650
80	Northcliffe House. Grade II listed.	1262507
81	24 Tudor Street. Grade II listed.	1252119
82	Blackfriars House. Grade II listed.	1359215
83	The Black Friar public house. Grade II* listed.	1285723
84	Gateway to Tudor Street. Grade II listed.	1064649
85	Knightrider Street, Faraday Building. An evaluation by Oxford Archaeology Unit (OAU) in 1995 revealed a partially surviving Roman structure below the eastern end of Knightrider Street. Deposits, which are interpreted as most likely to be the infilling of 1st century Roman gravel quarrying, were seen in a trench in the north block basement of the building. The third trench, also in the north block basement, showed truncation of the natural gravels by the existing structure, and recovered some ornamental 19th-century building stone.	QVT95
86	Millennium Bridge. A MoLAS archaeological evaluation and foreshore survey in	MBC98

HEA Ref no.	Description	Site code/ GLHER ref/ List entry number
	1998 revealed post-medieval dumping only. Further excavations in 1999 and stretched from the City of London Boys School to Brook's Wharf, and numerous post-medieval structures revealed intense use of the riverfront.	
87	5 Burgon Street, 5 Friar Street, Blackfriars. A MoLAS watching brief in 1998 recorded substantial modern stone slabs capping a large void. Natural deposits were not observed.	BGO98
88	Cycle Hire Scheme dropshaft. A MoLAS watching brief in 2010 revealed 1.6m depth of archaeological stratigraphy included a late 16th or 17th century brick and chalk cesspit or soakaway and a late17th-18th century brick floor.	GDF10
89	36 St Andrew's Hill. A MoLAS watching brief in 1997 revealed truncated chalk and ragstone masonry foundations cutting into earlier medieval dumping. These were part of the King's Great Wardrobe complex (constructed in 1360). A tiled floor, probably a later phase of surfacing, was sealed by fire debris. The latter is likely to represent the destruction of the Wardrobe in the Great Fire. Truncated brick cellar walls were the remnants of the 17th or 18th century buildings on the site; they were sealed by destruction debris. The standing 19th-century building appears to follow the same property lines as those of the post-Fire buildings.	SNW97 199720
90	31–32 St Andrews Hill. A MoLAS watching brief in 1997. No archaeological remains were recorded due to modern disturbance. St Andrew by the Wardrobe. A MoLAS watching brief in 1997 revealed a brick-built vault. 1–8 Addle Hill, 146A Queen Victoria Street, Carter Lane. A MoLAS evaluation in 1997 and 1998 revealed redeposited brickearth and gravel, probably a result of Roman quarrying. Alluvial deposits associated with the 'Western Stream' were recorded. The channel was infilled in the early 14th century. Chalk foundations of the 14th-century King's Wardrobe were also identified, along with a well associated with the King's Wardrobe. Some elements of post-Great Fire brick buildings survived within the fabric of Victorian basement walls.	SRW97 SAA97 433818 WDC97 WDC98

HEA Ref no.	Description	Site code/ GLHER ref/ List entry number
91	VOID	
92	146 Queen Victoria Street, Bible House. A DUA excavation in 1986 noted Victorian terracing during construction of Queen Victoria Street. A north-south drainage ditch, filled waterlain silts and pottery dated to AD 1000-1100 were recorded. Other features included medieval, post-medieval and Victorian wells, Roman rubbish pits and the foundations of St Andrew by the Wardrobe church to the immediate west of the site.	BHO86 199711
93	VOID	
94	Upper Thames Street, Trigg Lane. A DUA excavation in 1974 revealed a series of riverfront revetments and associated features dating to the mid-13th-mid-15th century. A massive ragstone-faced riverwall was constructed to the south of the timber revetments to produce a common frontage and stair which functioned with the earlier riverwall. Associated with this riverfront was a narrow building fronting onto Trig Lane.	TL74
95	VOID	
96	Knightrider Street, Faraday Buildings. An evaluation by Lawson Price Archaeology (LPA) in 2005. Evidence of Roman gravel extraction pits; medieval dumping, pits and makeup, and large 17th-18th century cess or refuse pits and dump layers survived. They were sealed by a sequence of 18th and early 19th-century building remains.	FBN05
97	Mermaid Theatre, Puddle Dock, Upper Thames Street. A watching brief carried out by GM in 1957. The trench was abandoned 'owing to the presence of very thick concrete rafts which were continuing at a depth of 2-3ft'.	GM189
98	Blackfriars Wreck 3, Trig Lane (west of). A watching brief was carried out by GM in 1970. The wreck of a late 15th century flat, clinker-built river barge was found. The barge was 16m long and 3m wide. It was held together with rivets made water-tight with a luting of hair. A mast-step timber was found, but there was no rudder, indicating that the boat was probably steered using oars. The bargehead had clearly been repaired a number of times. Finds of pottery, shoes, two pewter pilgrim badges, and 2000 cylindrical lead weights (for a fishing net) were noted. The finds indicated that the vessel sunk in the 15th century. The wreck of a second clinker-built ship (Blackfriars Wreck 4, **HEA 147**), carrying a cargo of	GM19 041389

HEA Ref no.	Description	Site code/ GLHER ref/ List entry number
	Kentish ragstone, was found in the bed of the river nearby. It had probably also sunk during the 15th century.	
99	39 St Andrew's Hill. A GM watching brief in 1934 recorded parts of a north-south medieval wall. The wall was thought to be part of the Blackfriars friary complex but lies to the east of the precinct, on the site of the King's or Great Wardrobe.	GM224
100	Blackfriars Wreck 2, Thames foreshore A watching brief by GM in 1962. The wreck of a 17th century boat was found in the bed of the river, off Paul's Stairs. The vessel was roughly 14m long and 3m wide, and was carrying a cargo of bricks. Dating evidence in the form of pottery, clay pipes and wineglass stems, suggest that the sinking was around the time of, or possibly after, the Great Fire of 1666.	GM181
101	Upper Thames Street, Baynards Castle. An excavation by GM in 1974 and 1975. Excavations revealed part of the north wing of the medieval Baynard's Castle, including the north gate and gate tower; the frontages of medieval houses between the medieval castle and the East Watergate dock; part of the north wing of the 16th-century addition to the castle; the cobbled entrance to the castle from Thames Street; and evidence for Thames Street before the Great Fire of 1666. Observation and limited excavation recorded a 115m stretch of the Roman riverside city wall dated to the 4th century. Parts of medieval timber waterfronts were also recorded.	BC74 BC75
102	Upper Thames Street, Baynards Castle. An excavation by GM in 1981. Four periods of medieval and post-medieval river frontages were recorded, although extensively robbed. The southeast corner tower of Baynard's Castle was identified.	BYD81
103	Upper Thames Street, Baynards Castle. An excavation by GM in 1974. A trench disclosed two parallel 'limestone' walls which may be part of Baynard's Castle. A late 17th-century cellar with several phases of walls and floors was also recorded.	UT74
104	160–162 Queen Victoria Street. A watching brief by GM in 1960. A natural stream-bed was found cutting into waterlaid gravels. Roman masonry remains and a number of medieval walls were recorded. An east-west wall and a well of post-medieval date were found to contain many moulded stones. The well contained fragments of a	GM135 QNW98

HEA Ref no.	Description	Site code/ GLHER ref/ List entry number
	medieval window. The medieval walls and moulded stones probably come from the Blackfriars friary which stood on the site. A watching brief by AOC in 1998. Modern building construction had truncated the site down to the natural clay.	
105	The site of a wall dating from the Roman period through to the 16th century and a post-medieval church and chapel. Recorded on the GLHER.	041197 040424 041194
106	A medieval and post-medieval wall and the site of a post-medieval theatre/playhouse yard. Recorded on the GLHER.	041194/19 044988
107	The chance find of a prehistoric lithic implement and prehistoric human remains. Recorded on the GLHER.	042526 042527
108	Excavation by the DUA in 1988 revealed late Saxon burials near the confluence of the Thames and the Fleet. The remains showed evidence of quartering and decapitation, and were interpreted as burials of criminals.	VAL88
109	Part of the Roman and medieval city walls. Recorded on the GLHER.	040412 040413
110	The chance find of an architectural fragment dating to the post-medieval period during building work in 1980. Recorded on the GLHER.	041200
111	The recording of a medieval wall during building works in 1871 which possible relate to the Blackfriars Monastery. Recorded on the GLHER.	041188 041189
112	The chance find of Mesolithic worked flint. Recorded on the GLHER.	041111
113	A post-medieval revetment structure recorded on the Thames foreshore. Recorded on the GLHER.	044666
114	The foundation of a post-medieval well. Recorded on the GLHER.	092638
115	The chance find of an undated purse. Recorded on the GLHER.	10081
116	The site of a post-medieval windmill. Recorded on the GLHER.	090737
117	A post-medieval jetty and slipway. Recorded on the GLHER.	092636

HEA Ref no.	Description	Site code/ GLHER ref/ List entry number
118	An unclassified prehistoric deposit. Recorded on the GLHER.	092633
119	Post-medieval steps, an unclassified structure, a drain a mooring pollard and a crane. Recorded on the GLHER.	092630 092631 092632
120	The Church of St Andrew by the Wardrobe. Grade I listed.	199712
121	The Church of St Benet. Grade I listed.	199790
122	Four Gate Piers To Middle Temple Lane Victoria Embankment. Grade II listed.	199793
123	Lodge To Gateway From Victoria Embankment Middle Temple Lane. Grade II listed.	199638
124	1-4 Temple Gardens, Middle Temple Lane. Grade II listed.	199637
125	Pair Of Griffins On Pedestals At City Boundary Victoria Embankment. Grade II listed.	199791
126	K2 Telephone Kiosk At Junction With Temple Place, Milford Lane. Grade II listed.	418226
127	Thames Channel Approximate findspot of a Neolithic axe.	114037
128	Middle Temple (Gardens), Plowden Buildings, Middle Temple Lane. Archaeological investigation by Oxford Archaeology in 2010. No details held in LAARC.	MDI10
129	Middle Temple Gardens, Grade II registered gardens. The gardens date to the late 12th century when the Knights Templar moved to the area and it is likely that there were gardens associated with the monastery that they built there. By the mid 15th century the Temple buildings and gardens had been separated into the Middle and Inner Temple. The former was granted to students of law in the 17th century. The gardens were enclosed in 1870 by Victoria Embankment.	224422
130	The Library, Middle Temple Lane, City of London. An OAU watching brief in 1997 revealed no significant archaeological remains, only demolition rubble resulting from WWII bomb damage.	MDT97
131	The Temple, Fountain Court, Middle Temple Lane, City of London. An OAU watching brief in 1994 found post-medieval layers, including a gravel surface. Residual medieval pottery was	MTL94

HEA Ref no.	Description	Site code/ GLHER ref/ List entry number
	recovered.	
132	Crown Office Row. Gates With Gate Piers And Steps. Grade II listed.	199527
133	1-4 Paper Buildings, Kings Bench Walk. Grade II listed.	199545
134	No. 4 Paper Buildings, Inner Temple A PCA archaeological watching brief in 2004. A medieval or post-medieval dump layer and a late 18th or early 19th century wall were recorded.	MLO 78410
135	Lamp Standard Opposite Number 7 Kings Bench Walk. Grade II listed.	199547
136	Thames Water Mains Replacement throughout the City of London. Archaeological monitoring by Compass Archaeology (CA) in 2006 revealed largely 19th century and later made ground or fills, often relating to previous and existing services.	TMM06
137	King's Bench Walk, Inner Temple, City of London. DUA watching brief in 1989 revealed two possible clay pits originally on the Thames foreshore. Both were backfilled with waterlogged silt and peat. The backfill of one pit was dated to the 12th century and may coincide with documented occupation of the site by the Knights Templar. Both features were overlaid by thick dumps of post-medieval rubble and soil.	TCP89 041706 041707
138	6 Kings Bench Walk. Grade I listed.	199539
139	5 King's Bench Walk, City of London A MoLAS watching brief in 1994 revealed natural gravels to the north and possible alluvial deposits to the south, reflecting the slope of the ground down to the river. The natural deposits were overlain by medieval ground consolidation dumps.	KNB94 042889
140	5 Kings Bench Walk. Grade I listed.	199538
141	Daily News Site at 22 Bouverie Street, City of London An early GM watching brief on the site of the gardens of the medieval Carmelite Whitefriars in 1924 revealed 16th century stoneware, a candlestick, and 17th and 18th century glass and pottery.	GM266
142	This point marks a number of chance finds and findspots, some of which are recorded in the Portable Antiquities Scheme database. Artefacts recorded here are mostly post-medieval, and include 2 vessels, 2 spoons, kiln furniture, a coin, a badge and a book fitting. A medieval buckle was also recovered.	MLO100026 MLO100028 MLO100033 MLO100035

HEA Ref no.	Description	Site code/ GLHER ref/ List entry number
		MLO100064 MLO100066 MLO100199 MLO100200 MLO100201
143	Barge House Street. Site of post-medieval landing steps named the Barge House Stairs. Noted on the GLHER.	090187
144	36 St. Andrew's Hill. The Rectory. Grade II listed.	199721
145	31–32 St. Andrew's Hill. Grade II listed.	433818
146	146 Queen Victoria Street. Grade II listed.	199711
147	Blackfriars Wreck 4, Trig Lane Stairs, EC4. An investigation by P. Marsden for GM in 1970, during the construction of a cofferdam, revealed the wreck of a clinker-built ship, orientated north-south, which had been carrying a load of Kentish ragstone. It was discovered close to Blackfriars Wreck 3 (**HEA 98**); off Trig Lane. Time pressures/constraints meant that the boat was not fully excavated; however, a provisional date of a 15th century sinking was allocated. The wreck was exposed using a mechanical grab; thus only a few details were recorded.	MLO 16847
148	2–3 Trig Lane The former location of a late medieval structure.	MLO 20618
149	26 Upper Thames Street (formerly East Paul's Wharf) Former location of a post-medieval sewer. Late 15th–19th century.	MLO 17972
150	Trig Lane The location of a late medieval revetment.	MLO 68808
151	Farraday Buildings The location of a Roman quarry.	MLO 66790
152	The Rectory, St. Andrew's Hill Former location of a late 18th century vicarage/house and associated railings (1767–1799).	MLO 199720
153	Printing House Square, EC4 Former location of medieval and post-medieval chapel.	MLO 43579

E.2 Site location, topography and geology

Site location

E.2.1 The site comprises two parcels of land: the 'main site' and the 'Blackfriars Pier site' to the east, so called because the current Millennium Pier would be relocated there. Together they are collectively referred to here as 'the site'.

E.2.2 The site is located on the north bank of the River Thames, and includes the Victoria Embankment river wall, which lies adjacent to the northern site boundary. The western part of the main site lies c. 50m to the east of Temple Pier, whilst the eastern part lies beneath the northern approach to Blackfriars Bridge. The southern bank of the River Thames lays c. 150m to the south. The site lies adjacent to the southern boundaries of the ancient parishes of Whitefriars, St. Bride, and Bridewell; areas of London which were extensively developed in the later medieval and post-medieval periods.

E.2.3 Within the main site, the eastern end of the largely submerged foreshore is currently occupied by the northern approach to Blackfriars Bridge. Underneath the bridgehead, opening out from the river wall, are outfall gates constructed in the 1960s, as part of the re-aligned river wall. These release water from the canalised subterranean River Fleet (**HEA 1F**), now the Fleet Main sewer.

E.2.4 The Blackfriars Millennium Pier and an earlier ex-London Fire Brigade pump house structure (**HEA 1G**) are located on the foreshore in the eastern part of the main site. The President ship (**HEA 1C**) is permanently moored in the centre of the site.

E.2.5 The Blackfriars Pier site lies on an area of undeveloped foreshore and includes a section of the 1960s river wall within its north-western boundary.

Topography

E.2.6 The site spans the confluence of the historic Fleet (now a canalised stream with an outlet which discharges into the Thames beneath Blackfriars Bridge) and Thames rivers, lying well within the northern part of the Thames floodplain (Barton, 1992)[1]. The area to the north of the site would have consisted of a network of channels and sandbanks, or islands, in prehistory, prior to the manipulation of the watercourses and extension of the riverfront from the Roman period onwards, and particularly in the post-medieval period, to its present location.

E.2.7 The site currently lies on the northern foreshore of the Thames. Most of the foreshore within the main site lies at c. 100.0m ATD (above Tunnel Datum) and is submerged during high tide. The riverbed within the western part of the main site (adjacent to the Inner Temple Garden, landward of the Embankment) has been dredged, and lies at c. 92.0m ATD. Further into the river and eastwards, as far as the Blackfriars Millennium Pier (in the eastern part of the main site), it lies at c. 94–95.5m ATD, rising slightly to 97.0m ATD beneath Blackfriars Bridge. On the

Blackfriars Pier site, the riverbed drops from c. 98.0m ATD at the northern end of the foreshore (adjacent to the riverwall) to 94.0m ATD, at the southern boundary of the site. Geoarchaeological boreholes were recently drilled to 1-2m depth on the foreshore between the eastern boundary of the Blackfriars Pier site and the Millennium Bridge. These found over 1m of historic foreshore deposits, but did not reach gravels or London Clay.

E.2.8 Ground levels on the Victoria Embankment, adjacent to the main site, slope upwards from c. 104.5m ATD to the west opposite Audit House, to c. 106.0m ATD opposite the Blackfriars Millennium Pier, before sloping down again towards Blackfriars Bridge. The rise in ground levels towards the Blackfriars Bridge approach (c. 109.0m ATD at the approach itself, adjacent to Blackfriars Passage) reflects artificial ground raising to accommodate the later 19th century subterranean Metropolitan District Railway line, which runs c. 30m to the north of the river wall, beneath the Victoria Embankment. The subway of the Victoria Embankment road (Blackfriars Underpass, constructed in the 1960s) runs above the railway line adjacent to Blackfriars Station and continues westwards along the Victoria Embankment (between the Embankment wall and the subterranean railway), with the road emerging from the underpass adjacent to the centre of the site. The underpass is located partially within the northeastern boundary of the site.

E.2.9 The riverwall adjacent to the Blackfriars Pier site lies at c. 104.8m ATD, sloping down from c. 108.4m ATD at Queen Victoria Street, c. 130m to the north.

Geology

E.2.10 The site is mapped by the British Geological Survey (BGS) as alluvium overlying bedrock geology of London Clay. Taplow and Hackney Gravels underlie the river terraces, which are capped by brickearth on either side of the Fleet[2], c. 250m to the north of the site. Bathymetric data indicates that the Thames channel is deeper towards the northern bank than the southern bank in this stretch of the river, indicating greater levels of erosion on the river bank on which the site is located. Other, now redundant, minor tributaries flowed from the river terraces into the Fleet confluence area in the past, transporting sediments and dissecting the London Clay and/or gravels[3].

E.2.11 Borehole data for the surrounding area indicates the alluvium below made ground can variably consist of sands, sandy clays, peats, and sands and gravels varying between 1.0m and 5.0m in thickness. The alluvium is likely to be of varying date, as channels carved into the London Clay may have infilled during the Late Glacial and Early Holocene (Late Upper Palaeolithic and Mesolithic), or as a result of channel migration and abandonment in later periods. A deep channel of the Fleet was recorded cutting through the London Clay to 90.4m ATD, with gravels at 93.1m ATD from a borehole at Unilever House (**HEA 4**) (UNH04BH7), c. 100m north of the site. This channel probably dates to the late Pleistocene, as organic bands within the lower sand deposits over the gravels were dated on the same site to 11,100 BC. This date corresponds to the Late Upper Palaeolithic period, and is very rare for this area of London. The gravels

rise steeply southwards to a high point c. 30m north of the main site (TQ38SW4407), where they lie at c. 96.0m ATD, before sloping back downwards, toward the river. Within the river itself, c. 35m to the south of the main site, only the London Clay survives, at c. 95.0m ATD (TQ38SW94). Should the gravels survive within the site it is estimated that they will lie at c. 95.5m ATD.

E.2.12 Typically, late Pleistocene gravels are overlain by sands which become increasingly organic over the higher gravel area at c. 96.5m to 97.5m ATD (TQ38SW4406) c. 60m north of the site, indicative of river marginal environments or possibly soil horizons relating to the early prehistoric (Mesolithic). In the Roman period, the river levels fluctuated, reaching a high of c. 101.0m ATD (Rackham and Sidell, 2000)[4]. In the area of the site these fluctuations in river levels are likely to have led to scouring by the Fleet and consequent truncation of the underlying sands during the Roman period. This is likely to have removed later prehistoric levels typically found to exist at 100.0m ATD in similar environments, such as Thorney Island and Westminster (Rackham and Sidell, 2000)[5]. Following the steady increase in river levels from the end of the Roman period, surviving medieval and post-medieval remains (eg, boats and fishtraps, as well as palaeo-environmental evidence) may be present within the grey silty clay alluvium.

E.2.13 The presence of made ground within the foreshore area of the site is expected to be minimal, other than under Blackfriars Bridge and to the east (the eastern half of the site) where there are concrete blocks. These were probably laid down to stop the foreshore eroding below the level of the river wall footings and north bridge pier, caused by scouring eddies around the bridge piers. Vibro cores have confirmed that minimal foreshore gravels or made ground exists across the foreshore of the site, recording c. 0.4m thickness. The surface of the underlying London Clay lies at c. 95.1m ATD to the west, 95.0–95.4m ATD to the east and c. 92.9m ATD at the centre of the site. The lower London Clay at the centre of the foreshore area may relate to the former confluence of the Fleet and Thames Rivers or to dredging activity in the area.

E.3 Past archaeological investigations within the assessment area

E.3.1 A single archaeological investigation has been carried out within the main site in the past. During construction work carried out as part of the Blackfriars Bridgehead Improvement Scheme, in September 1962, substantial remains of a north-south aligned Roman ship wreck ('Blackfriars Wreck 1'; **HEA 1B**) were recorded. A number of finds, including a late 1st century coin, dated the sinking of the ship to approximately the 2nd century. The wreck (a flat-bottomed barge) is believed to have sunk whilst carrying a cargo of Kentish ragstone, some of which was discovered within the wreck; to be used as building material.

E.3.2 Nearby archaeological excavations to the main site have been carried out c. 40–70m to the northeast, at Bridge House on Queen Victoria Street (**HEA 3**), and Unilever House on the Victoria Embankment (**HEA 4**), which

revealed extensive post-medieval dock and revetment remains. At 167–179 Queen Victoria Street (**HEA 6**), c. 80m to the northeast of the site, a medieval foreshore wall, stairs and moorings were discovered, along with evidence of reclamation and building in the post-medieval period. Medieval and post-medieval remains, including burials, were discovered at Blackfriars House, on New Bridge Street (**HEA 7**), c. 115m to the north of the site. Investigations c. 135–165m to the north and northwest (**HEA 8**, **11, 13, 14** and **15**) uncovered further evidence of medieval land reclamation and post-medieval building. An excavation carried out at the former City of London Boys' School (**HEA 12**), c. 100m to the north of the site, revealed an extensive sequence of similar evidence, including medieval organic material. At 9–12 Bridewell Place, c. 180m to the north of the site (outside the assessment area), foundations of the 16th century Bridewell Palace were discovered.

E.3.3 Further to the northwest of the main site, past archaeological investigations have revealed some medieval activity comprising residual medieval pottery recovered c. 110m to the north (**HEA 131**), 12th century backfilled clay pits c. 195m to the north (**HEA 137**), and medieval consolidation dumps c. 205m to the north (**HEA 139**), while the remainder of investigations in this area have recorded post-medieval remains, such as evidence of World War Two bomb damage c. 130m to the north (**HEA 130**) and 19th century fills or made ground or potentially brick footings c. 200m to the north (**HEA 136**).

E.3.4 No past archaeological investigations have been carried out within the Blackfriars Pier site. The closest investigation to the Blackfriars Pier site was carried out on the foreshore adjacent to its eastern boundary in 1962 (**HEA 100**)., where 'Blackfriars Wreck 2', dated to the 17th century, was discovered. An investigation at 223–225 Upper Thames Street, (**HEA 61**), c. 20m to the north, revealed four periods of medieval and post-medieval east-west river frontages. Excavations at Blackfriars Bridge Station (**HEA 59**), c. 70m to the north-west and the Mermaid Theatre (**HEA 60**), c. 80m to the north, revealed riverine deposits and revetment timbers and remains of the Roman and medieval riverside walls respectively. An excavation at Baynard's Castle (a Scheduled monument) (**HEA 62**), c. 40m to the north-east of the site, revealed the foundations of the 15th century and Tudor castle, overlying earlier tenements and a public watergate. Other features associated with Baynard's Castle have also been recorded; including the north gate and tower (**HEA 101**), c. 110m to the north; the south-east corner tower (**HEA 102**), c 65m to the north-east; and two limestone walls (**HEA 103**), c. 120m to the north of the site.

E.3.5 Within the assessment area around the Blackfriars Pier site, numerous archaeological investigations have recorded evidence of Roman activity; including several sections of Roman river walls, (**HEA 60**), c. 80m to the north; (**HEA 61**), c. 30m to the north-east and (**HEA 101**), c. 120m to the north/north-east; terraced ground (**HEA 61**); a Roman structure (**HEA 85**), c. 200m to the north-east; Roman masonry (**HEA 101**), c. 120m to the north-east; quarrying, (**HEA 85**); **(HEA 90**), c. 175m to the north and (**HEA 96**), c. 200m to the north; and rubbish pits (**HEA 92**), c. 170m to the north. Two investigations also revealed early medieval remains, including walls

(**HEA 61**), c. 30m to the north-east of the site, and a Saxon burial ground (**HEA 108**), c. 160m to the north-west.

E.3.6 Within the assessment area on the foreshore, to the east of the Blackfriars Pier site, two further wrecks (both post-medieval) (**HEA 98** and **147**) were discovered in 1970. Blackfriars Wrecks 3 and 4 were discovered on the foreshore immediately to the south of Trig Lane, c. 70m and c. 100m to the east of the Blackfriars Pier site. Both were dated to the 15th century and were carrying loads of Kentish ragstone. All four shipwrecks, whilst of different dates, had been used as cargo vessels, carrying building material to the city.

E.3.7 The results of these investigations allow for a good understanding of the environs of the site and reflect the historic character of the western part of the City of London as an area of settlement from the Roman period onwards, located adjacent to (and partly within) the western city wall of Londinium, and incorporated into the boundary of the subsequently expanded medieval and post-medieval City. Understanding of the site in the prehistoric period is limited in comparison, due to a scarcity of known archaeological remains. The results of the investigations, along with other known sites and finds within the assessment area, are discussed by period, below.

E.4 Archaeological and historical background of the site

E.4.1 The following section provides a detailed archaeological and historical background for the site. It should be read alongside the research framework presented in Appendix C to Vol 2 Appendix E2, which sets the overall Thames Tideway Tunnel project, and the individual site-specific assessments, within a broader historic environment context (i.e. past landscapes and human activity within such landscapes). It identifies the main route-wide heritage themes, of which the built and buried heritage assets identified within this assessment form a part.

Prehistoric period (700,000 BC–AD 43)

E.4.2 It is likely that the site lay in an area of deep channels, marshy hollows, pools and islands, formed in the confluence area of the Fleet and the Thames, in prehistory. The results of recent borehole samples taken from Unilever House (**HEA 4**), c. 70m to the north of the site, suggest that river processes at the mouth of the Fleet created a bank of higher land, c. 100m to the north of the site, (an eyot), which may have been dry and suitable for settlement. The exact extent of this area of higher ground (subsequently buried beneath alluvium following the rise in sea/river levels) is uncertain, but it is conceivable that it extended into the site.

E.4.3 Whilst river activity is likely to have eroded any prehistoric landsurfaces from islands within the confluence area, prehistoric deposits could survive within deeper channels, which may also preserve environmental remains and artefacts. The floodplain environment was likely to have been attractive for exploitation by hunter-gatherer groups. Despite this,

Mesolithic remains are not frequently recovered from this stretch of the Thames floodplain, although they are frequently encountered in the tributary valleys of the Middle and Lower Thames. A single chance find of a Mesolithic mace (**HEA 112**), was made c. 160m to the northeast of the Blackfriars Pier site.

E.4.4 A late Neolithic or Bronze Age sword was discovered by chance from within the Thames Channel in the Blackfriars Pier site (**HEA 1H**) in the mid-20th century, and is likely to have been a residual find (ie, discovered outside of its original depositional context).

E.4.5 Within the assessment area, two Neolithic hand-axes (**HEA 19 and 127**) and a late Neolithic/Bronze Age hand-axe (**HEA 18**) were recovered from the Thames Channel c. 65m to the south of the main site, and a Bronze Age spear (**HEA 17**), c. 85m to the southwest. A Neolithic hand-axe (**HEA 63**) was also discovered c. 100m to the north of the Blackfriars Pier site. An undated prehistoric lithic implement, along with human remains, (**HEA 107**) have also been recorded c. 180m to the north-west of the Blackfriars Pier site, and an unclassified prehistoric deposit (**HEA 118**) has been recorded c. 180m to the south-east. It is possible that redeposited material may be recovered from within the Thames and Fleet alluvium on the site, representing activity on the shoreline during the Neolithic period, when river levels were lower than in later periods. It is also possible that ritual objects were deposited in the river at this location, as has been found elsewhere along the Thames.

Roman period (AD 43–410)

E.4.6 In the mid-1st century the site would have been submerged within the channel of the River Thames, c. 230m to the south of the Roman riverbank. The main site lay c. 80m to the southwest of the Roman city of Londinium, which lay on the eastern bank of the River Fleet, whilst the Blackfriars Pier site lay immediately to the south of its south-western boundary. By the late 1st century AD, revetments, quays, jetties and warehouses had been built along the waterfront in Londinium to the east. The process of reclaiming land from the river and establishing waterfront structures continued throughout the 2nd and into the 3rd century. This activity was concentrated within the town and there is currently no evidence of riverside construction within the main site comparable to the remains of river walls, masonry and gravel quarrying discovered to the north and north-east of the Blackfriars Pier site.

E.4.7 Contemporary with the expansion of the Roman waterfront are the remains of a Roman shipwreck (**HEA 1B**), discovered in the north-eastern part of the main site, in 1962. Large parts of a north-south aligned Roman ship wreck were recovered during construction of the current riverwall (Vol 18 Plate E.1 and Vol 18 Plate E.2).

E.4.8 The wreck lay approximately mid-way between Blackfriars Road Bridge (**HEA 1I**) and the old railway bridge (of which only the abutments remain; (**HEA 41**), c. 18m to the south of the old Embankment wall. Initially, two phases of excavation were carried out by the Guildhall Museum and the Corporation of London, at low tide. During these excavations, small areas

of the northern part of the wreck were exposed and recorded. In July 1963, a sheet-piled cofferdam was built across the southern section of the wreck (effectively cutting through it, so that the tip of the bow was left lying outside the cofferdam; see Vol 18 Plate E.3). Once the cofferdam had been constructed, it was possible to expose and record most of the southern part of the wreck (Vol 18 Plate E.4 and Vol 18 Plate E.5).

E.4.9 The wreck was discovered immediately to the east of the ancient mouth of the Fleet. The bottom of the vessel was uncovered at 96.4m ATD, at the base of the channel in the Roman period (comprising part of the modern foreshore). River levels are believed to have fallen from c. 102.0m ATD to 100.0m ATD in the early Roman period and then to have risen again in the 3rd or 4th century (Brigham, 1990)[6]. (The evidence for this is derived from a general reduction in ATD heights of known successive Roman revetments.) As the ship is believed to have sunk in the 2nd century, the channel was likely to have been c. 3.6–5.0m deep at the point where the vessel sunk.

E.4.10 Previous investigations within the assessment area have also uncovered evidence of Roman activity to the north of the main site, along what would have been the northern bank of the Thames in the Roman period. An excavation carried out in 1985 at 60 Victoria Embankment (**HEA 12**), c. 100m to the north of the main site, recorded alluvium containing eroded Roman tile and pottery fragments. In 1999, an evaluation at 19–21 Tudor Street (**HEA 15**), c. 130m to the north of the main site, revealed residual fragments of Roman pottery within medieval reclamation deposits. An excavation at the Mermaid Theatre (**HEA 60**), c. 80m to the north of the Blackfriars Pier site, revealed the Roman riverside wall immediately to the east of Puddle Dock road, c. 75m to the north of the present river wall, indicating the extent of reclamation which has since taken place. Roman piles were also discovered at Baynard's Castle (**HEA 62**), c. 40m to the north-east of the site; these are likely to be related to the construction of the Roman river wall. Roman to medieval flood defences (**HEA 66**) were recorded c. 90m to the north of the site.

E.4.11 Three investigations (**HEA 60, 61** and **101**), c. 80m and 140m to the north, and c. 120m to the north/north-east of the Blackfriars Pier site, respectively, have also recorded evidence of Roman riverside walls. Evidence of quarrying to the north-east of the Blackfriars Pier site has been recorded c. 200m to the north-east (**HEA 85**) and c. 200m to the north (**HEA 96**); probably for the construction of buildings and roads within the city of Londinium. Other investigations within the assessment area around the Blackfriars Pier site have recorded Roman redeposited brick earth and gravel along with pottery (**HEA 90**), c. 175m to the north; rubbish pits (**HEA 92**), c. 170m to the north; a timber building (**HEA 61**), c. 30m to the north-east; and roman walls (**HEA 104**), c. 180m to the north/north-west.

E.4.12 Roman law required the dead to be buried outside the city boundaries; burials adjacent to the western city wall have been discovered c. 300m to the north of the Blackfriars Pier site, well inland from the river edge at that

time. Evidence of milling on the gravel eyots of the east bank of the Fleet have also been identified c. 450m to the north-east of the main site.

Early medieval (Saxon) period (AD 410–1066)

E.4.13 Following the withdrawal of the Roman army from England in the early 5th century AD, the Roman city was abandoned and the trading port of Lundenwic developed in the area now occupied by Aldwych, the Strand and Covent Garden, c. 1km to the west of the site (Cowie and Blackmore, 2008)[7]. In the 9th century the former walled Roman city was reoccupied in response to devastating Viking raids.

E.4.14 No archaeological remains dating to the early medieval period have been recovered from within the site. Although outside the settled areas, there is evidence of peripheral activity on the riverbank to the north of the site, which lay within the Thames, c. 200m to the south of the early medieval riverbank. Chance discoveries of a mid-7th century gold coin and a 7th–8th century knife, (**HEA 73**), were made in 1848, adjacent to the eastern boundary of the main site. An early medieval pot (**HEA 64**) was also discovered c. 115m to the north of the Blackfriars Pier site. A Saxon burial ground (**HEA 108**) was identified during the Fleet Valley investigation, c. 150m to the northeast of the main site. The site is believed not to have been consecrated and a number of the burials showed signs of quartering or decapitation, suggesting that the area may have been a burial ground for criminals. Residual pottery dating from the 10th to the mid-12th century, was uncovered during an evaluation at 19–21 Tudor Street (**HEA 15**), c. 130m to the north of the main site, while unspecified Saxon activity was recorded during an excavation in 1981 (**HEA 61**), c. 30m to the north-east of the Blackfriars Pier site.

E.4.15 St. Bride's Church, c. 300m to the north of the main site, is likely to be of Saxon foundation and certainly existed by the 11th century, when it probably acquired its parish. The parish boundary was noted during a previous investigation of the Fleet Valley in 1988 (**HEA 108**), c. 150m to the north-east of the main site, following the west bank of the Fleet, and enclosed part of the east bank of the Fleet to the north of Ludgate Hill, c. 425m to the north of the main site. The location of the parish boundaries may correspond to two large gravel islands (eyots), discovered during the investigation, which formed a natural boundary along the Fleet in the 10th–12th centuries.

Later medieval period (AD 1066–1485)

E.4.16 There are no known later medieval archaeological remains within the site itself, which lay within the River Thames some distance south of the riverfront.

E.4.17 Throughout this period, the banks of the Thames were systematically drained and reclaimed, pushing the riverbank southwards, probably to a line c. 100m north of the present river wall. Reclamation also took place along the Fleet, and new waterfront structures were built.

E.4.18 After the Norman Conquest in 1066, the defences of the city were rebuilt. Fortresses were established on the western city wall, at Baynard's Castle

(**HEA 75**), c. 30m to the northeast of the Blackfriars Pier site (established by 1087), and at Montfichet's Tower, c. 100m to the northeast (established by 1136). The earliest surviving structural remains and layout of Baynard's Castle dates to the 13th century but it was altered, partially re-built and enlarged several times. The remains, uncovered by partial excavation in 1984 and 1994, revealed that it was built on four wings around a central courtyard. The southernmost side originally fronted the river and remains of a series of 16th century projecting towers survive in this part of the castle. A riverside entrance in one of the small south towers is attested in literary sources. Surviving internal features include tiled flooring and the remains of a fireplace in the south wing. A bastion tower, part of a rebuilding programme initiated by Henry III in the 13th century, lies c. 150m to the northeast of the site (outside the assessment area). Numerous excavations within the assessment area have recorded evidence of Baynard's Castle. In 1934 a watching brief (**HEA 101**), c. 110m to the north/north-east of the Blackfriars Pier site recorded the north wing of Baynard's Castle which included the north gate and gate tower as well as houses outside the castle. In 1981 further evidence of Baynard's castle was recorded (**HEA 102**), c. 65m to the north-east of the Blackfriars Pier site, while a watching brief in 1984 (**HEA 61**), c. 30m to the north-east of the Blackfriars Pier site recorded a length of wall and foundation which was associated with the castle. Two limestone walls, also thought to be part of Baynard's Castle were recorded in 1974 (**HEA 103**), c. 120m to the north of the Blackfriars Pier site.

E.4.19 In 1276, the site of Baynard's Castle (destroyed in 1213) was given to the Blackfriars (Dominicans) for a new religious precinct. A new castle was built to the east of Blackfriars shortly after. The earliest occupation within the vicinity, however, was by the Carmelite Friary (Whitefriars) complex, established in c. 1250, north of Tudor Street, c. 225m to the north of the main site. Two previous archaeological investigations have recorded evidence of the Blackfriars Friary. In 1934 an archaeological watching brief (**HEA 99**), c. 150m to the north of the Blackfriars Pier site, recorded a wall which was interpreted as being part of the Friary. In 1960 two further stone walls, also thought to be part of Blackfriars was recorded during a watching brief (**HEA 104**) c. 180m to the north/north-west of the Blackfriars Pier site. In addition to this, the GLHER records that during building works in 1871, a wall thought to be a part of the Blackfriars Friary (**HEA 111**) was identified c. 190m to the north of the Blackfriars Pier site.

E.4.20 Two previous archaeological investigations (**HEA 89** and **HEA 90**), c. 175m to the north of the Blackfriars Pier site have also recorded the remains of the Kings Great Wardrobe; an office which provided clothing and textiles to the Royal Family. Next to the Kings Great Wardrobe was a church, known simply as "St Andrew's by the Wardrobe". The church was constructed during the later medieval period and the foundations of the church were recorded during an excavation in 1986 **(HEA 92**), c. 170m to the north of the Blackfriars Pier site. Another later medieval church has been recorded within the assessment area. In 1981 the west wall of St Peter's Church (**HEA 61**), c. 30m to the north-east of the Blackfriars Pier site was recorded.

E.4.21 Most of the archaeological evidence in the assessment area is of extensive land reclamation of the Thames riverfront and Fleet valley. In 1157, Henry II granted the Order of the Knights Templars land on the banks of the Fleet. They reclaimed large tracts on both sides of the river, narrowing the mouth of the Fleet (**HEA 1F**). Excavations at Blackfriars House (**HEA 7**), c. 115m to the north of the main site, uncovered two parallel east-west timber revetments, possibly contemporary with the reclamation. At 1–3 Tudor Street (**HEA 8**), c. 140m to the north of the main site, medieval wooden revetments were uncovered at a depth of 97.0m TD. The north-south revetment was supported on oak piles at 1m intervals. At the crossing of a sewer tunnel from Kingscote Street to Tudor Street (**HEA 11**), c. 165m north of the main site, timber bases were discovered on piles, driven into natural gravel and also aligned north-south, suggesting a possible dock or inlet.

E.4.22 During an excavation at the former City of London Boys' School (**HEA 12**), c. 100m to the north of the main site, infill material dating to the 12th century, and a gravel bank, representing the Thames and Fleet confluence was discovered, along with a riverside wall of chalk built on the contemporary foreshore. A foundation trench for the wall was shored by a wattle fence. This reclamation activity extended the foreshore by c. 50m. Excavation at 9–12 Bridewell Place, c. 180m to the north of the main site (outside the assessment area), recorded large-scale reclamation on the west bank of the Fleet; timber revetments were constructed using boat timbers.

E.4.23 An excavation carried out in 1985 at 167–179 Queen Victoria Street (**HEA 6**), c. 80m to the northeast of the main site, at the confluence of the Thames and Fleet revealed a substantial 13th–14th century, east-west aligned river wall, along the line of the medieval foreshore, along with infill deposits and stairs from the top of the wall to the foreshore. Compacted gravel had been laid on the foreshore and several mooring timbers were found. An excavation at the Mermaid Theatre (**HEA 60**), c. 80m to the north of the Blackfriars Pier site also revealed the timber base-plates for a front and back-braced timber revetment, forming a frontage onto the river, dated to c. 1240.

E.4.24 During an evaluation at 19–21 Tudor Street (**HEA 15**), c. 130m to the north of the main site, a stone river wall, documented as having been constructed in 1396, was uncovered, along with associated land reclamation deposits containing a large quantity of artefacts. In 1974 a series of riverfront revetments and associated features; including a ragstone-faced riverwall was recorded (**HEA 94**), c. 150m to the east of The Blackfriars Pier site.

E.4.25 On the south bank of the river, c. 200m to the south of the main site is the location of the former King's Barge House, which was in use in the medieval and post medieval periods (**HEA 2**).

E.4.26 Further later medieval remains recorded north of the site, landward of the river wall, include: deposits and pits (**HEA 96**), a wall (**HEA 106),** residual medieval pottery (**HEA 131**), 12th century backfilled clay pits (**HEA 137**), and medieval consolidation dumps (**HEA 139**).

Post-medieval period (AD 1485–present)

E.4.27 The site remained within the Thames channel in this period, although continued land reclamation increased advancement of the waterfront towards the site. Continued reclamation of the Fleet eventually led to its narrowing to a sewer which now flows beneath New Bridge Street, leading to Blackfriars Bridge. Five post-medieval features of historic interest have been identified within the site (**HEA 1A**–**1F**), including the Victoria Embankment (**HEA 1A**); a 19th century river wall designed by Joseph Bazalgette, along the northern boundary of the site; the 17th century canalised mouth of the River Fleet, now the Fleet Main sewer (**HEA 1F**), which lies beneath the northernmost arch of Blackfriars Bridge; and the President ship (**HEA 1C**), an early 20th century warship.

E.4.28 The location of the site within the river channel is confirmed by two 15th century shipwrecks, c. 70m and 100m to the east of the Blackfriars Pier site, respectively. Wreck 3 (**HEA 98**) was excavated in 1970, and comprised a clinker-built barge, approximately 16m long and 3m wide. Finds, consisting of pottery, shoes, two pewter pilgrim badges and lead fishing weights, dated the vessel to the 15th century. Wreck 4 (**HEA 147**) was also discovered in 1970 but not excavated; however, a provisional date of a 15th century sinking was allocated. Both ships were carrying Kentish ragstone, to be used as building material within the City.

E.4.29 The earliest substantial land-based structure was Bridewell Palace (**HEA 23**), the southern boundary of which was located c. 115m to the north of the main site. This was constructed in c. 1515–1520 for Henry VIII, in the area to the west of the confluence of the Thames and the Fleet, south of St. Bride's Church. The palace had a Long Gallery extending southwards, terminating in a wing running east-west along the waterfront (Dyson, 1987)[8]. The foundations of the northern wing of the palace were uncovered during an excavation in 1978 (outside the assessment area), along with the approximate location of the palace river wall and later waterfronts. Foundations were also uncovered at 1–3 Tudor Street (**HEA 8**), c. 140m to the north of the main site.

E.4.30 The palace (**HEA 23**) is shown on the riverfront to the north of the main site on Braun and Hogenburgs' map of 1572 (Vol 18 Plate E.6), with the southern extent of the building directly on the waterfront. In 1556, the City had taken possession of the palace and it was converted into a prison, hospital and workrooms. The site is located within the Thames, c. 100m to the south of the riverbank.

E.4.31 During an excavation at Unilever House (**HEA 4**), mid-16th century infill deposits were discovered, c. 90m to the north of the main site, and are thought to have been tipped onto the contemporary foreshore. An evaluation carried out at 19–21 Tudor Street (**HEA 15**), c. 130m to the north of the main site, uncovered remains associated with the extension of the Carmelite precinct (Whitefriars), where medieval land reclamation deposits were covered by further post-medieval ground raising. A late 16th or early 17th century jug and a decorated plate were discovered within a timber-lined pit during an excavation at Blackfriars House (**HEA 7**), c. 115m to the north of the main site.

E.4.32 Faithorne and Newcourt's map of 1658 (Vol 18 Plate E.7) shows both parts of the site within the Thames, c. 100m to the south of the waterfront at that time. There has been considerable development to the north and west of the site, with dense rows of houses and other buildings. The mouth of the Fleet is named 'Bridewell Dock', illustrating its commercial function. An excavation at Blackfriars House (**HEA 7**), c. 115m to the north of the main site, uncovered successive post-medieval waterfronts with dumps of infill material. Early 17th century burials were also discovered, belonging to a secondary graveyard associated with St. Bridget's (Bride's) main burial ground to the north.

E.4.33 A 17th century shipwreck (**HEA 100**; 'Blackfriars Wreck 2'), was discovered in 1962, adjacent to the eastern boundary of the Blackfriars Pier site. The vessel was approximately 14m long and 3m wide and sunk whilst carrying a load of bricks. Dating evidence in the form of pottery, clay pipes and wineglass stems suggest that the sinking was around the time of the Great Fire of 1666.

E.4.34 Ogilby and Morgan's map of 1676 (not reproduced due to incomplete coverage of the assessment area), produced during the reconstruction of the city following the Great Fire, is the first to give a relatively accurate scale, making it easier to estimate the location of the site in relation to the 17th century waterfront. The site lay within the Thames, c. 80–100m to the south of the riverbank. A cluster of boats is shown at the mouth of the Fleet, called the 'New Canal', illustrating its continued commercial use. There is a contrast between the spaciously laid out commercial and residential buildings fronting the river and canal, and the tightly packed building plots to the north of the Temple and Bridewell. Most of the 16th century buildings were destroyed during the Great Fire of 1666 and many subsequently rebuilt. The map shows the former site of the southern galleries of Bridewell Palace replaced with wharf buildings and yards. Archaeological evidence for the fire was recorded during an excavation (**HEA 12**), c. 100m to the north of the main site, where a burnt horizon sealed earlier reclamation infill and revetments. Post-1666 timber revetments and extensive timber piling revealed the construction of new quays here.

E.4.35 Rocque's map of 1746 (Vol 18 Plate E.8) shows the site c. 80m to the south of the riverfront, illustrating the extent of the southward extension of the waterfront in the late 17th and early 18th centuries. In contrast to earlier maps, the importance of the Fleet as a commercial route had clearly begun to decline. It had narrowed and was now named the 'Fleet Ditch'. To the north of Fleet Bridge, it had begun to be built over, creating a new market area. The beginnings of industrialisation within the area are also shown, with a 'Glass House' (**HEA 26**), c. 200m to the north of the main site. This was constructed in c. 1680 and later became Powell's (Whitefriars) Glass Company. It was one of numerous industries along the Fleet.

E.4.36 Horwood's map of 1799 (Vol 18 Plate E.9) shows the site located in the River Thames, c. 50m to the south of the then riverfront. The original Blackfriars Bridge, built in 1760, had been constructed on the site of the

current bridge, and the Thames/Fleet confluence (**HEA 1F**), as well as the Fleet itself, has been entirely built over, to create an approach over New Bridge Street. An evaluation carried out at Bridge House, 181 Queen Victoria Street (**HEA 3**), uncovered substantial structural remains, including foundations of Portland stone, associated with the 1760 bridge, or with Chatham Place, a contemporary square constructed to the north of the bridgehead.

E.4.37 The original Blackfriars Bridge was largely demolished and replaced with the current structure in 1869. The London, Dover and Chatham Railway, running across the Thames, adjacent to the site, c. 15m to the east, was constructed in 1862 and removed in 1985. Its westernmost bridge piers survive adjacent to the east of the main site (**HEA 41**).

E.4.38 The Ordnance Survey (OS) 1st edition 25" scale map of 1875 (Vol 18 Plate E.10) shows the main site in its present location, adjacent to the Victoria Embankment, with c. 10m of exposed foreshore at high tide. The embankment was constructed in 1865–1870 by Joseph Bazalgette as part of London's sewage improvements (this project-wide theme is discussed in the route overview, Volume 1). Its construction necessitated building out onto the foreshore, from the 1865 to the current waterfront, an extension of c. 50m, as revealed during excavations at the former City of London Boys' School (**HEA 12**). In the eastern part of the site, modifications to the bridgehead were carried out to enable the construction of a subway. A tunnel was built for the Metropolitan District Railway within the embankment and roofed over to support the road and tramway shown on the map, adjacent to the river wall. The OS map also shows The City of London (Blackfriars) Gas Works (**HEA 25**), constructed at the beginning of the 19th century occupying a large area c. 110m to the north of the main site. The Blackfriars Pier site continues to lie partially submerged and partially on the foreshore, c. 30m to the south of a row of wharfs.

E.4.39 The OS 2nd edition 25" scale map of 1896 (Vol 18 Plate E.11) shows no changes to the site. In the northern part of the assessment area, the gas works had been replaced with the Duke's Theatre and the City of London Boys' School (**HEA 12**). A number of Grade II listed buildings and other structures (**HEA 1I, 32**–**46**) which front the Victoria Embankment or lie within the vicinity of the site were constructed immediately prior to the production of this map.

E.4.40 The OS 3rd edition 25" scale map of 1916 (Vol 18 Plate E.12) shows the main site as still undeveloped other than a 'Fire Brigade Pier' constructed on the foreshore. In 1907–1910, Blackfriars Bridge was widened to cope with increasing traffic. The widened bridge is shown on the map with a tramline running along its western side, leading from the Victoria Embankment. It is clear from the map that the street layout to the north of the main site had become much more formal and regularised in the late 19th/early 20th century in comparison to the early 19th and preceding centuries. The Blackfriars Pier site and its surroundings, by contrast, has changed little in the last 40 years, and continues to lie on the undeveloped foreshore, c. 30m to the south of a row of commercial docks and wharves.

E.4.41 The OS 25" scale map of 1947 (Vol 18 Plate E.13) shows a new pier structure (**HEA 1G**) in the eastern part of the main site, c. 10m to the west of the earlier Fire Brigade Pier, with a pump house and associated access ramps. This is likely to be the 'timber and iron jetty' (**HEA 1D**) with associated hand crane (**HEA 1E**), listed on the GLHER, as these do not appear to exist on earlier maps. The map shows a pier in the western part of the site, which was construction in the early 1920s and used as a mooring point for the President ship (**HEA 1C**). The Blackfriars Pier site remains unchanged.

E.4.42 Later OS maps (not reproduced) show construction of an underpass and realigned river wall in the 1960s and the construction of the Blackfriars Millennium Pier in the centre of the site in 2000.

The current site

E.4.43 The majority of the foreshore within the main site, adjacent to the Victoria Embankment (**HEA 1A**) (Vol 18 Plate E.14 and Vol 18 Plate E.15), currently lies unused, with the greater part usually submerged beneath the River Thames. The eastern end of the main site, on which the northern approach to Blackfriars Bridge (**HEA 1I**) is situated (Vol 18 Plate E.16 E. 16), and the section of foreshore comprising the Blackfriars Pier site (currently unused), lies above water level at low tide. An outfall gate opens beneath the bridgehead, discharging water from the now canalised Fleet sewer (**HEA 1F**) (Vol 18 Plate E.17). The Blackfriars Millennium Pier (a floating pontoon) and associated access steps, ramp and an earlier pump house structure (**HEA 1G**) are located in the eastern part of the main site, and the President ship (**HEA 1C**) (Vol 18 Plate E.18) is moored in the centre.

E.4.44 During the site visit the truncated remains of round timbers (**HEA 1B**) were noted immediately adjacent to the Victoria Embankment river wall on an east-west alignment, (Vol 18 Plate E.19), exposed within the main site at low tide. These are likely to be post medieval and related to the cofferdam used in the construction of Bazalgette's river wall.

E.5 Plates

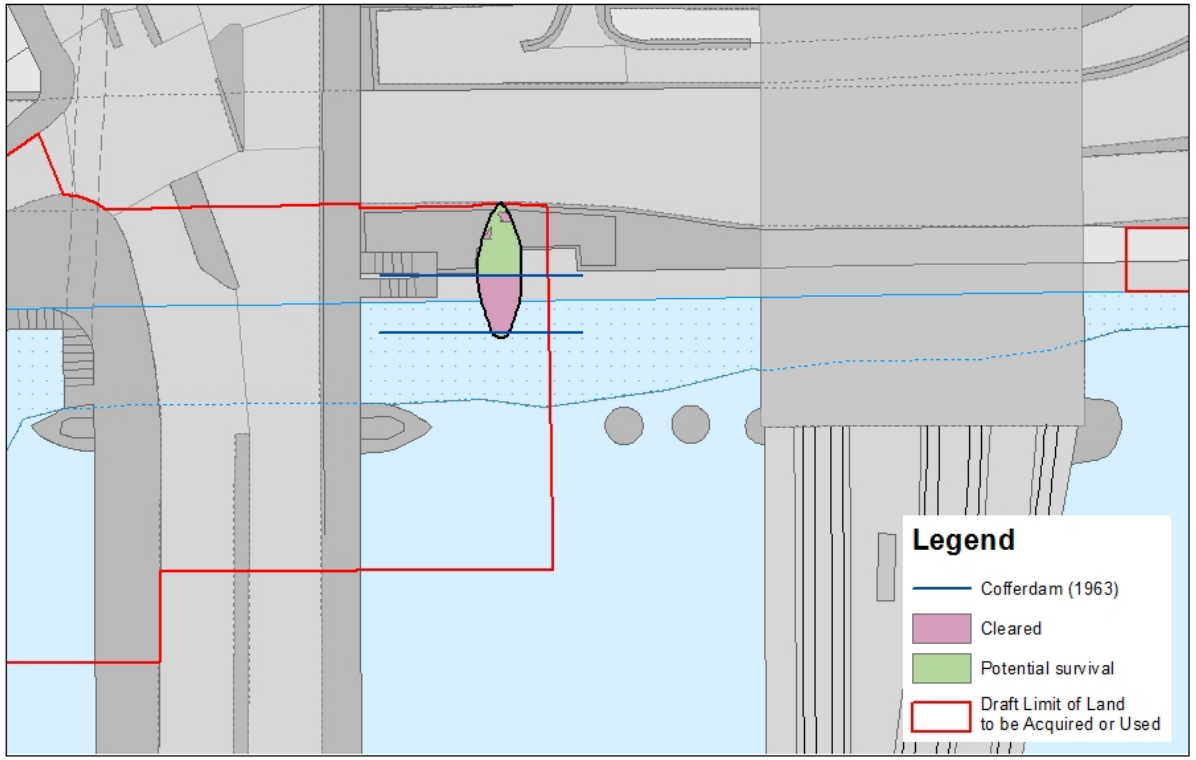
Vol 18 Plate E.1 Historic environment – Gantry constructed as part of the Blackfriars Bridgehead Improvement Scheme

** A gantry (constructed as part of the Blackfriars Bridgehead Improvement Scheme) located on the foreshore in 1962; looking east beneath Blackfriars Bridge. 'Blackfriars Wreck 2' was discovered further to the east of this gantry, on the other side of the bridge; (Guildhall Museum 1962)*

Vol 18 Plate E.2 Historic environment – The approximate location of the Roman ship wreck

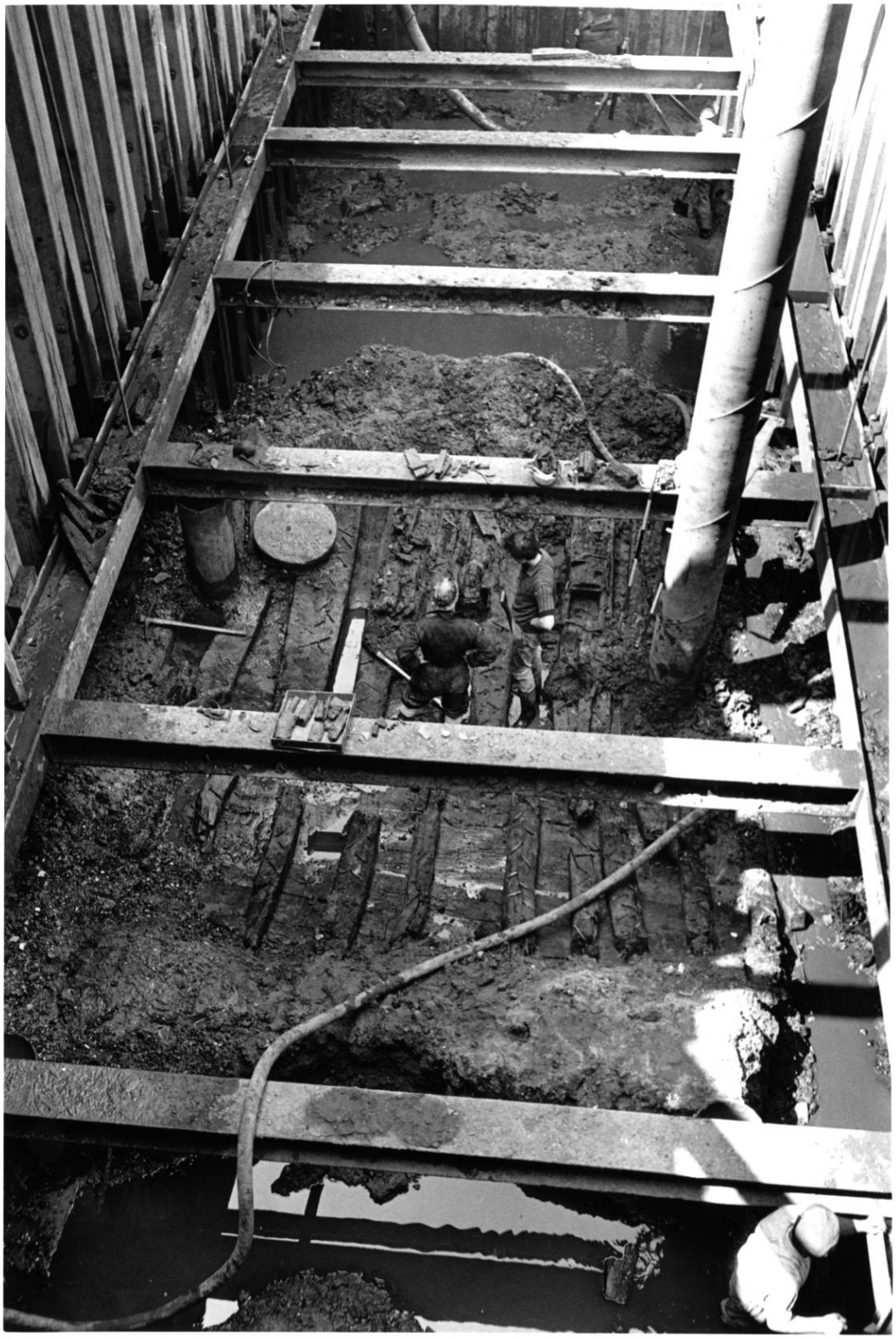
** The wreck is shown in relation to a gantry constructed as part of the Blackfriars Bridgehead Improvement Scheme. Water is being pumped from the bow section of the wreck, as part of the initial phase of excavation in 1962, prior to the construction of a cofferdam in 1963; (Guildhall Museum 1962)*

Vol 18 Plate E.3 Historic environment – The location of the Roman shipwreck in relation to the modern riverwall



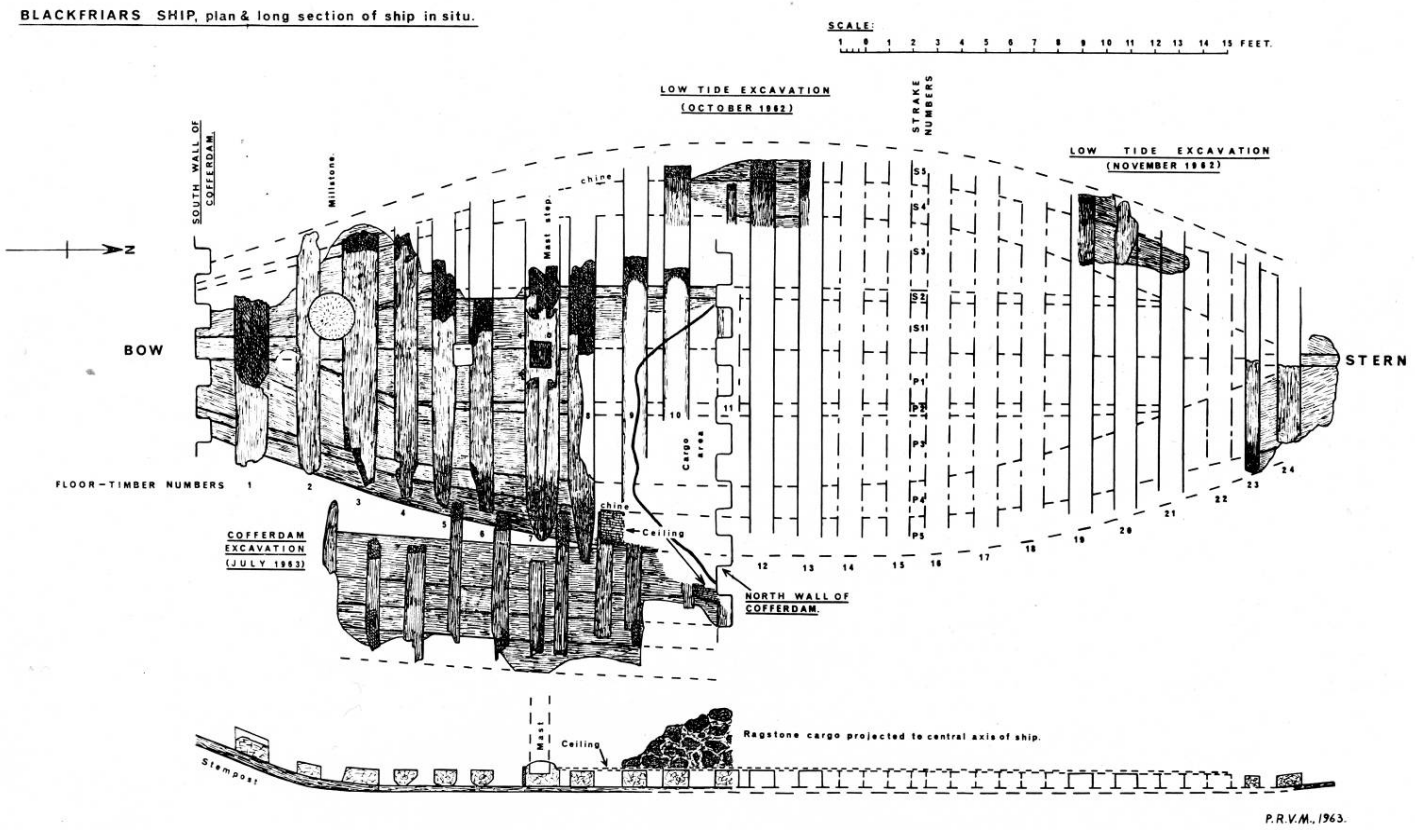
** The figure shows cleared, and potentially surviving, sections of the wreck which correspond to the location of the 1963 cofferdam used to excavate the bow section of the vessel; (MOLA 2011)*

Vol 18 Plate E.4 Historic environment – The Roman shipwreck being excavated within a cofferdam on the foreshore in 1963.

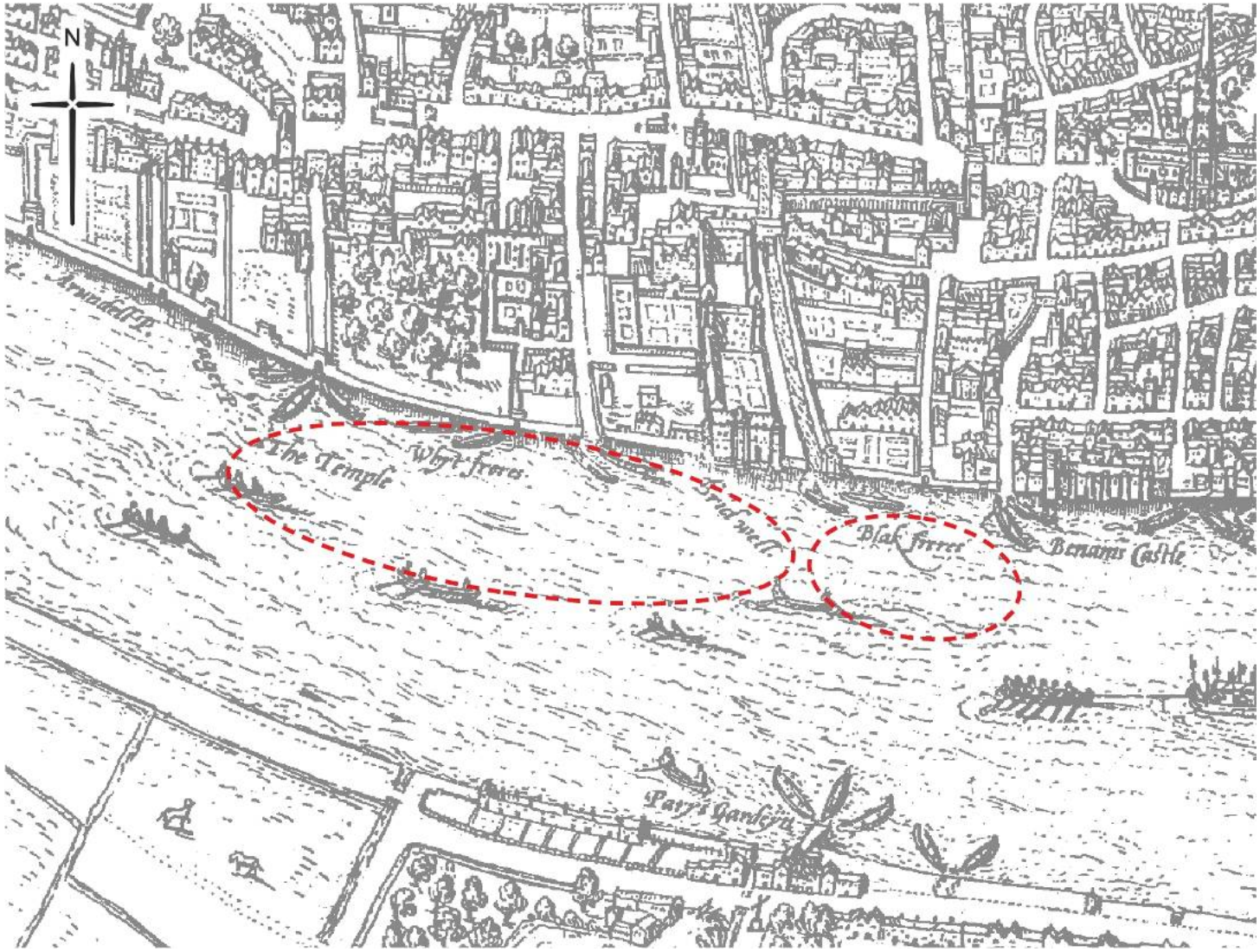


** Water pumps were used to remove overlying gravel and expose the ship's timbers. (Guildhall Museum 1963)*

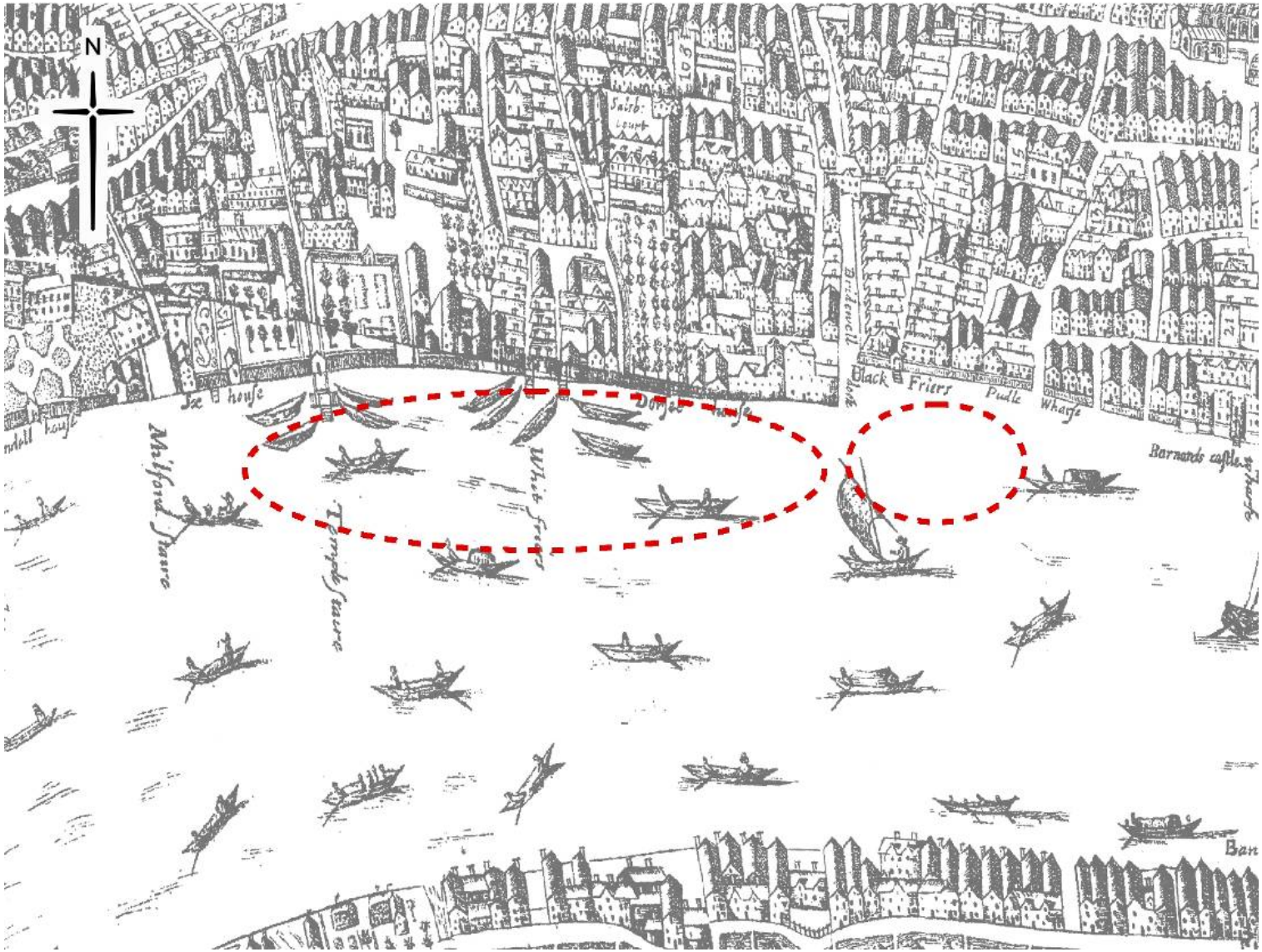
Vol 18 Plate E.5 Historic environment – A plan of the Roman ship wreck, showing the excavated sections of the wreck; the extent of low tide and cofferdam excavations and the unexcavated section of the bow (Guildhall Museum 1963)



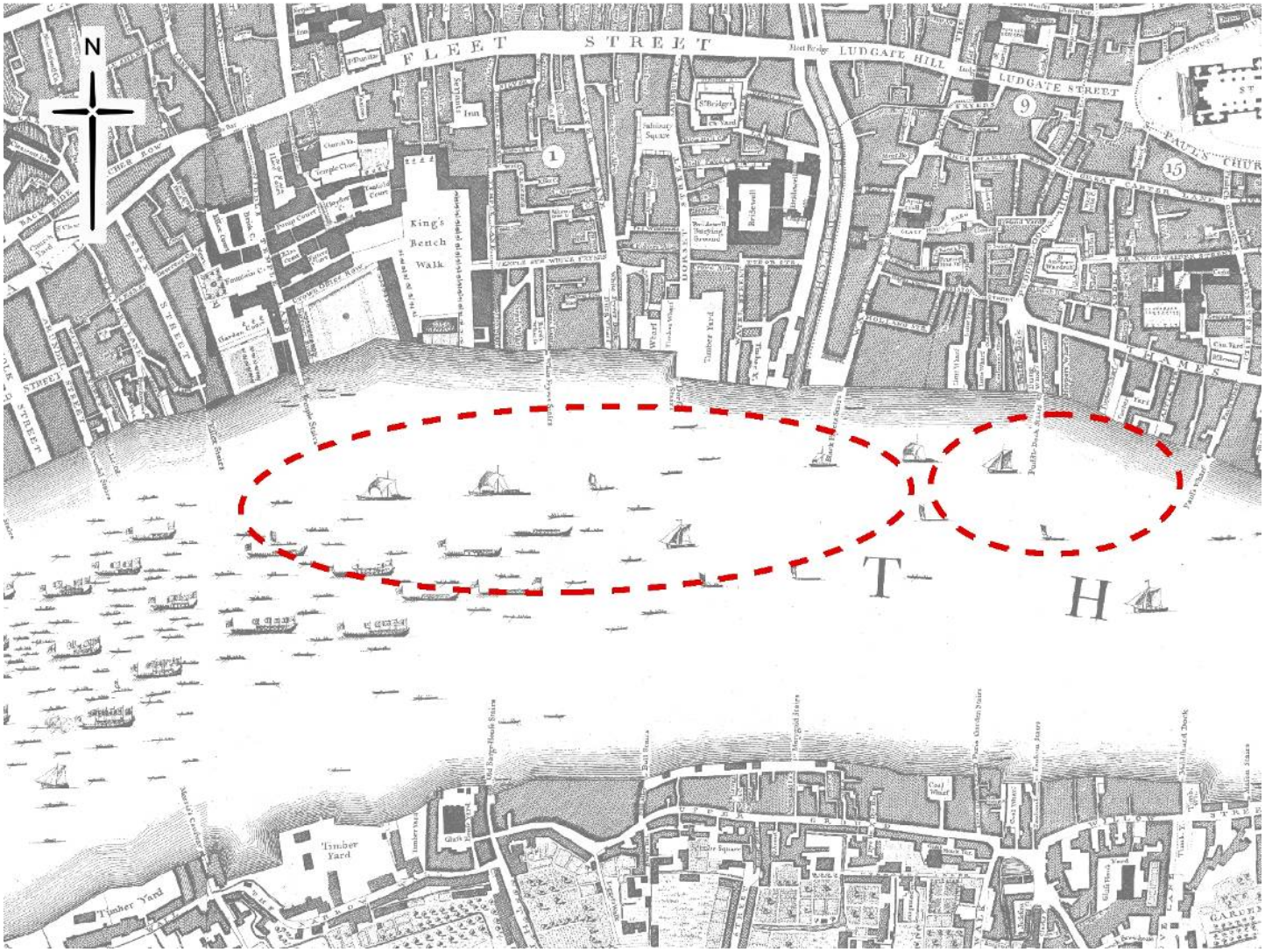
Vol 18 Plate E.6 Historic environment – Braun and Hogenburg map of 1572



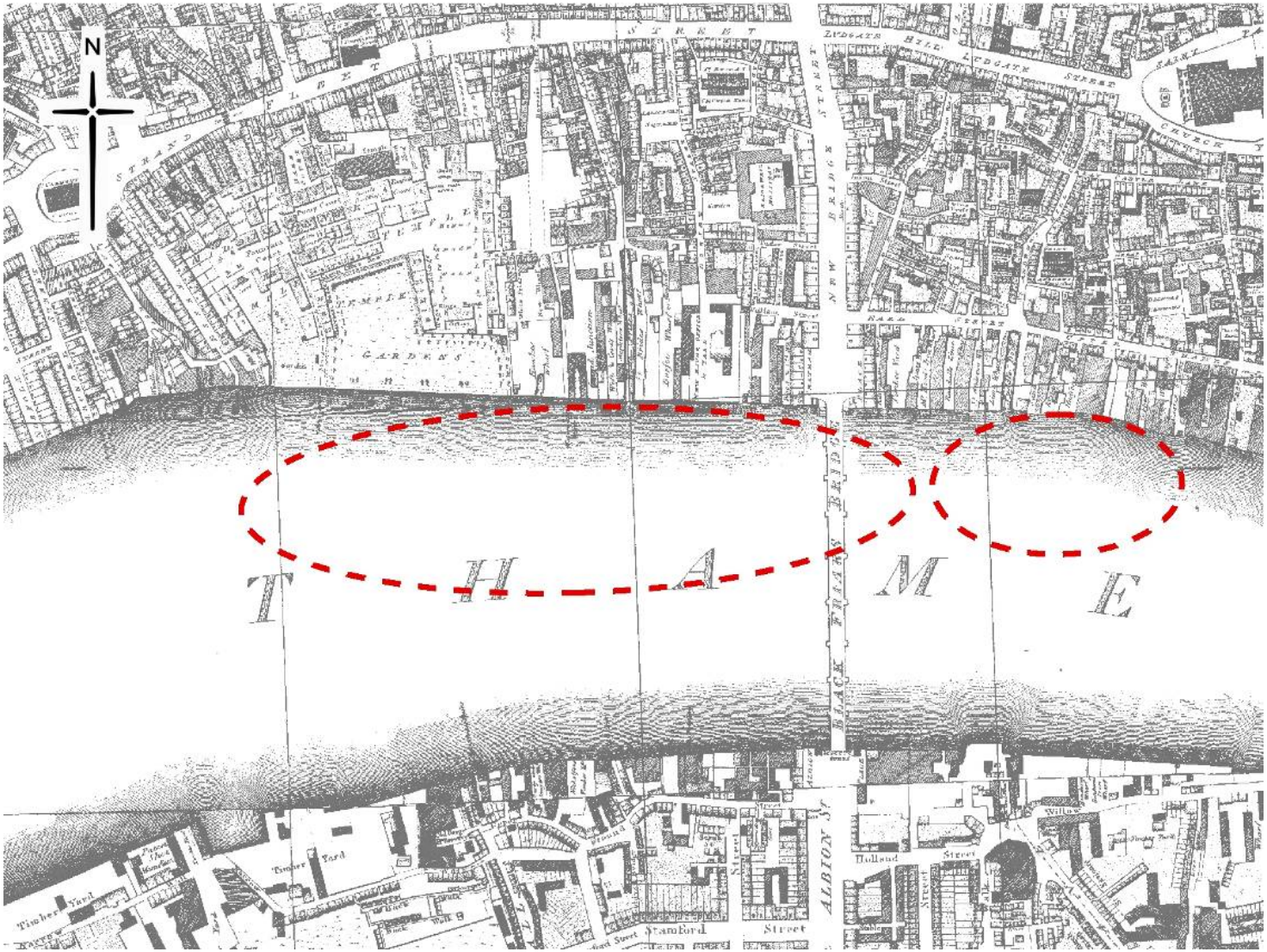
Vol 18 Plate E.7 Historic environment – Faithorne and Newcourt map of 1658



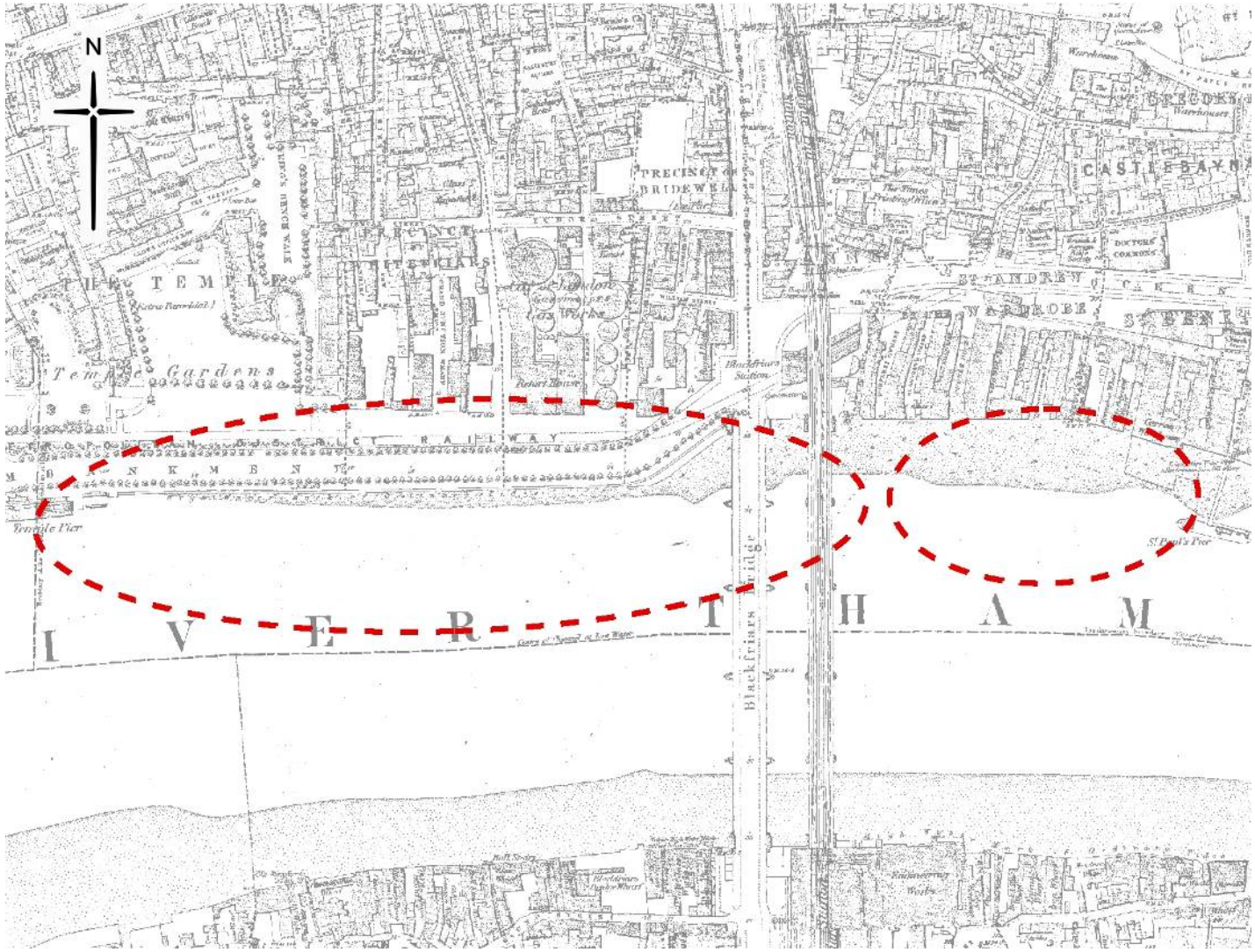
Vol 18 Plate E.8 Historic environment – Rocque's map of 1746



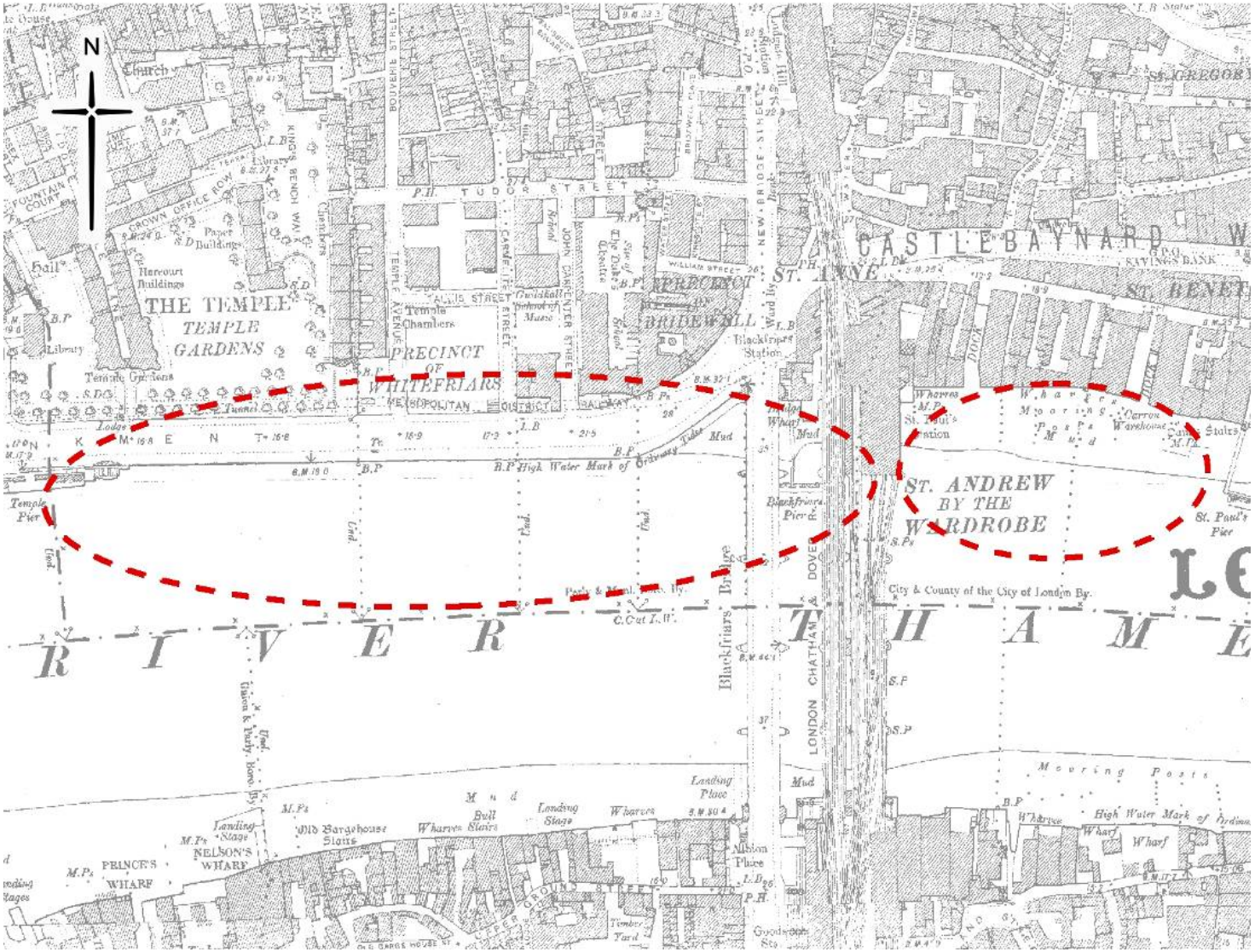
Vol 18 Plate E.9 Historic environment – Horwood's map of 1799



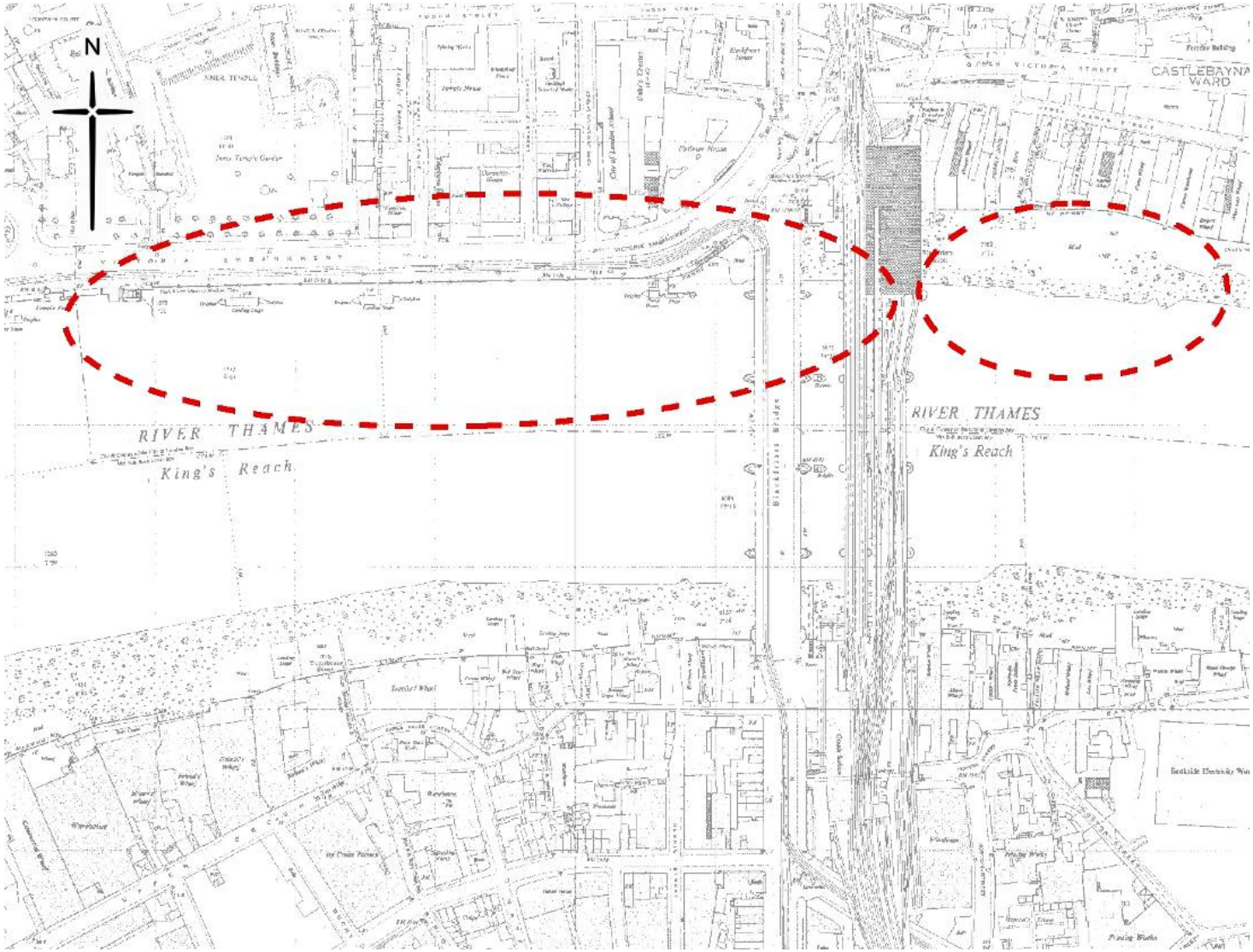
Vol 18 Plate E.10 Historic environment – Ordnance Survey 1st edition 25” scale map of 1862 (not to scale)



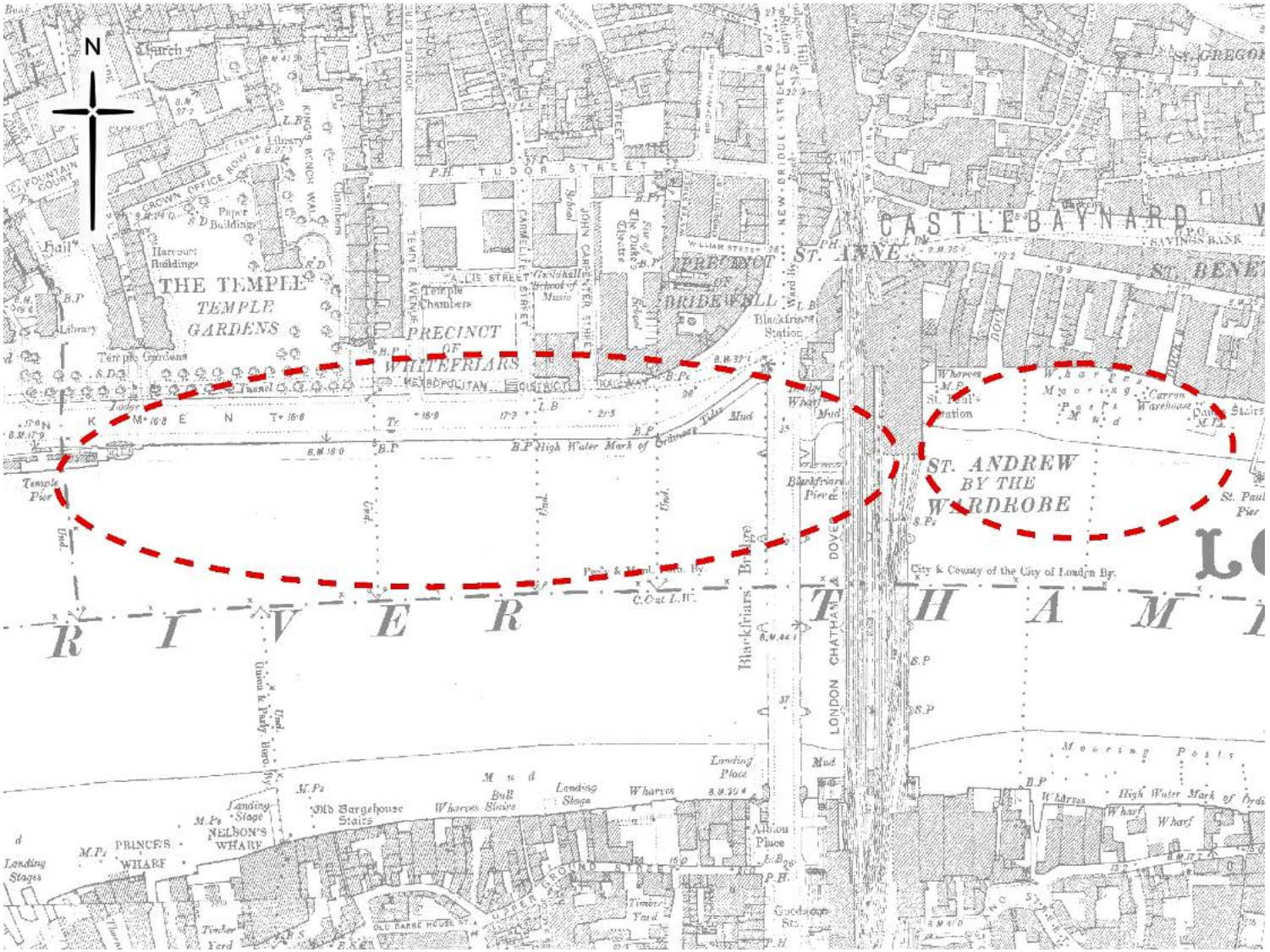
Vol 18 Plate E.11 Historic environment – Ordnance Survey 2nd edition 25” scale map of 1896 (not to scale)



Vol 18 Plate E.12 Historic environment – Ordnance Survey 3rd edition 25” scale map of 1909 (not to scale)



Vol 18 Plate E.13 Historic environment – Ordnance Survey 25” scale map of 1947 (not to scale)



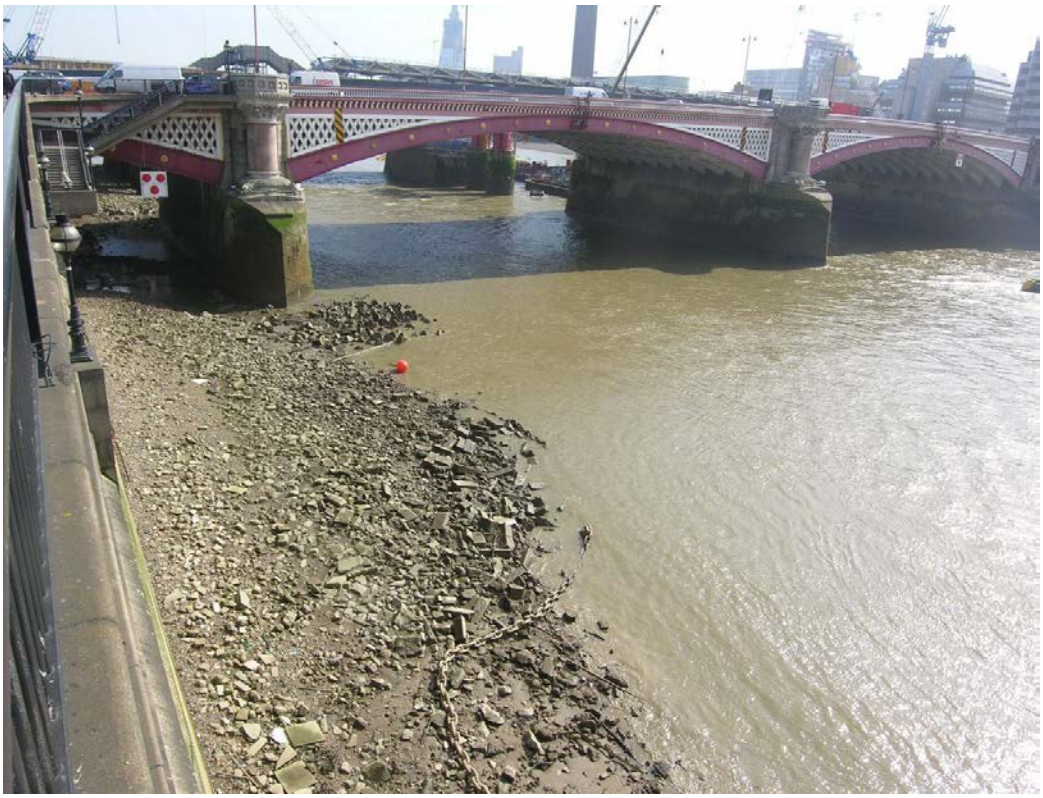
Vol 18 Plate E.14 Historic environment – Bazalgette's Victoria Embankment wall of Cornish granite

** March 2011; standard lens, looking west within the main site (MOLA 2011)*

Vol 18 Plate E.15 Historic environment – Part of Bazalgette's embankment wall, with a typical lion's head and a cast iron lamp

** March 2011; standard lens, looking north from within the main site (MOLA 2011)*

Vol 18 Plate E.16 Historic environment – The Grade II listed Blackfriars Bridge



** March 2011; standard lens, looking south-east from Victoria Embankment, within the site (MOLA 2011)*

Vol 18 Plate E.17 Historic environment – Fleet sewer outfall gates beneath the northern bridgehead of Blackfriars Bridge

** March 2011; standard lens, looking north-west from within the main site (MOLA 2011)*

Vol 18 Plate E.18 Historic environment – The President ship

** March 2011; standard lens, looking west from the embankment wall towards the western part of the site (MOLA 2011)*

Vol 18 Plate E.19 Historic environment – Remains of post-medieval wooden piles adjacent to the embankment wall from within the site

** March 2011; standard lens, looking north from within the main site (MOLA 2011)*

References

[1] Some sources consider the Fleet would have been c. 180m wide at its mouth; Barton N. *The Lost Rivers Of London*. Historical Publications, London (1992).

[2] British Geological Survey solid and drift geology, sheet 256.

[3] British Geological Survey digital data.

[4] Rackham J and Sidell EJ. *London's Landscapes: the changing environment*. In The Archaeology of Greater London. Museum of London Archaeology Service Monograph (2000).

[5] Rackham J and Sidell EJ. See citation above.

[6] Brigham T. *The Late Roman Waterfront in London*. In Britannia Vol. 21 (1990).

[7] Cowie R and Blackmore L. *Early and Middle Saxon rural settlement in the London region*. Museum of London Archaeology Service Monograph 41 (2008), xv.

[8] Dyson T. *The Medieval London Waterfront*. Museum of London (1987).

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Thames Tideway Tunnel
Thames Water Utilities Limited

Application for Development Consent

Application Reference Number: WWO10001

Environmental Statement

Doc Ref: **6.2.18**

Volume 18 Blackfriars Bridge Foreshore appendices

Appendix F: Land quality

APFP Regulations 2009: Regulation **5(2)(a)**

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Thames Tideway Tunnel

Environmental Statement

Volume 18 Blackfriars Bridge Foreshore appendices

Appendix F: Land quality

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Appendix F: Land quality

F.1 Baseline report

F.1.1 Baseline data is sourced from:

a. walkover survey

b. the Landmark Information Group database, which includes historic maps and environmental records

c. stakeholder consultation

d. the initial results from a preliminary intrusive ground investigation.

Site walkover

F.1.2 A site walkover was undertaken on 4th November 2010.

F.1.3 The aim of the walkover survey was to inspect the condition of the site and surrounding areas in order to identify evidence of historic or ongoing contamination sources, as well as any nearby sensitive receptors.

F.1.4 No potential contaminative sources were identified during the survey. No tidal outflows were visible within the river wall at the time of the survey.

F.1.5 Detailed site walkover notes are provided in Vol 18 Table F.1 below.

Vol 18 Table F.1 Land quality – site walkover report

Item (Site ref: PCL1X, Blackfriars Bridge Foreshore and Blackfriars Pier)		Details
Date of walkover	4th November 2010	
Site location and access	The site comprises two areas, the main site (Blackfriars Bridge Foreshore) and an associated site (Blackfriars Pier). Both situated on the foreshore of the River Thames, along the Victoria Embankment (A3211), City of London, the site is located on both sides of Blackfriars Bridge (A201).	
Size and topography of site and surroundings	Record elevation in relation to surroundings, any hummocks, breaks of slope etc.	The site forms the foreshore of the River Thames.
Neighbouring site use (in particular note any potentially contaminative activities or sensitive receptors)	North	The area is heavily trafficked and its character is predominantly commercial, with some residential areas and educational facility situated northwest. Immediately north of the site is the Blackfriars underpass which runs parallel to the site boundary. Inner Temple Gardens located north

Item (Site ref: PCL1X, Blackfriars Bridge Foreshore and Blackfriars Pier)		Details
	South	Bordered by the River Thames.
	East	Blackfriars Rail bridge used by national rail trains running between Blackfriars and London Bridge or Elephant and Castle. River Thames also located to the east.
	West	River Thames and Victoria Embankment.
Site buildings	Record extent, size, type and usage. Any boiler rooms, electrical switchgear?	Fixed structures including Blackfriars Millennium Pier (which would be permanently relocated) and the President (a stationary vessel used as a river dining venue) which is accessed from the river embankment by a walkway.
Surfacing	Record type and condition	Foreshore; sand, gravels and mud.
Vegetation	Any evidence of distress, unusual growth or invasive species such as Japanese Knotweed?	None observed
Services	Evidence of buried services?	None observed
Fuels or chemicals on-site	Types/ quantities?	None observed
	Tanks (above ground or below ground)	None observed
	Containment systems (e.g. bund, drainage interceptors). Record condition and standing liquids	None observed
	Refill points located inside bunds or on impermeable surfaces etc?	None observed
Vehicle servicing or refuelling onsite	Record locations, tanks and inspection pits etc.	None observed
Waste generated/stored onsite	Adequate storage and security? Fly tipping?	None observed

Item (Site ref: PCL1X, Blackfriars Bridge Foreshore and Blackfriars Pier)		Details
Surface water	Record on-site or nearby standing water	River Thames
Site drainage	Is the site drained, if so to where? Evidence of flooding?	No tidal outflows were visible within the river wall at the time of the survey.
Evidence of previous site investigations	Eg, trial pits, borehole covers.	None observed
Evidence of land contamination	Evidence of discoloured ground, seepage of liquids, strong odours?	None observed
Summary of potential contamination sources		No potential contamination sources were identified during the survey
Any other comments	Eg, access restrictions/ limitations	No

Review of historical contamination sources

F.1.6 Historical mapping (dated between 1878 and 1990) has been reviewed in order to identify potentially contaminating land-uses at the site and within the 250m assessment area.

F.1.7 Vol 18 Table F.2 tabulates the potentially contaminating land-uses, inferred dates of operation and typical contaminants associated with the land-uses in question. Information on potential contaminants are sourced from CLR8: *Potential contaminants for the assessment of land* (Defra and EA, 2002)[1] and former Department of the Environment industry profiles (Department of the Environment, 2011)[2].

F.1.8 All dates are approximate, where no other information is available the dates relate to when the items first appeared and disappeared from the mapping rather than actual dates of construction, operation or demolition.

F.1.9 Items listed in the table below are also shown in Vol 18 Figure F.1.1 (see separate volume of figures). In addition, figures illustrating the historical environment of the site and surrounding area are provided in Vol 18 Appendix E.

Vol 18 Table F.2 Land quality – potentially contaminating land-uses

Ref	Item*	Inferred date of operation	Potentially contaminative substances associated with item[1,2]
On-site			
None			
Off-site			
1	Blackfriars National Rail Station and Rail Bridge (5m west)	c1878-present	Polyaromatic hydrocarbons (PAHs), heavy metals, phenols, sulphates, fuel oil, lubricating oil, greases, polychlorinated biphenyls (PCBs), solvents, asbestos, chlorinated aliphatic hydrocarbons
2	City of London Gas Works and Retort House (40m north)	c1878-c1896	Heavy metals, arsenic, Complex and free cyanide, sulphates, asbestos, phenol, PAHs
3	Gasometer (50m north)	c1878-c1896	
4	Paper buildings (110m north)	c1896-c1965	PCBs , dioxins, furans, chlorinated phenols, organosulfur compounds, various heavy metals (zinc, lead, chromium), cyanide
5	Wharves and landing stages (northern and southern bank of the River Thames)	c1896-c1962	Heavy metals, arsenic, asbestos, phenols, oil/fuels, hydrocarbons, PAHs, PCBs, sulphide, sulphate, chlorinated aromatic hydrocarbons, chlorinated aliphatic hydrocarbons
6	Puddle Dock (12.5m north)	c1896-present	Heavy metals, arsenic, asbestos, phenols, oil/fuels, hydrocarbons, PCBs, PAHs, sulphide, sulphate, chlorinated

Ref	Item*	Inferred date of operation	Potentially contaminative substances associated with item[1,2]
			aromatic hydrocarbons, chlorinated aliphatic hydrocarbons
7	Printing works (160m north)	c1916	PCBs, dioxins, furans, chlorinated phenols, organosulfur compounds, various heavy metals (zinc, lead, chromium), cyanide Silver; solvents; acids; waste oils; inks and dyes; photographic chemicals
8	Glass works (185m north)	c1916	Heavy metals and metalloids, asbestos, oil/fuels, hydrocarbons
9	Hospital (185m north)	c1916-c1951	Radioactive isotopes, pathogens, polyaromatic hydrocarbons and dioxins associated with incinerators
10	Printing works (135m north)	c1951-c1952	PCBs, dioxins, furans, chlorinated phenols, organosulfur compounds, various heavy metals (zinc, lead, chromium), cyanide Silver; solvents; acids; waste oils; inks and dyes; photographic chemicals
11	Electrical substation (205m north)	c1951-c1990	Oils, PCBs
12	Various works (110m northwest)	c1878	Heavy metals, arsenic, boron, nitrates, sulphates, sulphides, asbestos, aromatic

Ref	Item*	Inferred date of operation	Potentially contaminative substances associated with item[1,2]
			hydrocarbons, chlorinated aliphatic hydrocarbons, PCBs
13	Temple Station (180m west)	c1896	PAHs, heavy metals, phenols, sulphates, fuel oil, lubricating oil, greases, PCBs, solvents, asbestos, chlorinated aliphatic hydrocarbons
14	Engineering works (220m south)	c1878	Heavy metals, arsenic, boron, nitrates, sulphates, sulphides, asbestos, aromatic hydrocarbons, chlorinated aliphatic hydrocarbons, PCBs

*items measured from nearest site to land-use

On-site

F.1.10 The historical mapping has identified no contaminative on-site uses. Records show the site to have remained the foreshore and banks of the River Thames.

Off-site

F.1.11 Within the 250m assessment area, the historical mapping has identified pockets of historical industrial activities in the vicinity of the site that in most cases have ceased.

F.1.12 The nearest current potential contamination source relates to railway land, which is a passenger terminal and rail bridge and thus is not considered to be a major ongoing pollution source that may affect the site.

Geology

F.1.13 Data from the Thames Tideway Tunnel project ground investigation indicates the anticipated geological succession, as summarised in Vol 18 Table F.3 below.

Vol 18 Table F.3 Land quality – anticipated site geology

Geological unit/ strata	Description	Approximate depth below river bed level (m)
Alluvium	Soft silty clay with	0.0 – 1.50

Geological unit/ strata	Description	Approximate depth below river bed level (m)
	occasional organic growth	
River terrace Deposits	Medium dense to dense sand and gravel (predominantly quartz sand and flint gravel).	1.50-3.50
London Clay	Slightly silty and sandy clay	3.50-29.66
Harwich Formation	Sand and shelly sandstone	29.66-29.98
Lambeth Group (Sand Unit)	The Lower and Upper Mottled Beds comprise mottled or multicoloured, stiff or very stiff fissured clay, compact silt, and dense or very dense sand Upnor Formation is a fine grained glauconitic sand	29.98-32.48
Lambeth Group (Upper Mottled Beds)		32.48-36.98
Lambeth Group (Laminated Beds)		36.98-37.73
Lambeth Group (Lower Shelly Beds)		37.73-38.28
Lambeth Group (Lower Mottled Beds)		38.28-41.95
Lambeth Group (Lower Mottled Beds)gravel)		41.95-44.02
Lambeth Group (Upnor Formation)		44.02-47.48
Thanet Sand Formation	Generally dense glauconitic silty fine sand with occasional rounded flint gravel. The base of the Thanet Sand is marked by rounded flints known as the Bullhead Beds.	47.48-57.75
Chalk Group (Seaford Member)	Weak fine grained limestone with nodular and tabular flints.	57.75-unproven

Unexploded ordnance

F.1.14 During World Wars I and II, the London area was subject to bombing. In some cases bombs failed to detonate on impact. During construction works Unexploded Ordnance (UXO) are sometimes encountered and require safe disposal.

F.1.15 A desk based assessment for UXO threat was undertaken at the Blackfriars Bridge Foreshore site (Vol 18 Appendix F.3). The report

reviews information sources such as the Ministry of Defence (MoD), Public Records Office and the Port of London Authority (PLA).

F.1.16 The report identified two high explosive strikes within Area A and none in Area B. Additionally four strikes occurred within the buffered site boundary and a further 24 recorded within 100m of the buffered site boundary.

F.1.17 The site (consisting of two areas as described in Vol 18 Table F.1) was given a high risk rating.

Thames Tideway Tunnel ground investigation data

F.1.18 This section summarises the ground investigation undertaken by the Thames Tideway Tunnel project.

F.1.19 Vol 18 Figure F.1.2 (see separate volume of figures) identifies boreholes excavated in vicinity of the site. These are not considered relevant to the contamination status of the site, either due to their distance from the proposed combined sewer overflow (CSO) drop shaft location or because certain boreholes were excavated purely for geotechnical purposes.

Soil contamination testing

F.1.20 No contamination testing was undertaken within the terrestrial limits of land to be acquired and used. See para. F.1.25 for sediment quality within the foreshore environment.

Soil gas testing

F.1.21 No soil gas testing was undertaken at or in the immediate vicinity of the site.

F.1.22 Whilst alluvial soils that may underlie the site can be the source of elevated carbon dioxide/methane (associated with the organic rich horizons), they would be expected to be saturated for a large proportion of time and are not considered to represent a major gassing source.

Groundwater contamination data

F.1.23 No groundwater quality data was available in the immediate vicinity of the site.

F.1.24 Refer to Section 13 Water resources – groundwater of this volume for further information.

Sediment quality testing

F.1.25 At the Blackfriars Bridge Foreshore main site, sediment samples retrieved from borehole SR2047 and analysed for a suite of metal and PAH contaminants. The results were compared against the 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].

F.1.26 The results of the analysis showed that a very slightly elevated arsenic concentration above the TEL.

F.1.27 No results were recorded as having contaminant values above the PEL.

Third party ground investigation data

F.1.28 No third party ground investigation was available for review at both the Blackfriars Bridge Foreshore (main and pier) sites.

Other environmental records

F.1.29 Details of environmental records (hazard and waste sites) in the vicinity of the site held by the Environment Agency (EA) and other bodies have been obtained from the Landmark Information Group and are presented in Vol 18 Table F.4. Pertinent records are discussed in further detail below.

F.1.30 The location of these records is shown in Vol 18 Figure F.1.3 (see separate volume of figures).

Vol 18 Table F.4 Land quality – hazard and waste sites

Item	On-site	Within 250m of site boundary
Active integrated pollution prevention and control	0	0
Control of major accident hazard sites	0	0
Historical landfill site	0	0
LA pollution prevention and control	0	0
Licensed waste management facility	0	0
Notification of installations handling hazardous substances	0	0
Past potential contaminated industrial uses	Areas of past potential contaminated industrial uses are present on-site and within 250m.	
Pollution incident to controlled water*	1	6
Registered waste transfer site	0	0
Registered waste treatment or disposal site	0	0

**Does not include regular CSO discharges*

F.1.31 Inspection of the data has identified one pollution incident to controlled water recorded as being present within the boundary of the site.

F.1.32 Both on-site and within 250m of the site are areas recorded as having past potential contaminated industrial uses present. These refer to the previous gas works to the north, Blackfriars Station and industries located on the southern bank of the river as shown on Vol 18 Figure F.1.1 (see

separate volume of figures). Contaminants associated with these types of previous land-use are identified in Vol 18 Table F.2.

F.1.33 There are also six recorded pollution incidents to controlled waters; these are from sewage and other substances entering the river as indicated in the local authority consultation below.

Land quality data from local authority

F.1.34 Consultation with the City of London Corporation Environmental Health department was undertaken as part of the baseline data gathering and identified that the study site itself and adjacent sites have not been identified for inspection or further review under the City's Contaminated Land Strategy.

F.1.35 The City of London Corporation provided detail of three potential pollution incidents within the 80m search area, which are as follows:

a. sewage was released into the Thames in June 1993

b. oil spill into the Thames in January 1997

c. fire fighting runoff released into the Thames in June 2001.

F.1.36 It should be noted that although the City of London Corporation keeps records of occasional sewage discharges to the river, the majority of regular discharges are not recorded by the council and do not appear in the above consultation.

F.1.37 As identified in Section F.2, the City of London Corporation holds one record of an environmental report produced at one site within 80m of the search area. This was produced by Environ in 2002 for a site at Puddle Dock. The response from the City of London Corporation states that mitigation was not proposed at the site, due to the low risk from soil contamination.

F.1.38 The City of London Corporation response is provided in full within Section F.2.

Summary of contamination sources

F.1.39 Following the review of the baseline data, the following sources of on-site contamination which may impact on the construction of the proposed development have been identified:

a. historic contamination of foreshore sediments – potential minor PAH and metals contamination of soils/sediments in comparison with PLA guidance for protection of aquatic organisms

b. CSO discharge – sewage (bacteriological) contamination of sediments

c. potential UXO.

F.1.40 Following the review of the baseline data no viable off-site contamination sources have been identified.

F.2 Local authority consultation

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Philip Everett, BSc, CEng, MICE
Director of Environmental Services

CITY OF LONDON

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Your ref 276212/IA/MA
Our ref WK/201013101

Date 4 January 2011

Dear Dino

Blackfriars Bridge Foreshore Contaminated Land Information

Thank you for your enquiry concerning the environmental conditions of the above site in the City of London. Please note that, when enquiries are made outside of the Local Land Charges procedure, the City's Standing Orders prevent open access to the City records. In accordance with the Environmental Information Regulations 2004, the City can provide copies of documents such as Statutory Notices and entries in Statutory Registers, as well as advice on information held relating to environmental matters.
Accordingly, and in response to your specific questions, the following information has been provided regarding the site:

1. The study site or adjacent sites have not been identified for inspection or further review under the City's Contaminated Land Strategy (or Part IIA undertaking).

2. There have been three potential pollution incidents within the search area. In June 1993, Sewage was released into the Thames, this was deemed to have had no impacts. In January 1997, oil was spilled, this was deemed to have had no impacts. In June 2001, Fire fighting run-off was released into the Thames, and this was deemed to have had minor impacts.

   We have records of an environmental report at one site within the search area. In 2002, a report was prepared by Environ for a site at Puddle Dock. No mitigation was proposed due to the low risk of historical soil contamination.

3. At Blackfriars Bridge, there were a number of noise complaints in 2003, 2009 and 2010. In 2003 there was one complaint relating to a faulty alarm. In 2009 there were 7 complaints relating to construction and demolition noise. In 2010 there were 5 complaints relating to construction and demolition noise. All were resolved informally.

4. There are no records of enforcement action against the site.

5. There are no records of any LAAPC/ LAPPC authorisations licensed to the site or to adjoining properties

6. Within the City of London boundary, there are no records of any current or former landfills on or within a 250m radius of the site. Please refer to the Environment Agency for further details.

7. There are no private water supplies in the City of London. There are two boreholes, but these both supply service/ grey water. The closest is approx 400m to the Northwest of the site, at 37 Fleet Street. There are no known abstraction sites currently used for drinking water purposes.

8. Records from 1875 to 1971 show a number of different activities have taken place within the search area. These are summarised in the table below:

SITE USE	COMMENTS	YEAR
New Wharf		1875
Grand Junction Wharf		1875
City of London Gas Works	Site contains two retort houses, eleven Gasometers and assorted tanks	1875
Iron Warf		1875
Warehouses		1875
Warehouses		1875
St Pauls Station		1894
Bridge Wharf		1938
St Pauls Station		1938
Purfleet Wharf		1938
St Andrews Wharf		1938
Blackfriars Station		1951
Bridge Wharf		1951
Blackfriars Station		1971
Bridge Wharf	No definitive site footprint identification based on name	1971

A search of Kelly's Directories (for the years 1817 to 1890) found no records for the following addresses: Victoria Embankment, Blackfriars Underpass, King's Bench Walk, Temple Avenue, Tallis Street, Carmelite Street, John Carpenter Street, Watergate, New Bridge Street or Puddle Dock.

Please note that with reference to the Kelly's Directory search, there are limited records of street renaming and renumbering in existence prior to 1863. If we have listed a business as existing on this site for the years 1817 or 1850, it has been listed for your information only, and is intended to assist with your information gathering and potential site investigations. The Corporation has not confirmed that this business was actually located on site.

I hope the above information is of assistance to you. Should you have any further queries, please do not hesitate to contact me.

Yours faithfully

Edward Haythornthwaite

Mr Edward Haythornthwaite
Technical Officer
Pollution Team

F.3 Detailed Unexploded Ordnance (UXO) risk assessment

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Detailed Unexploded Ordnance (UXO) Risk Assessment

Study Site: Work Area PCL1X – Blackfriars Bridge Foreshore
Document Number: 336-RG-TPI-PCL1X-000001
Client Name: Thames Water
6 Alpha Project Number: P2853_R13_V1.0
Date: 12th June 2012

Originator: Max Chainey (6th June 2012)
Quality Review: Lisa Askham (6th June 2012)
Released by: Lee Gooderham (12th June 2012)

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EXECUTIVE SUMMARY

Study Site	The Client has specified the Study Site as Work Area PCL1X, located at National Grid Reference "531600, 180800". For the purposes of this report, the Site has been divided into **AREA A** (Foreshore and river of Work Area) and **AREA B** (Pier relocation).
Key Findings	In light of the research for this report, 6 Alpha has assessed the threat on this Site based on these pertinent facts: • Both **AREA A and AREA B** overlap the foreshore of the *River Thames*, and thus would have had little to no footfall. • World War Two (WWII) bombing targets in the form of "docks" and "wharves" have been identified within the buffered Site boundary, and numerous "opportunistic" bombing targets have been identified within the vicinity of **AREA A and B**. • **AREA A and B** are located within the administrative district of the *City of London County Council*, which recorded 520 High Explosive (HE) bombs per 1,000 acres. • Two HE bomb strikes occurred within **AREA A**, however none were recorded within **AREA B**. Additionally, four bomb strikes occurred within the buffered Site boundary and a further twenty-four HE bomb strikes were recorded within 100m of the buffered Site boundary. • Bomb damage was not recorded within either Work Area, however this can be explained by the lack of structural developments within either of them. • Whilst **AREA A** has experienced some ground works in the form of piling for *Blackfriars Millennium Pier,* the piling would not have involved a significant enough area to have removed buried Unexploded Ordnance (UXO) items. No other significant or noticeable developments have occurred within either Work Area. The risk assessment and risk mitigation outlined below are based on the indicative engineering drawings and proposed works provided by *Thames Water*, and therefore it should be noted that any changes to the engineering drawings or proposed works may affect the risk assessment.
Potential Threat Source	The threat is primarily posed by WWII *German* HE bombs, with a secondary threat from Incendiary Bombs and *British* Anti-Aircraft Artillery (AAA) projectiles.
Risk Pathway	Given the type of munitions that might be present on Site, all types of aggressive intrusive engineering activities may generate a significant risk pathway.
Risk Level	**AREA A** **HIGH** **AREA B** **HIGH**
Recommended Risk Mitigation	**The following actions are recommended before undertaking any activity on the Study Site:** **BOTH AREAS** **1. Operational UXO Risk Management Plan;** appropriate site management documentation should be held on site in the event of a suspected or real UXO discovery. **2. UXO Safety & Awareness Briefings;** the briefings are essential when there is a possibility of explosive ordnance encounter and are a vital part of the general safety requirement. **3. On-Site Banksman;** all enabling works and open excavation works should be accompanied by an UXO Specialist to monitor works down to the maximum bomb penetration depth. **4. Non-intrusive Magnetometer Survey**; Prior to any dredging or piling of the foreshore and slipway, 6 Alpha recommend a non-intrusive magnetometer survey. Any magnetic contacts that model as UXO should either be investigated or avoided.

ASSESSMENT METHODOLOGY	
Approach	6 Alpha Associates are independent, specialist risk management consultants and the UXO related risk on the Site has been assessed using the process advocated by both the *Construction Industry Research & Information Association* (CIRIA) best practice guide (C681) and by the *Health & Safety Executive* (HSE). Therefore, any risk levels identified in the assessments are objective, quantifiable and not simply designed to generate "follow on survey or contracting work"; any mitigation solution is recommended *only* because it delivers the Client a risk reduced to As Low As Reasonably Practicable (ALARP) at best value. Potential UXO hazards have been identified through investigation of Local and National archives covering the Site, *Ministry of Defence* (MoD) archives, local historical sources, historical mapping as well as contemporaneous aerial photography (as and if, it is available). Potential hazards have only been recorded if there is specific information that could reasonably place them within the boundaries of the Site. Key source material is referenced within this document, whilst data of lesser relevance (which may have been properly considered and discounted by 6 Alpha), is available upon request. The assessment of UXO risk is a measure of ***probability*** *of encounter* and ***consequence*** *of encounter*; the former being a function of the identified hazard and proposed development methodology; the latter being a function of the type of hazard and the proximity of personnel (and/or other "sensitive receptors"), to the hazard at the moment of encounter. Should a measurable UXO risk be identified, the methods of mitigation recommended are reasonably and sufficiently robust to reduce these to As Low As Reasonably Practicable (ALARP). We believe that the adoption of the legal ALARP principle is a key factor in efficiently and effectively ameliorating UXO risks. It also provides a ready means for assessing the Client's tolerability of UXO risk. In essence the principle states that if the cost of reducing a risk significantly outweighs the benefit, then the risk may be considered tolerable. Clearly this does not mean that there is no requirement for UXO risk mitigation, but any mitigation must demonstrate that it is beneficial. Any additional mitigation that delivers diminishing benefits **and** that consume disproportionate time, money and effort are considered *de minimis* and thus unnecessary. Because of this principle unexploded bomb (UXB) risks will rarely be reduced to zero (nor need they be).
Important Notes	Although this report is up to date and accurate, our databases are continually being populated as and when additional information becomes available. Nonetheless, 6 Alpha have exercised all reasonable care, skill and due diligence in providing this service and producing this report. The assessment levels are based upon our professional opinion and have been supported by our interpretation of historical records and third party data sources. Wherever possible, 6 Alpha has sought to corroborate and to verify the accuracy of all data we have employed, but we are not accountable for any inherent errors that may be contained in third party data sets (e.g. National Archive or other library sources), and over which 6 Alpha can exercise no control. The intention of this report is to provide the Client with a concise summary of the risks posed to the site investigation and construction works. The background risk has been established in a Threat & Preliminary Risk Assessment Report that will be provided separately. Whilst this document may be used in isolation, an overarching report is available that outlines the procedures, details and methodologies used to assess the UXO risk to this project.

STAGE ONE – SITE LOCATION AND DESCRIPTION

Study Site

The Client has specified the Study Site as Work Area PCL1X. The Site is located at National Grid Reference 531600, 180800. For the purposes of this study, a 50m assessment radius will be applied to the work area to provide flexibility should it need to be relocated.

Additionally, the Site has been divided into **AREA A and B** for the purpose of this report.

See *Figures 1* and *2* for the Site location and area divisions.

Location Description ***(Figure 3)***

The Work Area is situated in the *City of London County Council*. Current aerial photography has identified the following within each area:

AREA A: The *River Thames* and foreshore, *Blackfriars Pier*, *HMS President, Chrysanthemum Pier*, *Blackfriars Bridge* and a partial area of public highway.

AREA B: The *River Thames* and foreshore, as well as a partial area of public highway.

Proposed Engineering Works

Thames Water have specified a summary of the proposed engineering works, including working draft plans with drawing no. 100-DA-CNS-PCL1X-267105_AJ; 100-DA-CNS-PCL1X-267106_AJ; 100-DA-CNS-PCL1X-267107_AJ; 100-DA-CNS-PCL1X-267108_AI; 100-DA-CVL-PCL1X-367020_AK; 100-DA-CVL-PCL1X-367021_AL; and 100-DA-CVL-PCL1X-367022_AI. These works have been divided between **AREAS A and B**, however where not explicitly stated, 6 Alpha has made an assumption of which area the work will be carried out.

Area A

- A 24m internal diameter combined sewer overflow (CSO) drop shaft, approximately 64m deep.
- Underground chambers and ventilation ducts constructed with the permanent cofferdam in the foreshore.
- A 7.2m diameter main tunnel running through the CSO shaft.
- Two long connection culverts running beneath the foreshore linking the CSO shaft and overflow weir chambers.
- Temporary and permanent cofferdams and campshed construction in the foreshore to enable construction of the works. This will require dredging / excavation of the riverbed.

Area B

- Temporary relocation of pier requiring dredging and piling within the foreshore.

Ground Conditions

Thames Water have indicated the following ground conditions for the Work Areas as:

Site Geology	Depth Below Ground Level (m)	Thickness (m)
Alluvium	0.00	1.00
River Terrace Deposits	1.00	4.00
London Clay	5.00	26.80
Harwich Formation	31.80	0.20
Lambeth Group	32.00	17.80
Thanet Sand	49.80	9.20
Seaford Chalk	59.00	Not Proven

It is important to establish the ground conditions within this report to determine both the maximum *German* unexploded bomb (UXB) bomb penetration depth (BPD) as well as the potential for other types of munitions to be buried on this Site.

STAGE TWO – REVIEW OF HISTORICAL DATASETS	
Sources of Information Consulted	The following primary information sources have been used in order to establish the background UXO threat: 1. Home Office WWII Bomb Census Maps; 2. WWII & post-WWII Aerial Photography; 3. Official Abandoned Bomb Register; 4. National Archives in Kew; 5. Internet based research; 6. Historic UXO information provided by 33 Engineer Regiment (Explosive Ordnance Disposal) at Carver Barracks, Wimbish.
Site History and Use	According to the County Series (CS) & Ordnance Survey (OS) historical mapping, the following site history can be recorded immediately prior to and post-WWII: **1938 CS mapping – AREA A** is located on a prominent foreshore overlapping the *River Thames* and *Blackfriars Bridge*, and includes one pier located within the western aspect of the area. **AREA B is** located on the foreshore overlapping the *River Thames* and contains no development. **1949 OS mapping** – There are no significant or noticeable changes to the areas.
1945 Aerial Photography ***(Figure 4)***	**AREA A:** The 1945 aerial photography indicates the construction of a pier within the central aspect of the area. The position of the pier correlates with the current location of *HMS President.* **AREA B:** The 1945 aerial photography confirms that **AREA B** remained structurally unchanged pre- and post-WWII.
WWII Luftwaffe Bombing Targets ***(Figure 5)***	**BOTH AREAS**: The "drainage and coal storage" area located 1,000m to the northwest of the Site was considered a primary *Luftwaffe* bombing target. "Opportunistic" targets include "railway stations" and railway infrastructure, "depots", "goods sheds", "power stations", "works", "factories" and "docks and wharves" all located within 1,000m of the Site. The latter target of "docks and wharves" overlap within the eastern aspect of the buffered Site boundary.
WWII HE Bomb Strikes ***(Figure 6)***	Air Raid Precaution (ARP) reports indicate the following: **AREA A:** Two bomb strikes were recorded. **AREA B:** No bomb strikes. Four bomb strikes occurred within the buffered Site boundary and twenty-four strikes occurred within 100m of the buffered Site boundary. Additionally, two V1 strikes were recorded within 100m of the areas.
WWII Bomb Damage ***(Figure 7)***	*London County Council* (LCC) bomb damage maps indicate the following: **BOTH AREAS:** No bomb damage. Several structures on the embankment and within the buffered Site boundary suffered "general blast damage; minor in nature" and "damage beyond repair". Bomb damage was typically only recorded for building structures and not for damage done to land features. This may explain the lack of damage recorded within the Site, as no building structures are present.
WWII HE Bomb Density ***(Figure 8)***	The Study Site is located within the administrative district of *City of London County Council,* which recorded 520 HE bombs per 1,000 acres. This figure does not include incendiary devices, as they were often released in such large numbers that they were seldom recorded.
Abandoned Bombs	The Official Abandoned Bomb Register has no records of abandoned bombs within 1,000m of the Site.

STAGE THREE – DATA ANALYSIS	
Was the ground undeveloped during WWII?	**AREA A:** Mostly; the Work Area predominantly consists of the *River Thames* and foreshore, although an unidentified pier and *Blackfriars Bridge* were also situated within this area and a small portion of the Work Area overlaps the embankment. **AREA B:** Yes; this area overlaps the *River Thames* and was undeveloped except for a small portion of the area that overlaps the public highway.
Is there a reason to suspect that the immediate area was a bombing target during WWII?	**BOTH AREAS:** Yes; numerous *Luftwaffe* bombing targets existed within proximity of the Work Area. Additionally, the scale of indiscriminate bombing within this area of *London* was particularly high.
Is there firm evidence that ordnance landed on Site?	**AREA A:** Yes; two HE bomb strikes were recorded within this area. **AREA B:** No; but unlikely to have been recorded given the environment. There is also evidence of four bomb strikes within the buffered Site boundary.
Is there evidence of damage sustained on Site?	**BOTH AREAS:** No. However, damage to land features, public highways and bridges was not recorded on the *LCC* bomb damage maps.
Is there any reason to suspect that military training may have occurred at this location?	**BOTH AREAS:** There is no evidence to suggest that military training may have occurred at this location.
Would an UXB entry hole have been observed and reported during WWII?	**BOTH AREAS:** Unlikely; typically, UXBs falling in the *River Thames* are unlikely to have been observed and reported. Additionally, any impact craters of UXBs falling on the foreshore during low tide would have been masked and covered by tidal changes. The observation and reporting of two bomb strikes within **AREA A** can likely be explained by the fact that one fell on the embankment, and the other immediately next to *Blackfriars Bridge*, where the foreshore is more prominent and raised.
What is the expected UXO contamination?	**BOTH AREAS:** The most likely source of UXO contamination is from *German* aerial delivered ordnance, which ranges from small Incendiary Bombs (IBs) through to large HE bombs (of which the latter forms the principal threat).
Would previous earthworks have removed the potential for UXO to be present?	**AREA A:** Unlikely; the development of *Blackfriars Pier* would have required engineering works in the form of piling, however the works are too marginal within the larger area to have removed the potential for UXO to be present across the entire area. **AREA B:** No; no significant earthworks have occurred at this location.

STAGE FOUR – RISK ASSESSMENT		
Explanation For Non-Division Of Site	The Site has a slight overlap at street level off the foreshore. However this street level overlap is considered too marginal to warrant the division of the Site. Additionally, the area under the bridge does not represent a decreased probability of UXO encounter due to the J-curve effect, whereby a UXBs sub-surface trajectory can be lateral and come to rest up to 15m from the original entry hole position.	
Threat Items	The threat is predominately posed by WWII *German* HE bombs and IBs. Additionally, *British* AAA projectiles may also be present. However, AAA does not have the potential for deep burial, and thus is unlikely to be encountered at depths greater than 1m below ground level (bgl).	
Maximum Penetration	The general ground conditions (highlighted in Stage 1) of **AREA A** and **AREA B** that are relevant consist of *Alluvium, River Terrace Deposits* and *London Clay*, and thus the most likely Bomb Penetration Depth (BPD) for a 250kg bomb is assessed to be a maximum of 8m bgl, dependant on the depth of any rock sediment. As **BOTH AREAS** overlap with the foreshore of the *River Thames* and the river itself, the BPD will vary due to the softer ground conditions and the water causing a deceleration of the impacting bomb. It is important to note that strong river currents, sedimentation build-up and erosion over time can cause complete or partial burial of UXO. Whilst the *Luftwaffe* used larger bombs, their deployment was so few and only used against notable targets, therefore to use them within this risk assessment would not be justified. Additionally, smaller items such as *German* incendiary bombs and *British* AAA projectiles would have a significantly reduced penetration capability and would not be expected to be encountered at depths greater than 1m.	
Risk Pathway	Intrusive engineering activities are likely to be in the form of excavations. Although for the purposes of this report 6 Alpha will use a range of generic construction activities for the risk assessment.	
Consequence	**Potential consequences of UXO initiation**	1. Kill and/or critically injure personnel 2. Severe damage to plant and equipment 3. Blast damage to nearby buildings 4. Rupture and damage underground services
	Potential consequences of UXO discovery	1. Delay the project 2. Disruption to local community/infrastructure 3. Incurring of additional costs
Site Activities	A number of construction methodologies have been identified for analysis on this Site. There is a large amount of variation in the probability of encountering, or initiating items of UXO when conducting different activities on Site. Additionally the consequences of initiating UXO vary greatly depending on how the item of UXO was initiated on Site.	

STAGE FOUR – RISK ASSESSMENT (…continued)

UXO RISK CALCULATION TABLE

Risk Rating Calculation	6 Alpha's Semi-Quantitative Risk Assessment identifies the Risk Rating posed by the most probable threat items when conducting a number of different construction activities on the Site. Risk Rating is determined by calculating the probability of encountering UXO and the consequences of initiating it.

Activity	AREA A		
	Probability (SHxEM=P)	**Consequence** (DxPSR=C)	**Risk Rating** (PxC=RR)
Enabling Works	3x1=3	3x2=6	3x6=18
Tunnelling	1x2=2	1x2=2	2x2=4
Shaft Installation	3x2=6	1x2=2	6x2=12
Open Excavations	3x2=6	2x2=4	6x4=24
Cofferdam (Sheet Piles)	3x3=9	2x2=4	9x4=36
Dredging	3x3=9	3x2=6	9x6=54

Activity	AREA B		
	Probability (SHxEM=P)	**Consequence** (DxPSR=C)	**Risk Rating** (PxC=RR)
Enabling Works	3x1=3	3x2=6	3x6=18
Temporary Pier (Piling)	3x3=9	2x2=4	9x4=36
Dredging	3x3=9	3x2=6	9x6=54

Abbreviations – Site History (SH), Engineering Methodology (EM), Probability (P), Depth (D), Consequence (C), Proximity to Sensitive Receptors (PSR) and Risk Rating (RR).

STAGE FIVE – RECOMMENDED RISK MITIGATION MEASURES WITH RESULTING RISK RATING	
If a geophysical survey is required are the ground conditions an issue?	**Non-Intrusive Methods of Mitigation** – The suitability for an effective non-intrusive method of mitigation is largely dependent on the depth and composition of made ground, as any magnetometer results are highly likely to be affected by ferro-magnetic contamination due to previous construction activities within the Study Site location. This method is likely to be effective on the foreshore and within the cofferdam as this is area is undeveloped, however any scrap metal may mask buried items of UXO. **Intrusive Methods of Mitigation** – Intrusive magnetometry is expected to be possible on this Site. It should be noted that ferro-contamination of any made ground/fill material, particularly at the fill layer, is likely to adversely affect detection capability of the equipment.

MITIGATION MEASURES TO REDUCE RISK TO 'ALARP'		
Activity	**Risk Mitigation Measures**	**Final Risk Rating**
BOTH AREAS	**The following actions are recommended before undertaking any activity on the Study Site:** **1. Operational UXO Risk Management Plan;** appropriate site management documentation should be held on site to plan for and guide upon the actions to be carried out in the event of a suspected or real UXO discovery. **2. UXO Safety & Awareness Briefings;** the briefings are essential when there is a possibility of explosive ordnance encounter and are a vital part of the general safety requirement. All personnel working on the site should receive a general briefing on the identification of UXB, what actions they should take to keep people and equipment away from the hazard and to alert site management. Posters and information of the general nature of the UXB threat should be held in the site office for reference and as a reminder. **3. On-Site Banksman;** all enabling works and open excavation works should be accompanied by an UXO Specialist to monitor works down to the maximum bomb penetration depth. **4. Non-intrusive Magnetometer Survey**; Prior to any marine piling or dredging of the foreshore, 6 Alpha recommend a non-intrusive magnetometer survey. Any magnetic contacts that model as UXO should either be investigated or avoided. It should be noted that there is likely to be scrap metal on the foreshore and riverbed that will reduce the effectiveness of non-intrusive magnetometry.	ALARP
This assessment has been conducted based on the information provided by the Client, should the proposed works change then 6 Alpha should be re-engaged to refine this risk assessment.		

Report Figures

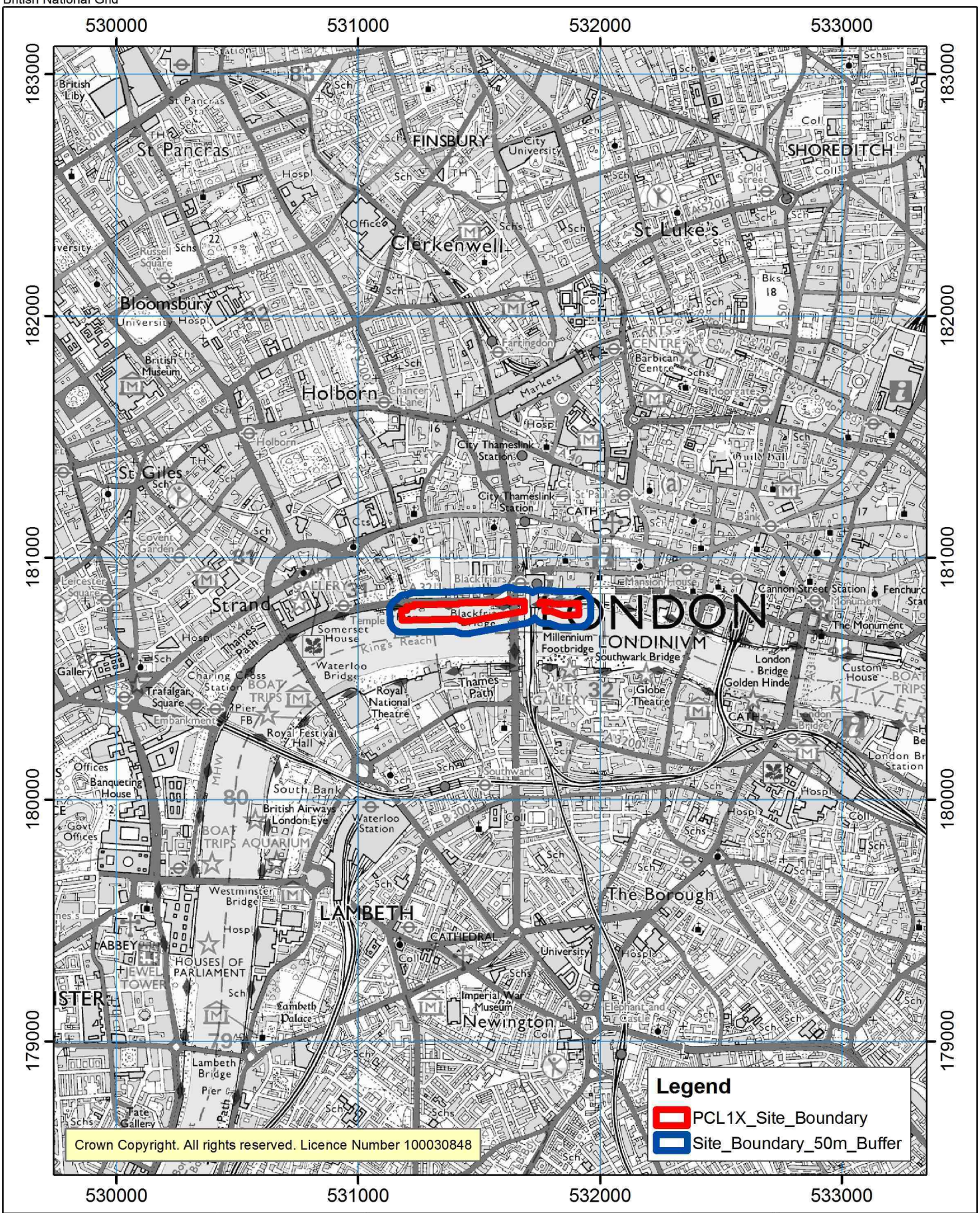
Figure One

Site Location

Thames Tideway Tunnel - Work Area PCL1X
Site Location

Figure 1

British National Grid



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6 Alpha Associates Ltd.
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www.6alpha.com
0203 371 3900

0 100 200 400 600 800 1,000 Meters

N

Project Number: P2853_PCL1X
Drawn By: Dominique René
Checked by: Lee Gooderham
Date: 22nd May 2012

Figure Two

Site Plan

Thames Tideway Tunnel - Work Area PCL1X
Site Boundary

Figure 2

British National Grid

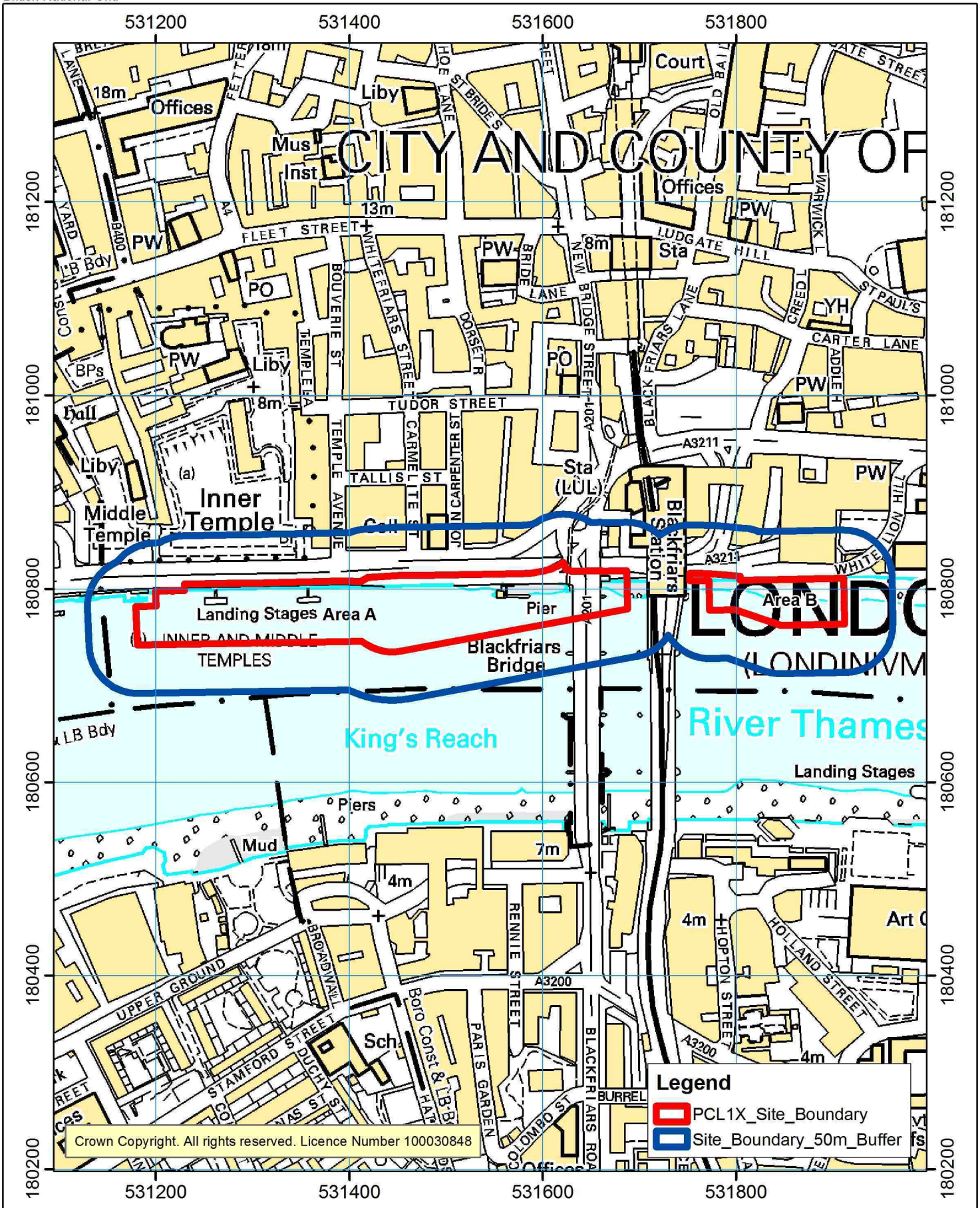

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Figure Three

Current Aerial Photography

Thames Tideway Tunnel - Work Area PCL1X
Current Aerial Photography

Figure 3

British National Grid

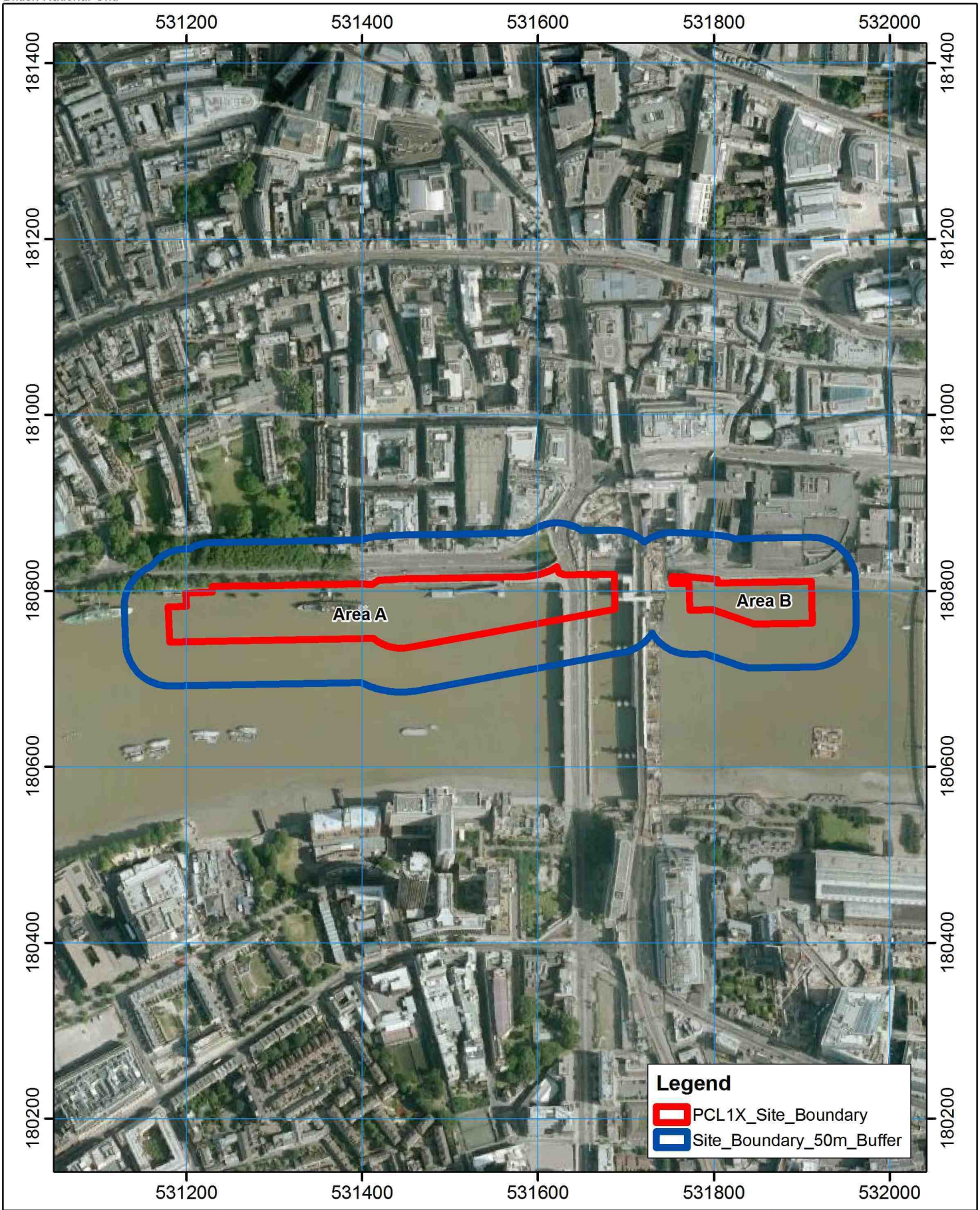

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Figure Four

1945 Aerial Photography

Thames Tideway Tunnel - Work Area PCL1X
1945 Aerial Photography

Figure 4

British National Grid

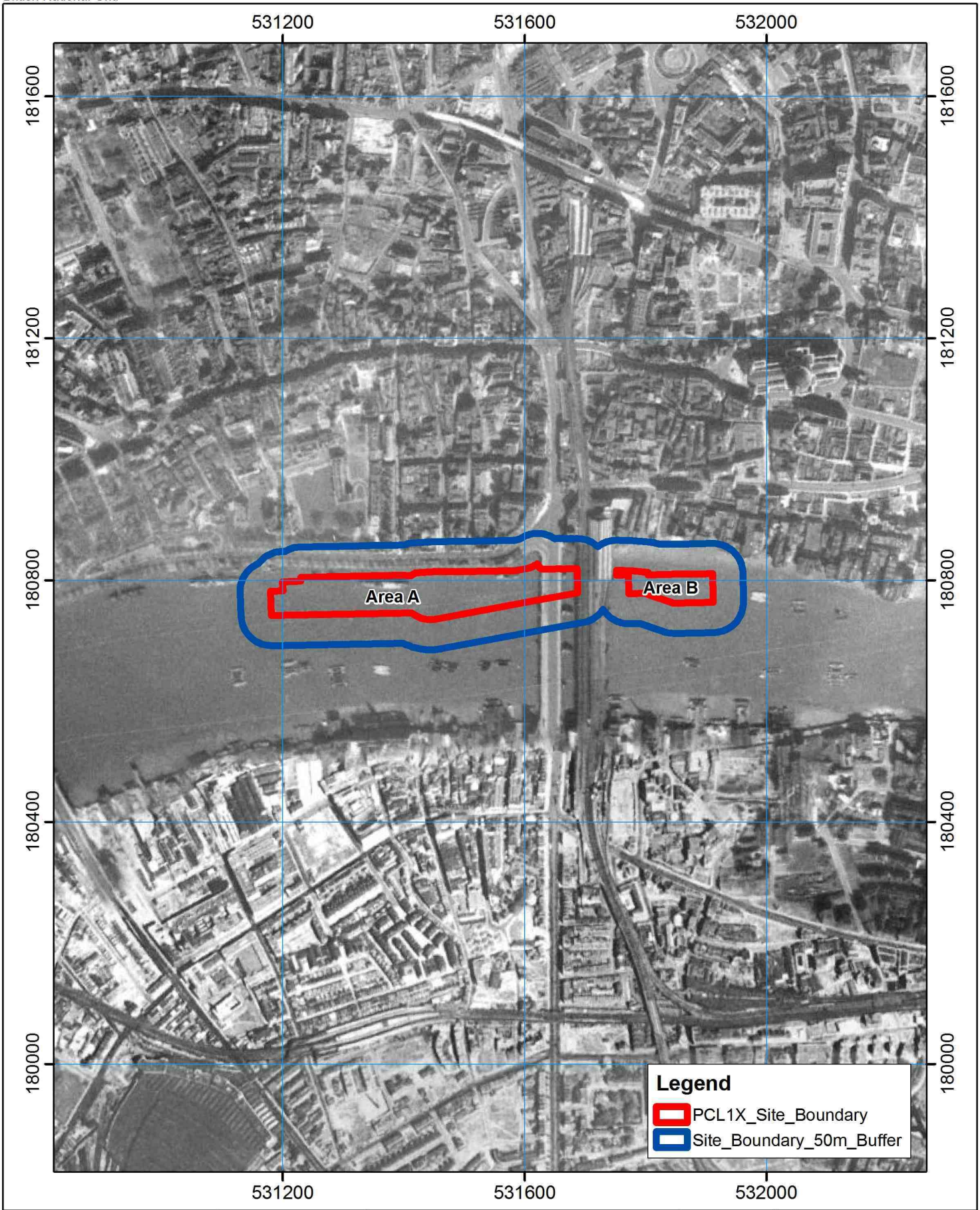

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Figure Five

WWII Luftwaffe Bombing Targets

Thames Tideway Tunnel - Work Area PCL1X
WWII Luftwaffe Bombing Targets

Figure 5

British National Grid

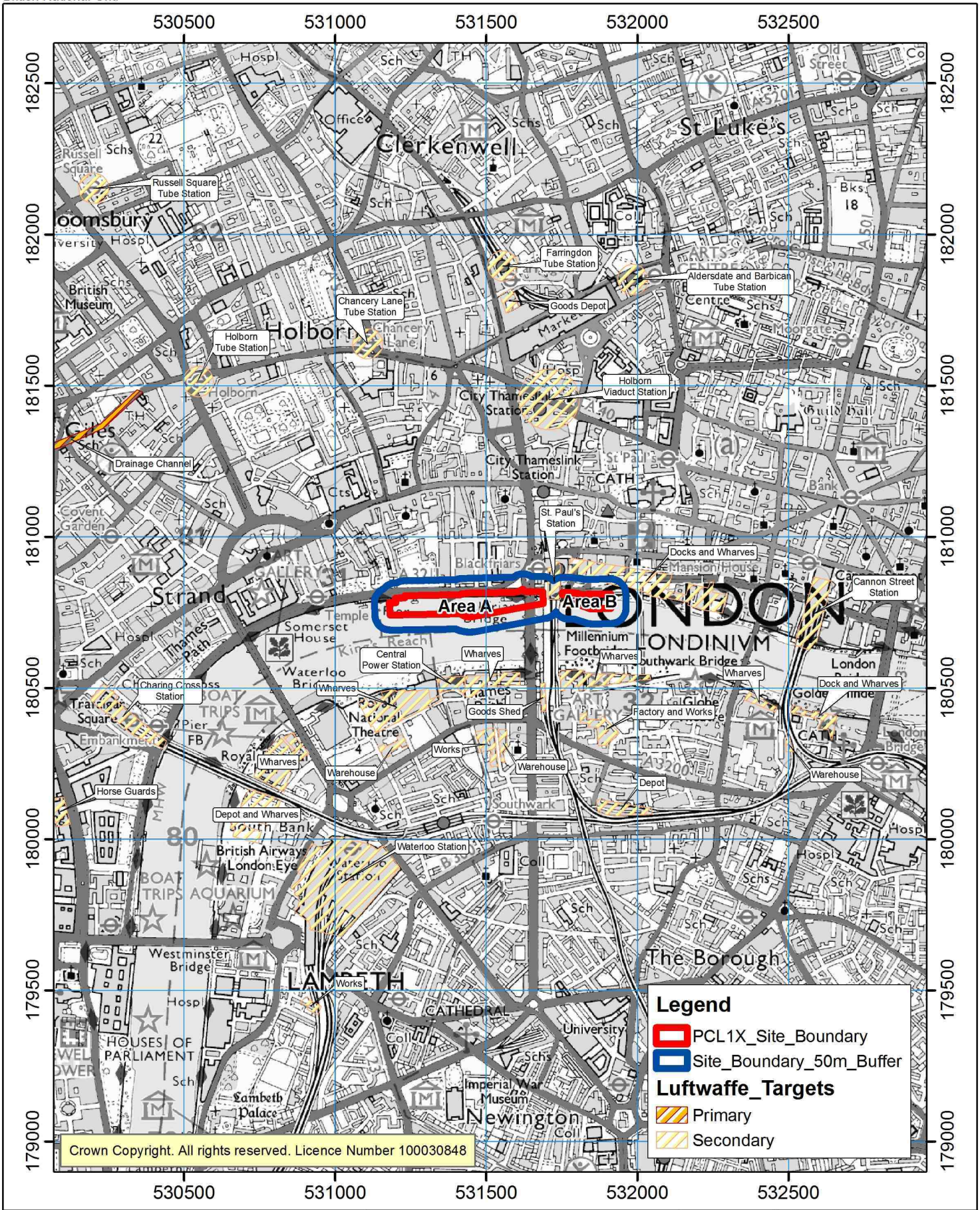

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Figure Six

WWII High Explosive Bomb Strikes

Thames Tideway Tunnel - Work Area PCL1X
WWII High Explosive Bomb Strikes

Figure 6

British National Grid

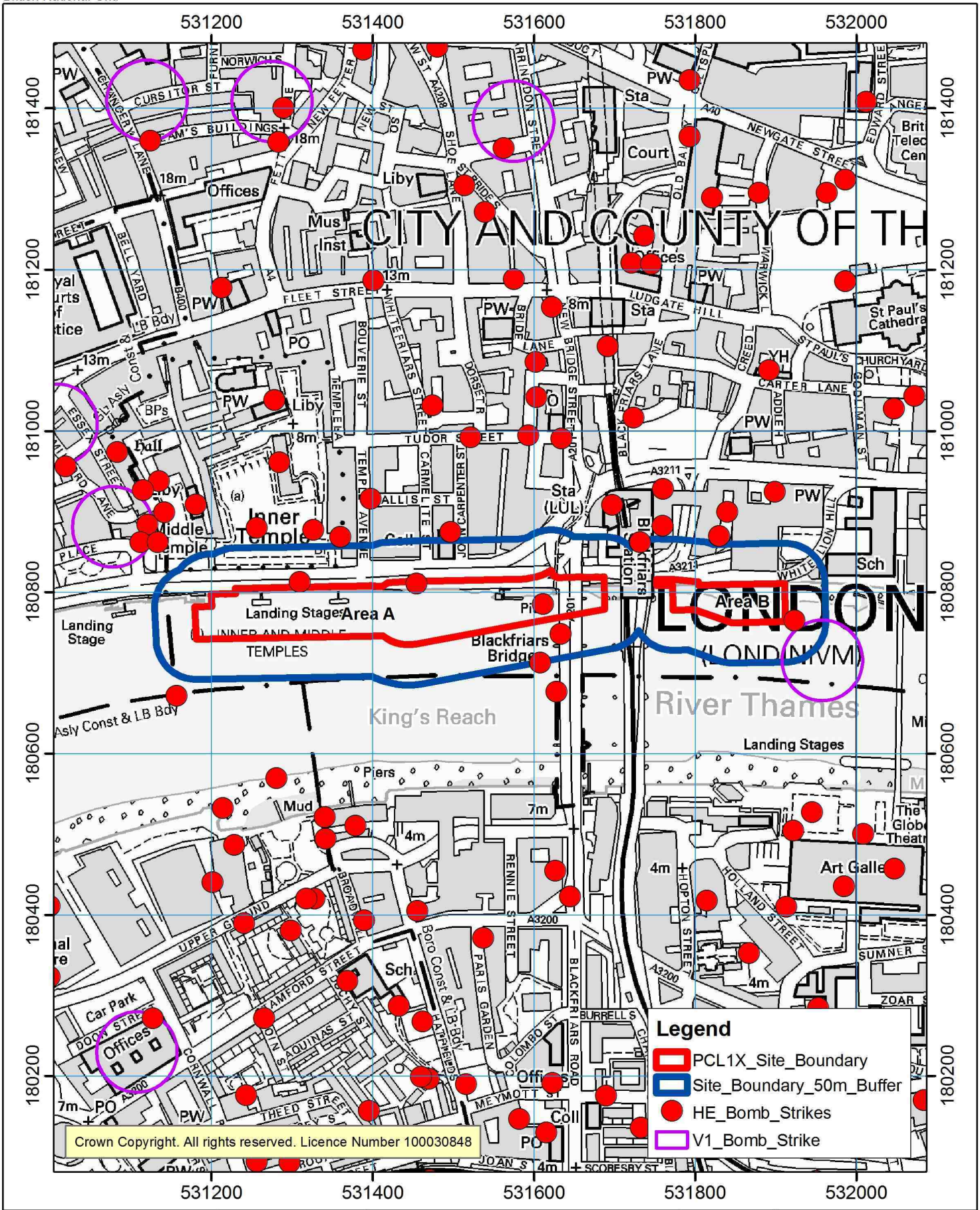

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Figure Seven

London County Council Bomb Damage Mapping

Thames Tideway Tunnel - Work Area PCL1X
London County Council Bomb Damage Map

Figure 7

British National Grid

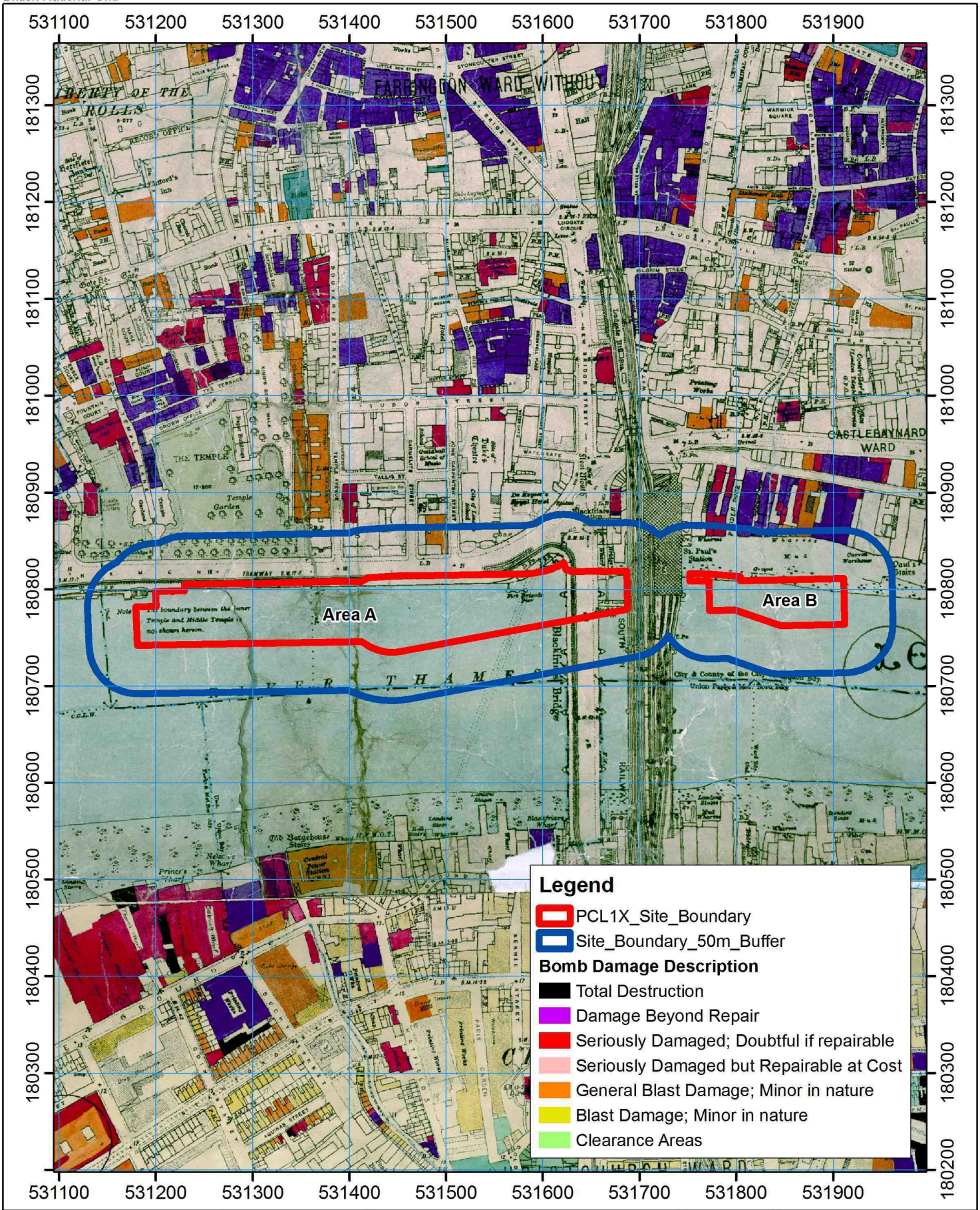

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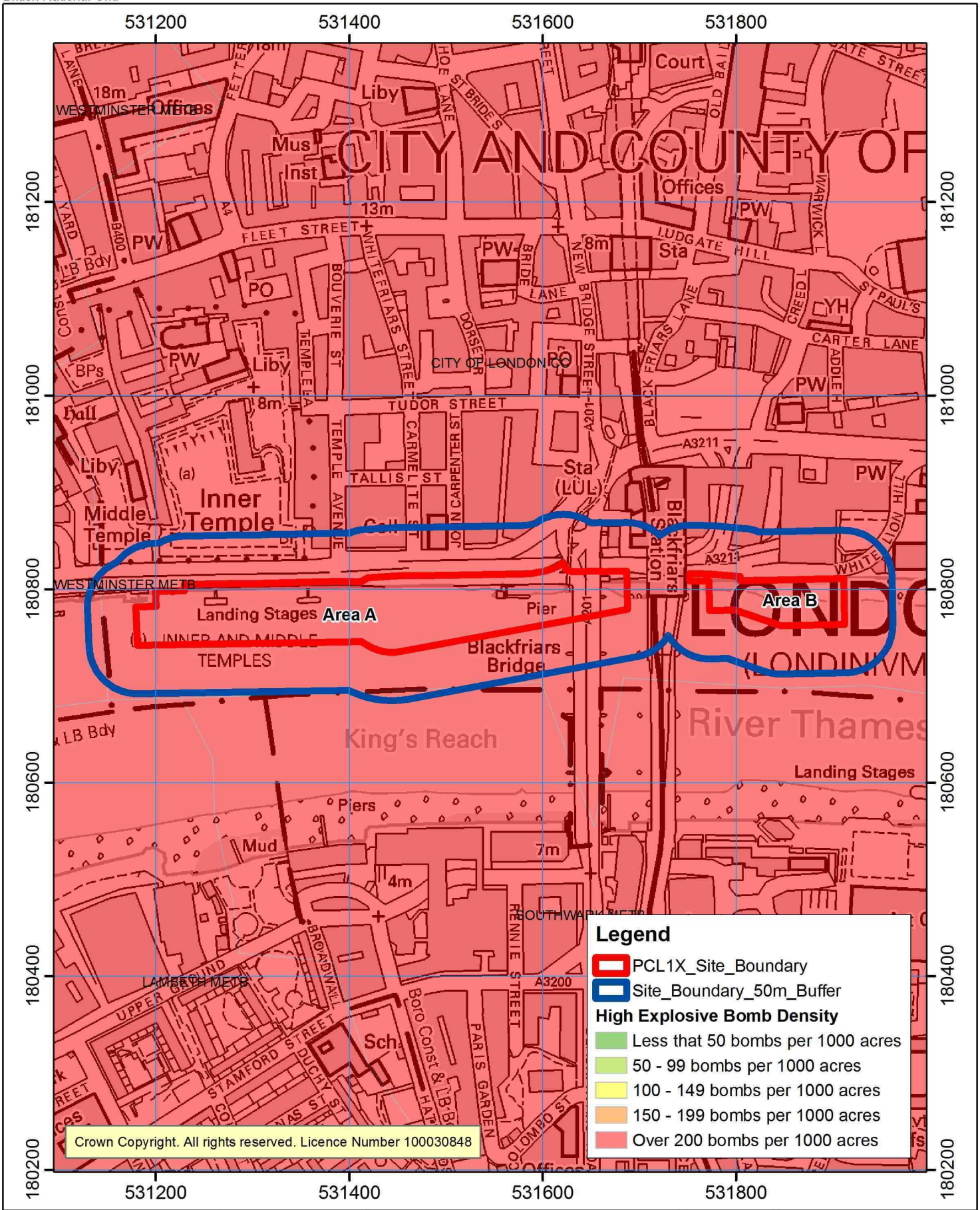
Figure Eight

WWII High Explosive Bomb Density

Thames Tideway Tunnel - Work Area PCL1X
WWII High Explosive Bomb Density

Figure 8

British National Grid



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[2] Department of the Environment, Industry Profiles (various). Available from http://www.environment-agency.gov.uk/research/planning/33708.aspx. Accessed 25th March 2011.

[3] Canadian Council for the Environment. *Sediment Quality Guidelines for the Protection of Aquatic Life.* Available at http://st-ts.ccme.ca/. Accessed on 20th December 2011.

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Thames Tideway Tunnel
Thames Water Utilities Limited

Application for Development Consent

Application Reference Number: WWO10001

Environmental Statement

Doc Ref: **6.2.18**

Volume 18 Blackfriars Bridge Foreshore appendices

Appendix G: Noise and vibration

APFP Regulations 2009: Regulation **5(2)(a)**

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Thames Tideway Tunnel

Creating a cleaner, healthier River Thames

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Thames Tideway Tunnel

Environmental Statement

Volume 18 Blackfriars Bridge Foreshore appendices

Appendix G: Noise and vibration

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Appendix G: Noise and vibration

G.1 Baseline noise survey

Introduction

G.1.1 As described in Volume 2 Environmental assessment methodology, the main purpose of the noise survey has been to determine representative ambient and background noise levels at a number of different types of noise sensitive receptor.

G.1.2 The nearest identified residential receptors to Blackfriars Bridge Foreshore are the residential dwellings on the upper floors of the buildings on Kings Bench Walk located northwest of the site. There are also residences at River Court immediately south of the site across the River Thames and adjacent to the site there are several non-residential receptors such as Sion Hall and 40-50 Victoria Embankment.

Survey methodology

G.1.3 The City of London has been consulted regarding the noise assessment and monitoring locations, prior to completing the surveys.

G.1.4 An initial baseline noise survey was completed on 1st April, 2011 and additional data was collected 1st November, 2011. The initial survey comprised short term attended measurements taken during the daytime only, at all measurement locations. The additional data collection comprised further short term attended measurements taken during the evening.

G.1.5 During the initial baseline survey measurements were undertaken during the interpeak periods of 10:00-12:00 and 14:00-16:00 on a typical weekday, so that the baseline data is representative of the quieter periods where any disturbance from construction would be most noticeable.

G.1.6 For the additional baseline survey, further short term attended noise monitoring was completed at all locations. Measurements were undertaken during the interpeak period of 20:00-22:00 on a typical weekday.

G.1.7 Vol 18 Table G.1 describes the survey equipment that was used to collect the baseline data at the site.

Vol 18 Table G.1 Noise – survey equipment

Item	Type	Manufacturer	Serial Number(s)	Laboratory Calibration Date*
Initial Baseline Survey – 1st April, 2011				
Hand-Held Analyzer(s)	2250	Brüel & Kjær	2626232 2626233	15/02/2010
½ " Microphone(s)	4189	Brüel & Kjær	2621211 2621212	15/02/2010
B&K Sound Calibrator(s)	4231	Brüel & Kjær	2619374 2619375	21/01/2010
Additional baseline survey – 1st November 2011				
Hand-Held Analyzer(s)	2250	Brüel & Kjær	2626232 2626233	15/02/2010
½ " Microphone(s)	4189	Brüel & Kjær	2621211 2621212	15/02/2010
B&K Sound Calibrator(s)	4231	Brüel & Kjær	2619374 2619375	21/01/2010

** Hand-held analyser(s) and ½ inch microphone(s) valid for two years from the date listed, calibrator(s) valid for one year from the date listed*

G.1.8 Prior to and on completion of the survey, the sound level meters and microphone calibration was checked using a Brüel and Kjær sound level meter calibrator. On-site calibration checks were performed before and after all measurements with no significant deviation being observed. The sound level meters and calibrators have valid laboratory calibration certificates.

G.1.9 The sound level meters were tripod-mounted with the microphone approximately 1.3m above ground level. A windshield was fitted over the microphone at all times during the survey period to minimise the effects of any wind induced noise.

G.1.10 The prevailing weather conditions observed for both baseline surveys are described in Vol 18 Table G.2.

Vol 18 Table G.2 Noise – weather conditions during baseline noise surveys

Wind Speed (ms^{-1})	Wind Direction	Temperature (°C)	Precipitation	Description
Initial Baseline Survey – 1st April, 2011 (daytime, 10:00-12:00)				
Maximum: 1.4-4.4 Average: 0.3-0.9	WSW; SW	14-15	No	Overcast, dry, breezy
Initial Baseline Survey – 1st April, 2011 (daytime, 14:00-16:00)				
Maximum: 1.1-2.4 Average: 0.3-0.6	WSW; SW	17	No	Overcast, dry, light breeze
Additional baseline survey – 1st November, 2011 (evening, 20:00-22:00)				
Maximum: 0-3.9 Average: 0-1.5	S; SE	11-13	No	Clear and dry, occasional breeze

Measurement locations

G.1.11 Vol 18 Table G.3 details the measurement locations which are also presented in Vol 18 Figure G.1 Noise – measurement locations (see separate volume of figures), and shown in Plates G.1 to G.4.

Vol 18 Table G.3 Noise – measurement locations

Measurement Location Number	Description	Co-ordinates	
		X	Y
BBF01	Victoria Embankment (outside Unilever House)	531558	180842
BBF02	Victoria Embankment (outside Hamilton House)	531373	180834
BBF03	Marigold Alley to the rear of River Court	531502	180555
BBF04	Puddle Dock (behind The Mermaid Conference Centre)	531839	180860

Results

G.1.12 The range of values for each of the parameters collected during the baseline surveys are summarised in Vol 18 Table G.4 to Vol 18 Table G.8.

Vol 18 Table G.4 Noise – sampled noise survey results - BBF01

Location Detail: BBF01, alongside Victoria Embankment, outside Unilever House						
Measurement period	**Noise level (dB(A) free-field)**			**Averaged ambient noise level, $dBL_{Aeq,15min}$**		**$dBL_{Aeq,15min}$ (rounded to nearest 5dB)**
	L_{AFmax}	**$L_{A90,15min}$**	**$L_{Aeq,15min}$**	**Free field**	**Façade**	**Façade**
Daytime (10.00-12.00, 14.00-16.00)	86	65	69-70	70	73*	75
Evening (20.00-22.00)	79	61	67-69	67	70*	70

** An approximation of the averaged ambient façade noise level has been obtained by adding 3dB to the calculated averaged ambient free-field level*

Vol 18 Table G.5 Noise – sampled noise survey results - BBF02

Location Detail: BBF02, alongside Victoria Embankment, outside Hamilton House						
Measurement period	**Noise level (dB(A) free-field)**			**Averaged ambient noise level, $dBL_{Aeq,15min}$**		**$dBL_{Aeq,15min}$ (rounded to nearest 5dB)**
	L_{AFmax}	**$L_{A90,15min}$**	**$L_{Aeq,15min}$**	**Free field**	**Façade**	**Façade**
Daytime (10.00-12.00, 14.00-16.00)	100	64	74-75	74	77*	75
Evening (20.00-22.00)	89	63	71-73	72	75*	75

** An approximation of the averaged ambient façade noise level has been obtained by adding 3dB to the calculated averaged ambient free-field level*

Vol 18 Table G.6 Noise – sampled noise survey results - BBF03

Location Detail: BBF03, along Marigold Alley to the rear of River Court						
Measurement period	**Noise level (dB(A) free-field)**			**Averaged ambient noise level, $dBL_{Aeq,15min}$**		**$dBL_{Aeq,15min}$ (rounded to nearest 5dB)**
	L_{AFmax}	**$L_{A90,15min}$**	**$L_{Aeq,15min}$**	**Free field**	**Façade**	**Façade**
Daytime (10.00-12.00, 14.00-16.00)	94	58	60-67	63	66*	65
Evening (20.00-22.00)	81	55	59-60	59	62*	60

** An approximation of the averaged ambient façade noise level has been obtained by adding 3dB to the calculated averaged ambient free-field level*

Vol 18 Table G.7 Noise – sampled noise survey results - BBF04

Location Detail: BBF04, alongside Puddle Dock, behind The Mermaid Conference Centre						
Measurement period	**Noise level (dB(A) free-field)**			**Averaged ambient noise level, $dBL_{Aeq,15min}$**		**$dBL_{Aeq,15min}$ (rounded to nearest 5dB)**
	L_{AFmax}	**$L_{A90,15min}$**	**$L_{Aeq,15min}$**	**Free field**	**Façade**	**Façade**
Daytime (10.00-12.00, 14.00-16.00)	97	68	73 - 75	71*	74	75
Evening (20.00-22.00)	84	63	71 - 72	69*	72	75

** An approximation of the averaged ambient free-field level has been obtained by subtracting 3dB from the calculated averaged ambient façade noise level*

Vol 18 Table G.8 Noise - measurements near embankment (for river traffic)

Sensitive receptor locations	Measurement location	Measurement period	Noise level (dBL_{Aeq}, facade)
North bank of the Thames	BBF01	Day/evening (07.00-23.00)	72
South bank of the Thames	BBF04	Day/evening (07.00-23.00)	63

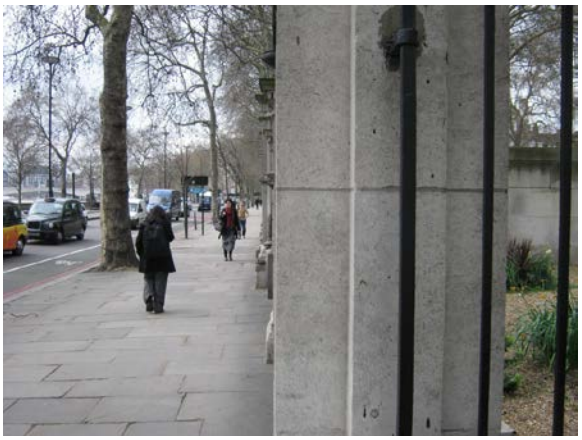
Plates of noise measurement locations

G.1.13 The following plates (Vol 18 Plate G.1 to Vol 18 Plate G.4) illustrate the noise measurement locations.

Vol 18 Plate G.1 Noise measurement location BBF01

Note: On public footpath alongside Victoria Embankment looking south towards Blackfriars Bridge

Vol 18 Plate G.2 Noise measurement location BBF02



Note: Outside Hamilton house looking east along Victoria Embankment

Vol 18 Plate G.3 Noise measurement location BBF03

Note: On Marigold Alley looking north over the River Thames towards the City of London School and Sion Hall

Vol 18 Plate G.4 Noise measurement location BBF04

Note: On Puddle Dock looking north towards Castle Baynard Street adjacent to The Mermaid Conference Centre (façade measurement)

G.2 Construction noise prediction results

G.2.1 The construction noise prediction methodology follows the methodology provided in Volume 2 Environmental assessment methodology. .

G.2.2 The assessment has been carried out based on a typical construction programme which has been used to calculate the average monthly noise levels.

G.2.3 Construction plant assumptions used in the assessment are presented in Vol 18 Table G.9.

G.2.4 Time histories of the predicted daytime construction noise levels across the programme of construction works are shown in Plates G.5 to G.12.

Vol 18 Table G.9 Noise – typical construction plant schedule

Construction activity	Plant	Unit No(s)	Activity LWA (dB)	% on-time	Data Source	Description of equipment used in the assessment
Hoarding General site equipment NOT applicable during this phase	Excavator digging post holes for hoarding	1	98	15	BS5228-1[i]: Table C.2, Item 7	Tracked excavator,
	Nail guns for erection of hoarding	2	101	10	BS5228-1: Table C.4, Item 95	Handheld cordless nail gun, 15 to 50 mm nails
	Hand-held percussive breaker	1	111	15	BS5228-1: Table C.1, Item 6	Hand-held pneumatic breaker,
	Compressor 250cfm	1	102	15	BS5228-1: Table C.1, Item 8	Hydraulic breaker power pack, 63 kg/ 138 bar
	Generator 35kVA	1	94	100	BS5228-1: Table C.4, Item 78	Diesel generator,
	Circular saw cutting timber	1	107	10	BS5228-1: Table D.7, Item 72	Hand-held electric circular saw,
	Cutting equipment (diamond saw)	1	108	10	BS5228-1: Table C.4, Item 93	Angle grinder (grinding steel), 4.7 kg
	Waste collection via skip or tipper lorry	1	106	5	BS5228-1: Table C.8, Item 21	Skip wagon,
	Oxyaceteline cutting equipment	1	93	10	BS5228-1: Table C.3, Item 35	Hand-held gas cutter, 230 bar
Site set up and general site	Oxyaceteline cutting equipment	1	93	10	BS5228-1: Table C.3, Item 35	Hand-held gas cutter, 230 bar
	Compressor 250cfm	1	93	50	BS5228-1: Table D.5, Item 5	Compressor for hand-held pneumatic breaker,

Construction activity	Plant	Unit No(s)	Activity LWA (dB)	% on-time	Data Source	Description of equipment used in the assessment
	Generator200 kVA	1	94	100	BS5228-1: Table C.4, Item 78	Diesel generator,
	Cutting equipment (diamond saw)	2	108	10	BS5228-1: Table C.4, Item 93	Angle grinder (grinding steel), 4.7 kg
	Telescopic Handler/FLT	1	99	30	BS5228-1: Table C.2, Item 35	Telescopic handler, 10 t
	Wheel wash	1	91	20	BS5228-1: Table C.3, Item 13	Water Jet Pump,
	Hiab lorry/crane	1	105	5	BS5228-1: Table C.4, Item 53	Lorry with lifting boom, 6 t
	Water settling/treatment	1	104	100	Measured	Dirty water plant
	Dewatering Pump	1	96	100	BS5228-1: Table C.4, Item 88	Water pump,
	JCB with hydraulic breaker	1	116	25	BS5228-1: Table C.5, Item 1	Backhoe Mounted Hydraulic Breaker
	Fuel delivery vehicle	1	104	5	BS5228-1: Table C.4, Item 15	Fuel tanker lorry
	Well drilling Rig	1	107	50	Manufacturer	Bauer BBA Well Drilling Rig
Demolition	Service Crane 25T mobile Crane	1	98	30	BS5228-1: Table C.4, Item 43	Wheeled mobile crane, 35 t
General site equipment	22T Excavator c/w hydraulic hammer	1	118	30	BS5228-1: Table D.1, Item 9	Tracked excavator fitted with breaker, 200 kg·m

Construction activity	Plant	Unit No(s)	Activity LWA (dB)	% on-time	Data Source	Description of equipment used in the assessment
also applicable during this phase	Site dumper	1	104	30	BS5228-1: Table C.4, Item 3	Dumper, 7 t
	Pneumatic breaker	1	111	20	BS5228-1: Table C.1, Item 6	Hand-held pneumatic breaker,
	Vibrating rollers	2	101	50	BS5228-1: Table C.2, Item 38	Roller, 18 t
Cofferdam construction General site equipment also applicable during this phase	Barges	1	101	10	Measured	Barges
	Generator	1	93	100	BS5228-1: Table C.4, Item 83	Diesel generator,
	Secant pile rig	1	107	60	BS5228-1: Table C.3, Item 16	Crane mounted auger
	400 cfm compressor	1	96	60	BS5228-1: Table C.3, Item 10	Power Pack,
	Oxyaceteline cutting equipment	1	93	10	BS5228-1: Table C.3, Item 35	Hand-held gas cutter, 230 bar
	Jack-up barge	1	100	10	Measured	Jack-up barge,
	Vibratory piling rig	1	116	60	BS5228-1: Table C.3, Item 8	Vibratory piling rig, 52 t
	Silent piler	1	91	60	BS5228-1: Table C.3, Item 9	Piling, 10 t
	150t crawler crane	1	98	60	BS5228-1: Table C.3, Item 29	Tracked mobile crane, 55 t
	25t excavator	1	105	80	BS5228-1: Table C.2, Item 19	Tracked excavator, 25 t

Construction activity	Plant	Unit No(s)	Activity LWA (dB)	% on-time	Data Source	Description of equipment used in the assessment
	Dewatering pumps - cofferdam	2	96	100	BS5228-1: Table C.4, Item 88	Water pump,
	Vibrating rollers	2	101	50	BS5228-1: Table C.2, Item 38	Roller, 18 t
	Plate compactors	2	108	10	BS5228-1: Table C.2, Item 41	Vibratory plate (petrol)
Diaphragm wall construction General site equipment also applicable during this phase	Diaphragm wall rig (grab)	1	114	5	BS5228-1: Table D.4, Item 10	D wall rig,
	Diaphragm wall rig (hydrofraise)	1	110	70	Measured	Hydrofraise D wall rig,
	Dumper	1	104	50	BS5228-1: Table C.4, Item 3	Dumper, 7 t
	Waste water treatment plant	1	104	100	Measured	Dirty water plant
	Diaphragm wall slurry treatment plant	1	100	100	Measured	Slurry treatment plant
	Concrete pump	1	95	100	BS5228-1: Table C.4, Item 24	Concrete pump + cement mixer truck (discharging), 8 t / 350 bar
	Compressor 400cfm	1	98	100	BS5228-1: Table D.6, Item 41	Compressor, 7m^3/min
	Concrete deliveries (discharging)	1	103	20	BS5228-1: Table C.4, Item 18	Cement mixer truck (discharging),
Shaft excavation	Ventilation fans	1	100	100	Measured	Ventilation fans,
	Dewatering pump	4	96	100	BS5228-1: Table C.4,	Water pump (diesel), 100

Construction activity	Plant	Unit No(s)	Activity LWA (dB)	% on-time	Data Source	Description of equipment used in the assessment
General site equipment also applicable during this phase					Item 88	kg
	Long reach excavator	2	106	80	BS5228-1: Table C.7, Item 1	Long reach tracked excavator, 21 m arm / 39 t
	20t excavator with breaker	2	118	50	BS5228-1: Table C.1, Item 9	Breaker mounted on excavator, 15 t
	25t excavator	1	105	50	BS5228-1: Table C.2, Item 19	Tracked excavator, 25 t
	80t crawler crane	1	103	50	BS5228-1: Table C.4, Item 52	Tracked mobile crane, 105 t
	Dumper	1	104	50	BS5228-1: Table C.4, Item 3	Dumper, 7 t
	150t crawler crane	1	103	50	BS5228-1: Table C.4, Item 52	Tracked mobile crane, 105 t
Shaft secondary lining General site equipment also applicable during this phase	Concrete deliveries (discharging)	1	103	20	BS5228-1: Table C.4, Item 18	Cement mixer truck (discharging),
	Concrete pump	2	95	20	BS5228-1: Table C.4, Item 24	Concrete pump + cement mixer truck (discharging), 8 t / 350 bar
	Fixed and portable concrete vibrators	4	106	20	BS5228-1: Table C.4, Item 33	Poker vibrator,
	100t crawler crane	1	103	50	BS5228-1: Table C.4, Item 52	Tracked mobile crane, 105 t

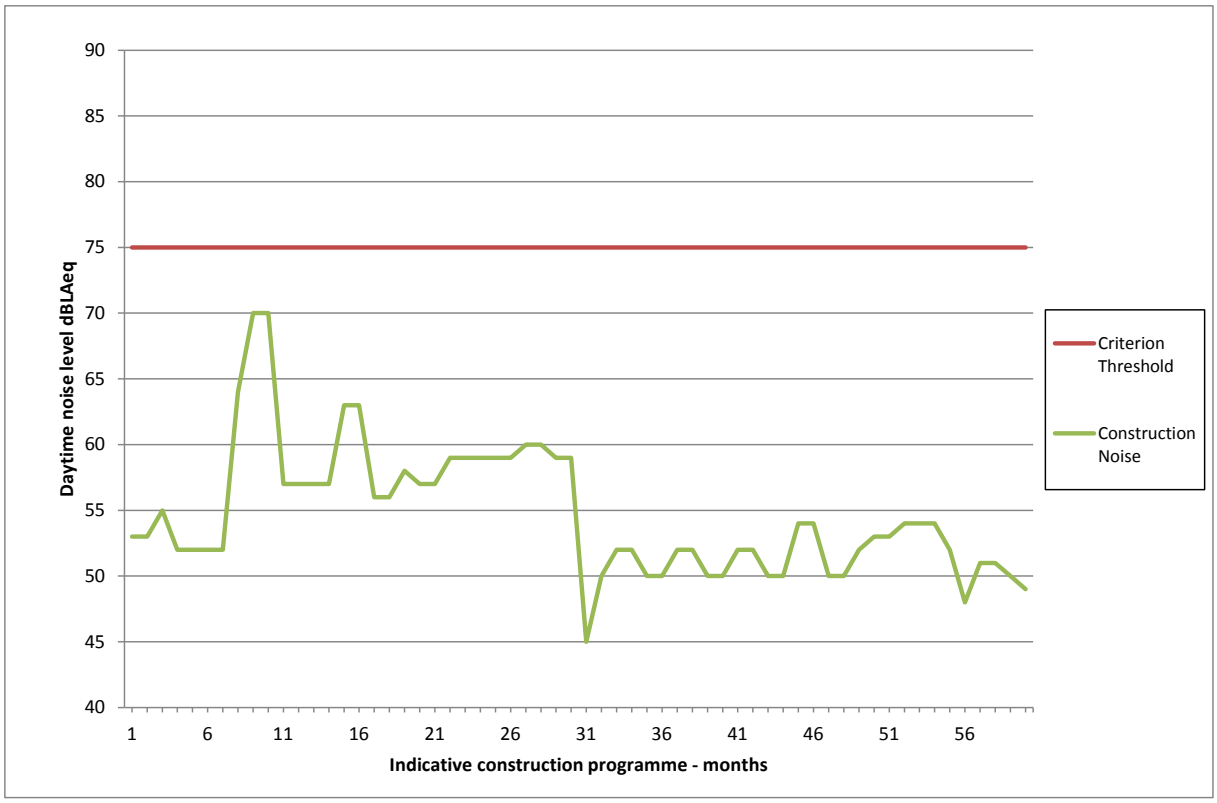
Construction activity	Plant	Unit No(s)	Activity LWA (dB)	% on-time	Data Source	Description of equipment used in the assessment
	Service Crane 40T mobile Crane	1	98	25	BS5228-1: Table C.4, Item 43	Wheeled mobile crane, 35 t
	Hand tools (e.g. drills and wrenches)	4	95	80	Estimated	Impact wrench and compressor,
Piling for shaft/culvert support	80t crawler crane	1	103	50	BS5228-1: Table C.4, Item 52	Tracked mobile crane, 105 t
	25 tonne mobile crane	1	98	50	BS5228-1: Table C.4, Item 43	Wheeled mobile crane, 35 t
	Vibratory piling rig	1	116	80	BS5228-1: Table C.3, Item 8	Vibratory piling rig, 52 t
Culvert and chamber works General site equipment also applicable during this phase	Service crane100T mobile crane	1	103	50	BS5228-1: Table C.4, Item 52	Tracked mobile crane, 105 t
	25t excavator	1	105	50	BS5228-1: Table C.2, Item 19	Tracked excavator, 25 t
	Fixed and portable concrete vibrators	4	106	20	BS5228-1: Table C.4, Item 33	Poker vibrator,
	Concrete deliveries (discharging)	1	103	20	BS5228-1: Table C.4, Item 18	Cement mixer truck (discharging),
	Concrete boom pump	1	108	20	BS5228-1: Table C.4, Item 29	Truck mounted concrete pump + boom arm, 26 t
	Dumper	1	104	50	BS5228-1: Table C.4, Item 3	Dumper, 7 t
	Hand tools (e.g. drills and	4	95	80	Estimated	Impact wrench and

Construction activity	Plant	Unit No(s)	Activity LWA (dB)	% on-time	Data Source	Description of equipment used in the assessment
	wrenches)					compressor,
Landscaping General site equipment NOT applicable during this phase	25t excavator	1	97	50	BS5228-1: Table C.2, Item 25	Tracked excavator, 14 t
	Dumper	1	104	70	BS5228-1: Table C.4, Item 3	Dumper, 7 t
	Telescopic Handler/FLT	1	99	30	BS5228-1: Table C.2, Item 35	Telescopic handler, 10 t
	Hiab lorry/crane	1	105	5	BS5228-1: Table C.4, Item 53	Lorry with lifting boom, 6 t
	Compressor for hand-held breaker	1	102	10	BS5228-1: Table C.1, Item 8	Hydraulic breaker power pack, 63 kg/ 138 bar
	Hand-held percussive breaker	1	111	10	BS5228-1: Table C.1, Item 6	Hand-held pneumatic breaker,
	Plate compactors	2	108	10	BS5228-1: Table C.2, Item 41	Vibratory plate (petrol)
	Vibrating rollers	1	101	70	BS5228-1: Table C.2, Item 38	Roller, 18 t

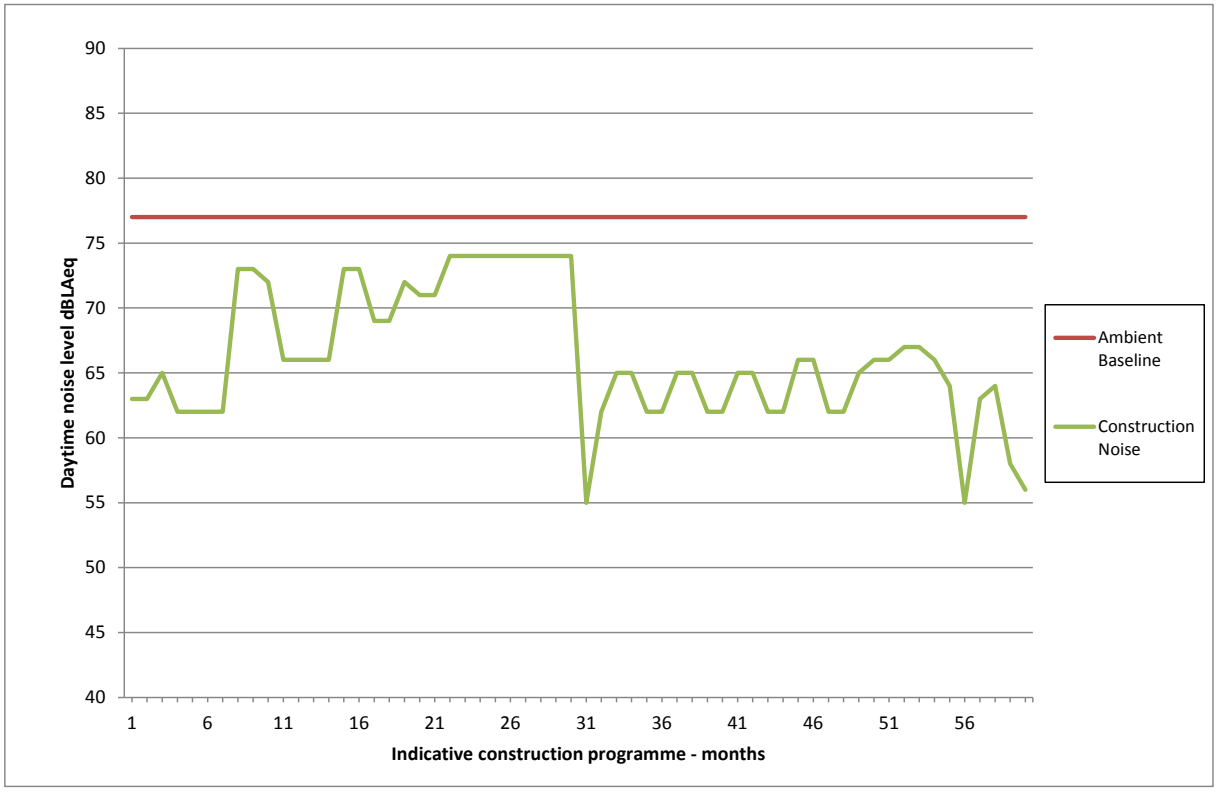
Note: This schedule provides an illustration of typical plant that could be used in the construction of the Thames Tideway Tunnel at this site. The appointed Contractor must comply with section 6 of the CoCP but may vary the method and plant to be used. This schedule therefore represents the most reasonable assumption for the assessment that can be made at this stage.

G.2.5 The predicted construction noise over time at each receptor is shown in the figures below. It should be noted that these representations are for the worst-case scenarios for noise exposure at the upper floors. For comparison with the construction noise, the figures also show either the potential significance criterion threshold for residential receptors, or the ambient noise level. This comparison is discussed in the main assessment text. The night-time noise levels have also been assessed for the short period of night-time works; these results are described in the main assessment text and not presented here.

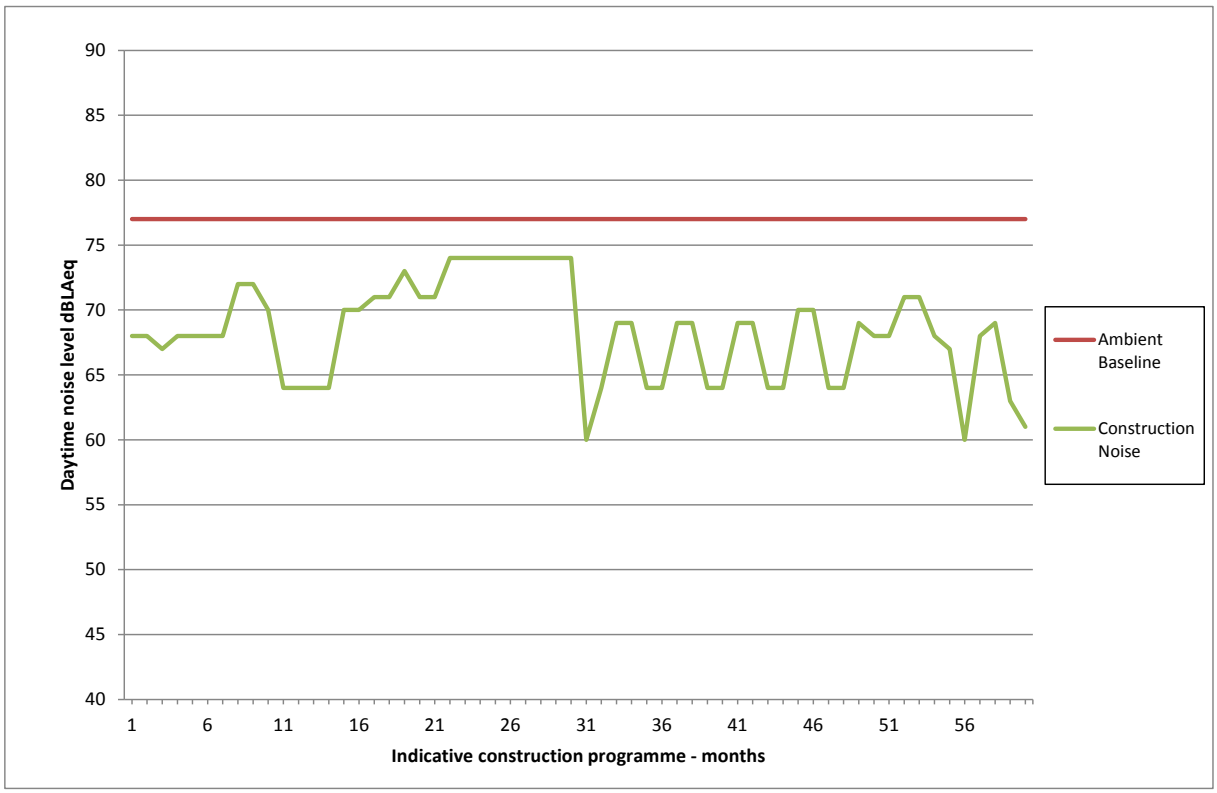
Vol 18 Plate G.5 Average monthly daytime noise level over duration of construction – Kings Bench Walk (BB1)



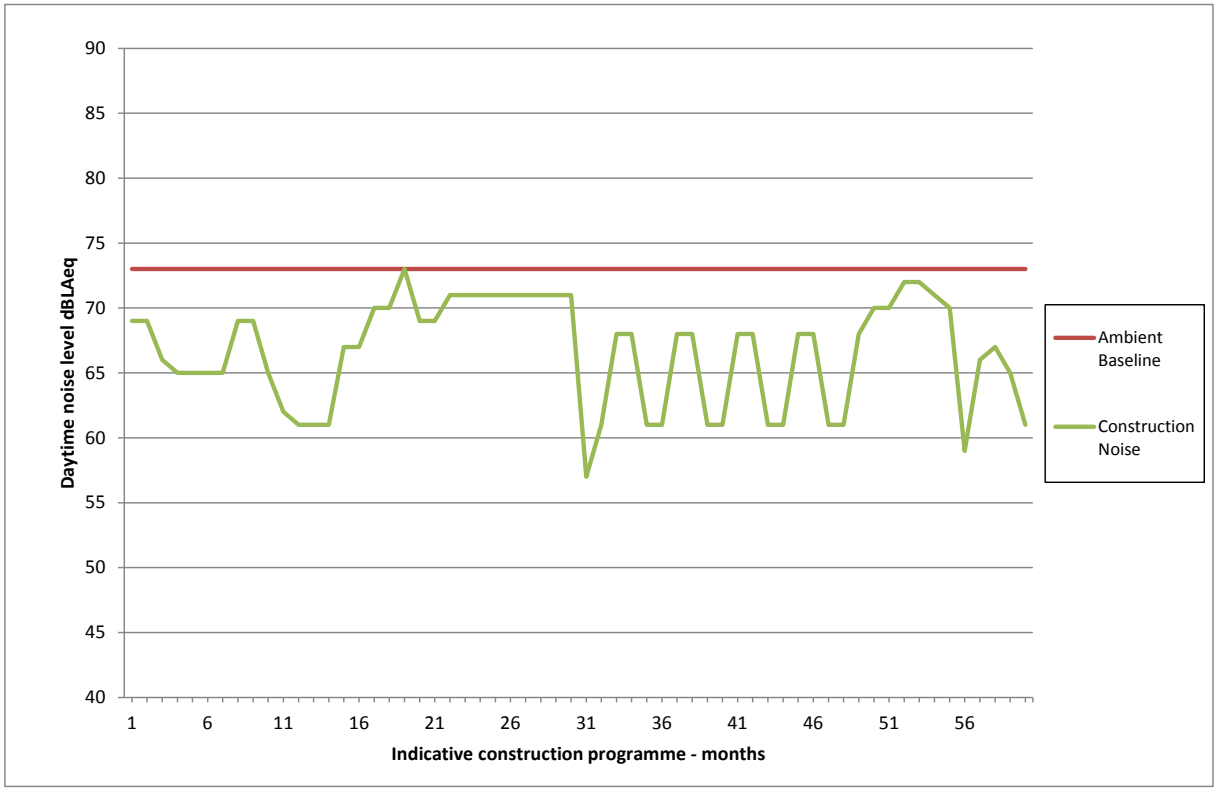
Vol 18 Plate G.6 Average monthly daytime noise level over duration of construction – 40-50 Victoria Embankment (BB2)



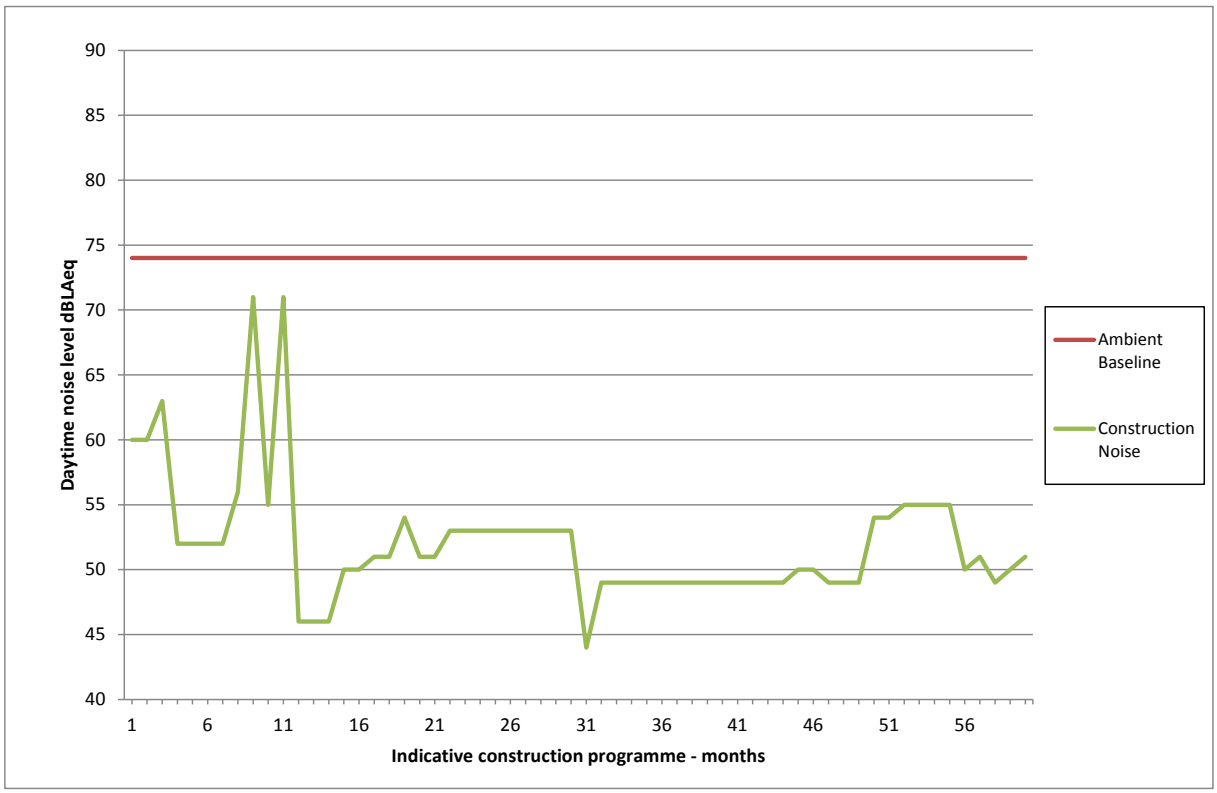
Vol 18 Plate G.7 Average monthly daytime noise level over duration of construction – Sion Hall (BB3)



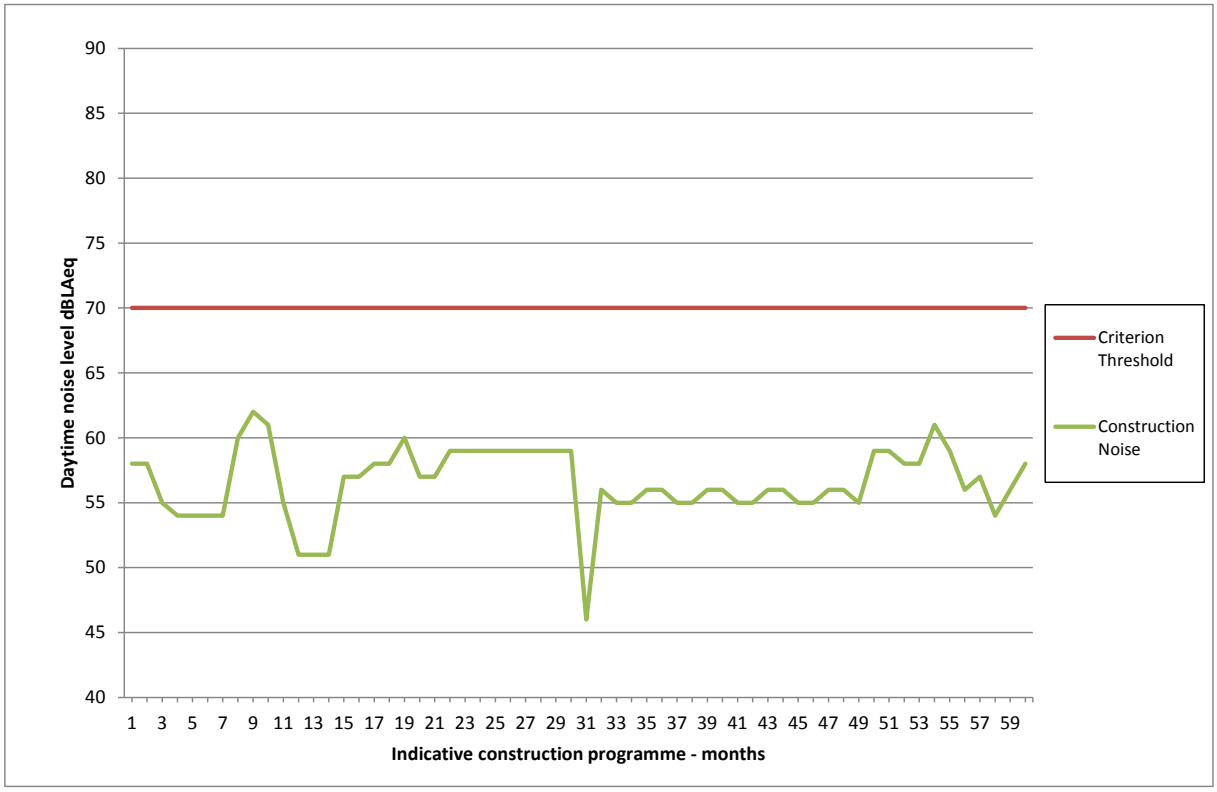
Vol 18 Plate G.8 Average monthly daytime noise level over duration of construction - 60 Victoria Embankment (BB4)



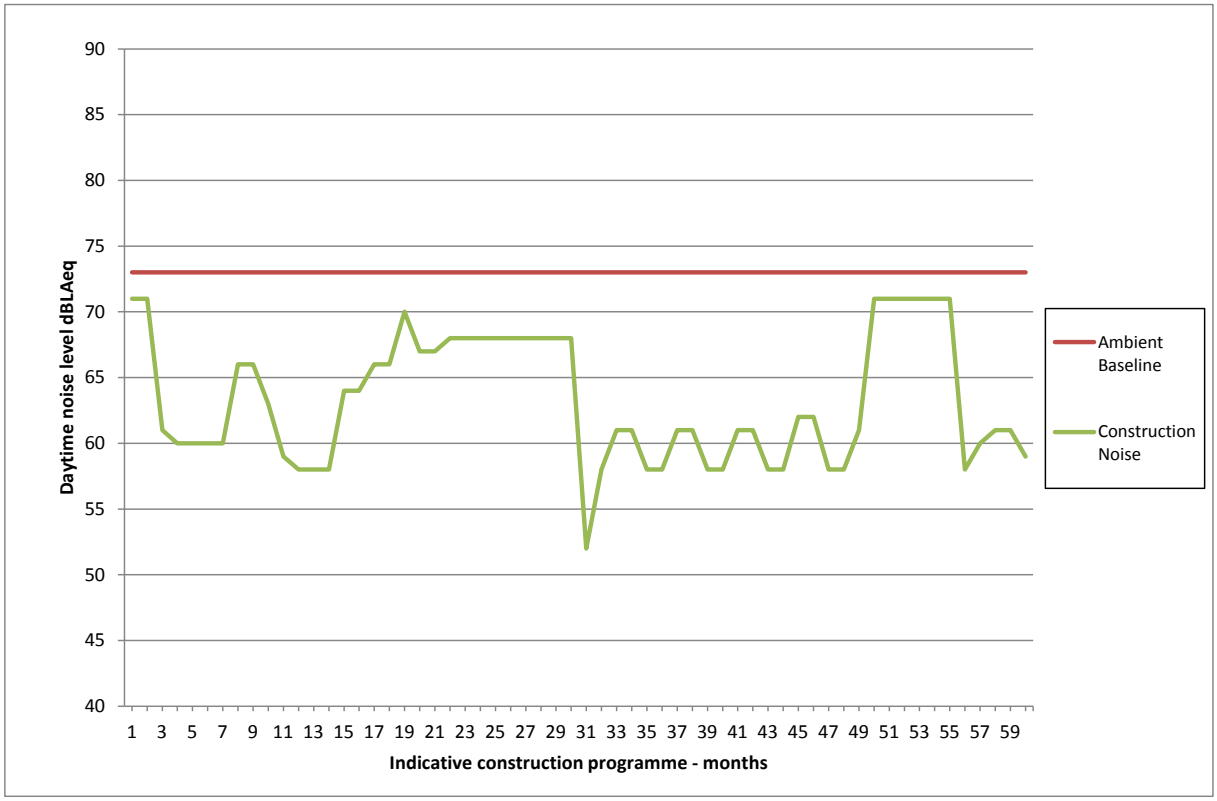
Vol 18 Plate G.9 Average monthly daytime noise level over duration of construction, Mermaid Conference Centre (BB5)



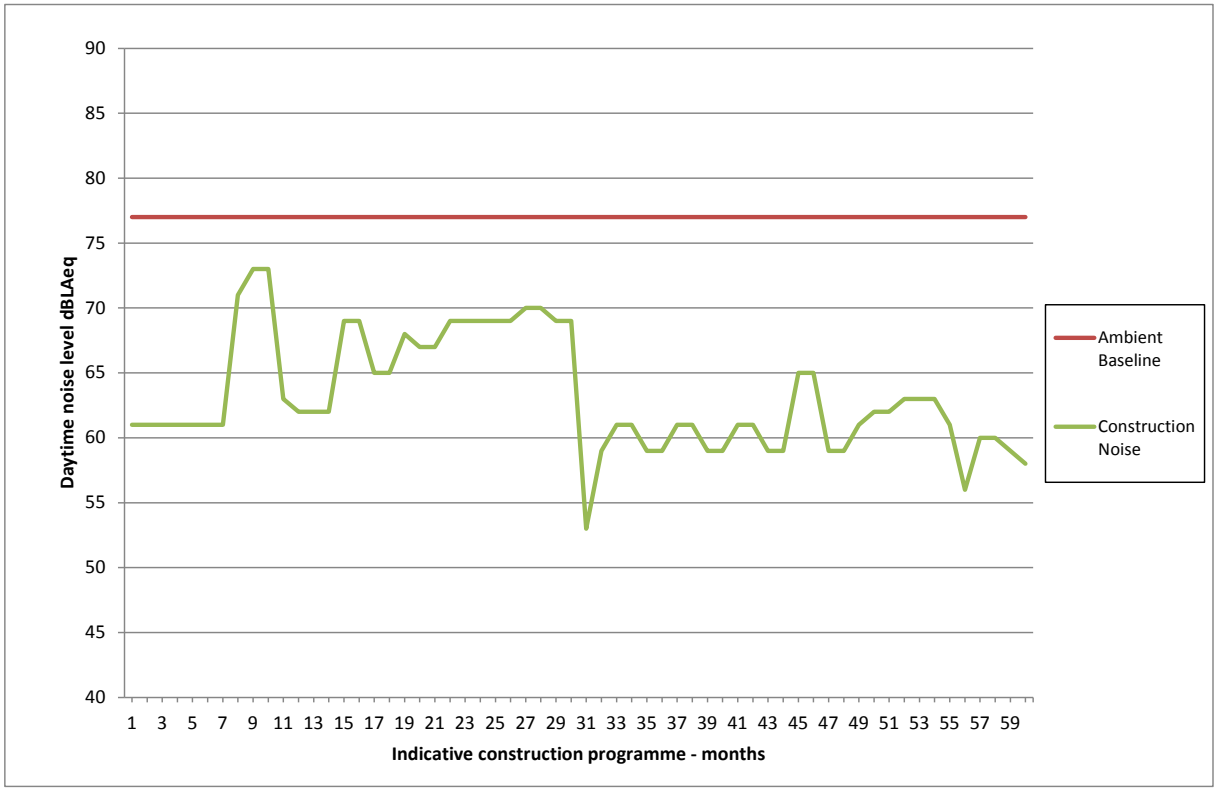
Vol 18 Plate G.10 Average monthly daytime noise level over duration of construction, River Court (BB6)



Vol 18 Plate G.11 Average monthly daytime noise level over duration of construction, Unilever House (BB7)



Vol 18 Plate G.12 Average monthly daytime noise level over duration of construction, The President (BB8)



References

[i] BRITISH STANDARDS INSTITUTION, *BS 5228 Code of Practice for Noise and Vibration Control on Open Construction Sites*, British Standards Institution (2009)

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Thames Tideway Tunnel
Thames Water Utilities Limited

Application for Development Consent

Application Reference Number: WWO10001

Environmental Statement

Doc Ref: **6.2.18**

Volume 18 Blackfriars Bridge Foreshore appendices

Appendix H: Socio-economics

APFP Regulations 2009: Regulation **5(2)(a)**

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Thames Tideway Tunnel

Environmental Statement

Volume 18 Blackfriars Bridge Foreshore appendices

Appendix H: Socio-economics

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Appendix H:Socio-economics

H.1 Baseline community profile

H.1.4 The community profile is based on Output Area (OA) and Local Authority level data from the Office of National Statistics (ONS). The data have been obtained from four sources: Census 2001[1] (the last census for which data are available[i]), Department of Communities and Local Government Deprivation Indices 2010[2], London Public Health Observatory 2012[3], and the Network of Public Health Observatories 2011[4] (see Volume 2 Methodology). Data is grouped according to those 'protected characteristics'[ii] or groups which are relevant for consideration in relation to this socio-economic impact assessment. This baseline community profile provides context for this socio-economic assessment.

H.1.5 On the basis of likely impacts on receptors identified in this socio-economic assessment, the community profile examines the 'immediate area' surrounding the construction site (ie, within a catchment of 250m) the 'wider local area' (ie, within a catchment of 1km) and the overall borough level (which in this case is the City of London).

H.1.6 The main risk groups concentrated[iii] within the immediate area surrounding the proposed construction site are:

a. persons aged over 65 year old

b. persons of Black ethnicity

c. persons suffering from a long term or limiting illness or claiming disability living allowance.

H.1.7 The main risk group concentrated within the wider local area surrounding the proposed construction site is 'persons of Black ethnicity'.

Resident population

H.1.8 The resident population was approximately 550 within 250m of the site and approximately 12,500 within 1km of the site at the time of the last census.

Gender and age

H.1.9 Of the total population within 250m of the construction site 54.3% of residents are male, slightly higher than the proportion of males within the wider local area (51.4%), however similar to borough wide levels of male residents (53.3%). At a Greater London level however, there is a slight predominance of females (51.6%).

[i] Census 2001. This type of data for the 2011 Census had not been released at the time of the assessment.

[ii] The Equalities Act 2010 defines 'protected characteristics' as: age, disability, gender reassignment, marriage and civil partnership, pregnancy and maternity, race, religion or belief, sex, and sexual orientation. Of these characteristics, age, disability, race and religion are relevant for consideration in relation to this socio-economic impact assessment.

[iii] In this instance, 'concentrated' refers to the occurrence of a particular protected characteristic group, the proportion of which is notably higher than borough wide proportions.

H.1.10 Table H.1 outlines age breakdown by assessment area, it illustrates that within a 250m (10.6%) and 1km (11.0%) catchment of the site, and at a borough wide level (9.4%) the proportion of under 16 year olds is broadly in line, and approximately half that of the Greater London average (20.2%).

H.1.11 Within 250m of the site, over 65 year olds (15.5%) are one third higher than within a 1km catchment of the site (10.5%). The Greater London average of over 65 year olds (12.4%) is somewhat lower than within 250m, however higher than the proportion of over 65 year olds within 1km. See Vol 18 Table H.1 below.

Vol 18 Table H.1 Socio-economics – age breakdown by catchment area

Age group	Assessment area			
	Immediate area (250m)	Wider local area (1km)	Borough wide (City of London)	Greater London
Under 16 years old	10.6%	11.0%	9.4%	20.2%
Over 65 years old	15.5%	10.5%	13.2%	12.4%

Ethnicity

H.1.12 Table H.2 outlines ethnicity by assessment area, showing that within 250m of the construction site, White residents comprise over four fifths of the population (84.0%) with Black and Minority Ethnic (BME) groups comprising the remaining 16.0% residents. The proportion of white residents within 250m of the site is broadly in line with the City of London level (84.5%) and approximately 10% higher than levels within the wider local area.

H.1.13 The proportion of BME residents within 250m (16.0%) is broadly in line with City of London levels (15.2%) however considerably lower than within 1km (25.9%) and the Greater London average (28.8%).Within 1km of the site and at a borough level, Asian residents are approximately half that of the Greater London average. Within 250m of the site, the proportion of Asian residents (2.9%) is considerably lower than the Greater London level (12.1%), as shown Vol 18 Table H.2 below.

Vol 18 Table H.2 Socio-economics – ethnicity by catchment area

Ethnicity	Assessment area			
	Immediate area (250m)	Wider local area (1km)	Borough wide (City of London)	Greater London
White	84.0%	74.1%	84.5%	71.2%
BME	16.0%	25.9%	15.2%	28.8%

Ethnicity	Assessment area			
	Immediate area (250m)	Wider local area (1km)	Borough wide (City of London)	Greater London
Asian	2.5%	5.9%	6.9%	12.1%
Black	8.2%	10.8%	2.4%	10.9%
Other	2.5%	3.3%	3.7%	2.7%
Mixed	2.9%	5.9%	2.2%	3.2%

Note: The figure for BME data presented in Table H.2 is the sum of data for Asian, Black, Other and Mixed ethnicities.

Religion and belief

H.1.14 Within 250m and 1km of the site and at a borough wide level, Christians are the predominant religious group at 61.7%, 57.4% and 55.0% respectively.

H.1.15 Muslims are the second most predominant religious group with 5.6% residents within a 1km catchment and 5.6% of residents at a borough wide level. The proportion of Muslims within 250m of the site (1.1%) is considerably lower than within 1km and borough-wide.

Health indicators

H.1.16 Table H.3 outlines health indicators by assessment area, noting that approximately 16.5% of residents within 250m of the site have a long term or limiting illness somewhat higher than within 1km of the site (14.3%) and the City of London level (13.3%).

H.1.17 Those residents who claim disability living allowance within 250m of the site (5.7%) are over twice as high as the City of London level (2.4%) and somewhat higher than within a 1km catchment (4.7%) and Greater London level (4.5%). See Vol 18 Table H.3.

Vol 18 Table H.3 Socio-economics – health indicators by catchment area

Health indicator	Assessment area			
	Immediate area (250m)	Wider local area (1km)	Borough wide (City of London)	Greater London
Long term limiting sick	16.5%	14.3%	13.3%	15.5%
Disability living allowance	5.7%	4.7%	2.4%	4.5%

H.1.18 In the Middle Layer Super output Area (MSOA)[iv](Office of National Statistics, 2012)[5] in which the construction site falls, levels of adult and child obesity measured across the entire borough fall within the lowest quintile (i.e., the lowest being the best) in the Borough.

H.1.19 Data available at a borough level only indicates that numbers of adults and children undertaking physical activity fall within the lowest quintile (i.e., the lowest being the worst) of all the London boroughs.

H.1.20 Death rates by heart disease, circulatory disease, cancer, strokes and heart disease within the MSOA which the site falls within are all in the lowest quintile (i.e. the lowest being the best) within the borough.

H.1.21 Male and female life expectancy in the MSOA in which the site falls within are in the highest quintile within the borough (i.e., the highest being the best) with average life expectancy for both male and female residents of 84.9 to 93.1 years old.

Lifestyle and deprivation indicators

H.1.22 Table H.4 outlines lifestyle and income deprivation indicators by assessment area, showing that a high proportion of households within 1km of the site do not own cars (63.5%), broadly in line with the City of London average (62.0%). Within 250m, 1km and at a borough level, the proportion of households without car ownership is significantly higher than the Greater London average (37.5%). See Vol 18 Table H.4 below.

Vol 18 Table H.4 Socio-economics – lifestyle and income deprivation levels by catchment area

Indicator	Assessment area			
	Immediate area (250m)	Wider local area (1km)	Borough wide (City of London)	Greater London
No car households	52.7%	63.5%	62.0%	37.5%
Income	0.0%	2.2%	0.0%	30.8%
Overall	0.0%	2.2%	0.0%	24.5%

H.1.23 Levels of deprivation measured both by income deprivation and overall deprivation within 250m and at the City of London level are recorded as 0%. Within a 1km catchment of the site, approximately 2.2% residents suffer from both income deprivation and overall deprivation. Income deprivation and overall deprivation within Greater London (30.8% and 24.5% respectively) are considerably higher than within 250m, 1km and at a borough wide level.

[iv] MSOAs are areas determined by the Office of National Statistics (ONS) to collect local area statistics. MSOAs have a minimum size of 5,000 residents and 2,000 households. MSOAs have an average population size of 7,200 residents.

H.2 Baseline economic profile

H.2.1 This section presents a profile of the economy local to the proposed construction site at Blackfriars Bridge Foreshore

H.2.2 Data are presented for the geographical area within a radius or 'catchment' of approximately 250m from the boundary of the Limits of land to be acquired or used (LLAU) of the project site. Data are also provided at the overall borough level (which in this case is the City of London)[6] and for Greater London.

H.2.3 Data are sourced from Experian's National Business Database (2012), which draws primarily on regularly updated records from Companies House[v].

Employment and businesses

H.2.4 Within 250m of the site there are approximately 23,795 jobs.[vi] Vol 18 Table H.5[vii] below illustrates the breakdown of employment by sector, based on the UK Standard Industrial Classification (SIC) 2007[7]. It shows data for those sectors which account for more than 5% of total employment within approximately 250m. It can be seen that:

a. Professional, Scientific and Technical Services account for 29% of employment within 250m, somewhat higher than within the City of London (24%) and considerably higher than within Greater London (11%).

b. Wholesale and Retail Trade / Repair of Motor Vehicles and Motorcycles accounts for 19% of employment within 250m, higher than within the City of London overall (8%) and somewhat higher than within Greater London (16%).

c. Information and Communication account for 11% of employment within 250m, somewhat higher than at the other two geographical levels (6% and 7%).

d. Administrative and Support Services account for 7% to 8% of employment at all three geographical levels.

e. Construction accounts for 8% of employment within 250m, higher than within the City of London (2%) and Greater London (5%).

f. Financial and Insurance Activities account for 7% of employment within 250m, considerably lower than within the City of London (29%) and slightly higher than within Greater London as a whole (4%).

[v] Information on employees and businesses reflects aggregated data for seven digit post-code units falling wholly or partially within a 250m boundary of the LLAU. This includes post code units on the opposite side of the River Thames, if relevant. Please refer to Volume 2 Appendix H for further details.

[vi] Employees data reflect a head count of workers on-site rather than Full Time Equivalent (FTE) jobs. While employee figures are mostly based on actual reported data, a proportion is based on modelled data.

[vii] Data in tables do not always sum due to rounding.

g. Accommodation and Food Services Activities account for 5% to 8% of employment at all three geographical levels.

Vol 18 Table H.5 Socio-economics – employment by top seven sectors (2012)

	Assessment area		
Sector (Standard Industrial Code 2007)	**Immediate area (250m)**	**Borough wide (City of London)**	**Greater London**
Professional, Scientific and Technical Activities	29%	24%	11%
Wholesale and Retail Trade / Repair of Motor Vehicles and Motorcycles	19%	8%	16%
Information and Communication	11%	6%	7%
Administrative and Support Services	8%	7%	8%
Construction	8%	2%	5%
Financial and Insurance Activities	7%	29%	4%
Accommodation and Food Service Activities	5%	6%	8%
Other (including unclassified)	14%	83%	59%

H.2.5 Within approximately 250m of the site there are approximately 1,100 businesses (defined here as business locations[viii]). Wholesale and Retail Trade / Repair of Motor Vehicles and Motorcycles account for 5% of businesses and Administrative and Support Services account for 16%; both considerably different to their respective employment levels. In other sectors, the proportion of businesses generally reflects their employment breakdown, with Professional, Scientific and Technical Activities accounting for both the largest share of businesses (19%) and employment (set out in Vol 18 Table H.5).

H.2.6 Vol 18 Table H.6 illustrates the size of businesses in terms of the number of employees on site. At all geographical levels, businesses within the smallest size band (one to nine employees) account for a majority. However, there is a considerably lower proportion of the smallest size category businesses within both 250m (65%) and the City of London (60%) than within Greater London (88%). Businesses with 25 or more employees account for 11% of all businesses within 250m of the site, similar to within the City of London (12%) but considerably greater than within Greater London as a whole (4%).

H.2.7 For the sectors accounting for the greatest proportions of jobs and businesses within approximately 250m, the size banding of businesses by number of employees varies. Whereas 75% of Wholesale and Retail

[viii] This count relates to business 'locations' or 'units'; an enterprise may have a number of business locations / units. It includes private sector, public sector and voluntary sector / charitable entities.

Trade / Repair of Motor Vehicles and Motorcycles businesses have one to nine employees, 48% of Professional, Scientific and Technical Activities and 46% of Financial and Insurance Activities businesses are within this band. Within 250m, 26% of businesses engaged in Professional, Scientific and Technical Activities employ in excess of 50 employees. Within the Administrative and Support Services sector, the proportion of businesses with one to nine employees is 68%, and 29% have ten to 24 employees, which are similar to the corresponding averages across all sectors within 250m (65% and 23%).

Vol 18 Table H.6 Socio-economics – businesses by size band (employees at site)

Assessment area / sector		Size band (employees at site)					
		1-9	10-24	25-49	50-99	100-249	250+
Immediate area (250m)		65%	23%	4%	4%	2%	1%
-	*Professional, Scientific and Technical Activities*	48%	16%	13%	15%	6%	1%
-	*Administrative and Support Services*	68%	29%	2%	0%	0%	1%
-	*Financial and Insurance Activities*	46%	46%	3%	1%	2%	1%
-	*Information and Communication*	54%	32%	5%	2%	2%	4%
-	*Wholesale and Retail Trade / Repair of Motor Vehicles and Motorcycles*	75%	18%	2%	0%	0%	5%
Borough wide (City of London)		60%	28%	6%	3%	2%	1%
Greater London		88%	8%	2%	1%	1%	0%

H.3 Baseline usage surveys

H.3.4 Please refer to Vol 2 Appendix H for details on the methodology used for the open space usage surveys and subsequent analysis.

Survey dates and times

H.3.5 Surveys were undertaken as follows.

Summer

a. Monday 1st August 2011, 1pm to 2pm, 3pm to 4pm and 5pm to 6pm (sunny, 26^{O}C)

b. Sunday 14th August 2011, 1pm to 2pm and 3pm to 4pm (sunny, 19^{O}C)

Autumn

a. Tuesday 4th October 2011, 1pm to 2pm, 3pm to 4pm and 5pm to 6pm (partly cloudy, 18OC)

b. Saturday 15th October 2011, 2pm to 3pm and 4pm to 5pm (sunny, 16OC)

Survey points

H.3.6 Vol 18 Figure H.1 (see separate volume of figures) shows the location of the survey areas listed in Vol 18 Table H.7below.

Vol 18 Table H.7 Socio-economics – survey zones and duration of survey period

Name	Location	Survey times	Frequency
Survey point 1	Thames Path: west	20 minutes	Every 2 hours
Survey point 2	Thames Path: St Paul's Walk	10 minutes	Every 2 hours

Site specific considerations

H.3.7 Construction work at Blackfriars Station was ongoing throughout the survey periods, with the stairway between the eastern side of Blackfriars Bridge and St. Paul's Walk being closed to pedestrian traffic as a result.

Key findings and observations

Survey point 1 – Thames Path: west

a. Observed to be very well used at most times, especially during lunchtime (1pm to 2pm) on weekdays and after working hours (during observations made between 5pm and 6pm).

b. A peak of 920 users per hour was estimated during a summer weekday lunchtime, with generally lower user numbers being recorded during autumn surveys.

c. During standard office lunch hours between 1pm and 2pm and between 5pm and 6pm, the Thames Path was predominantly used by walkers (on average 80% to 90%) and joggers (on average 15%).

d. The Thames Path was well used on weekends, during both summer and autumn, principally for walking, with an estimated peak of over 510 users per hour being recorded in autumn.

e. Based on the appearance of walkers (eg, carrying cameras, travelling in large groups, speaking non-English languages, and the manner in which they took note of nearby sights), the Thames Path appeared to be well used by tourists – both domestic and international – though this was somewhat less evident than at Victoria Embankment Foreshore (direct interviews were not conducted to confirm this observation).

f. Seating located along the Embankment at this location appeared to be used at least 50% of the time.

g. The majority of users (over 75%) recorded on each survey day were white, although somewhat higher proportions of ethnic minority users were recorded during mid afternoons than at peak times.

h. On average, 70 to 80% were young adults (18 to 39 years old), with the remainder being mostly older adults (40-59 years old and 60+ years old).

i. See Vol 18 Plate H.1 and Vol 18 Plate H.2 for further details.

Survey point 2 – Thames Path: St Paul's Walk

a. On weekdays, this section of the route was used comparatively less than the section at point 1, though was still generally well used. Usage peaked at 486 users per hour (around lunchtime) recorded during the autumn weekday and 416 users during the summer weekday.

b. On weekends, user numbers recorded were broadly similar to those recorded at point 1, with an estimated peak of 528 users per hour (around lunchtime) recorded during autumn.

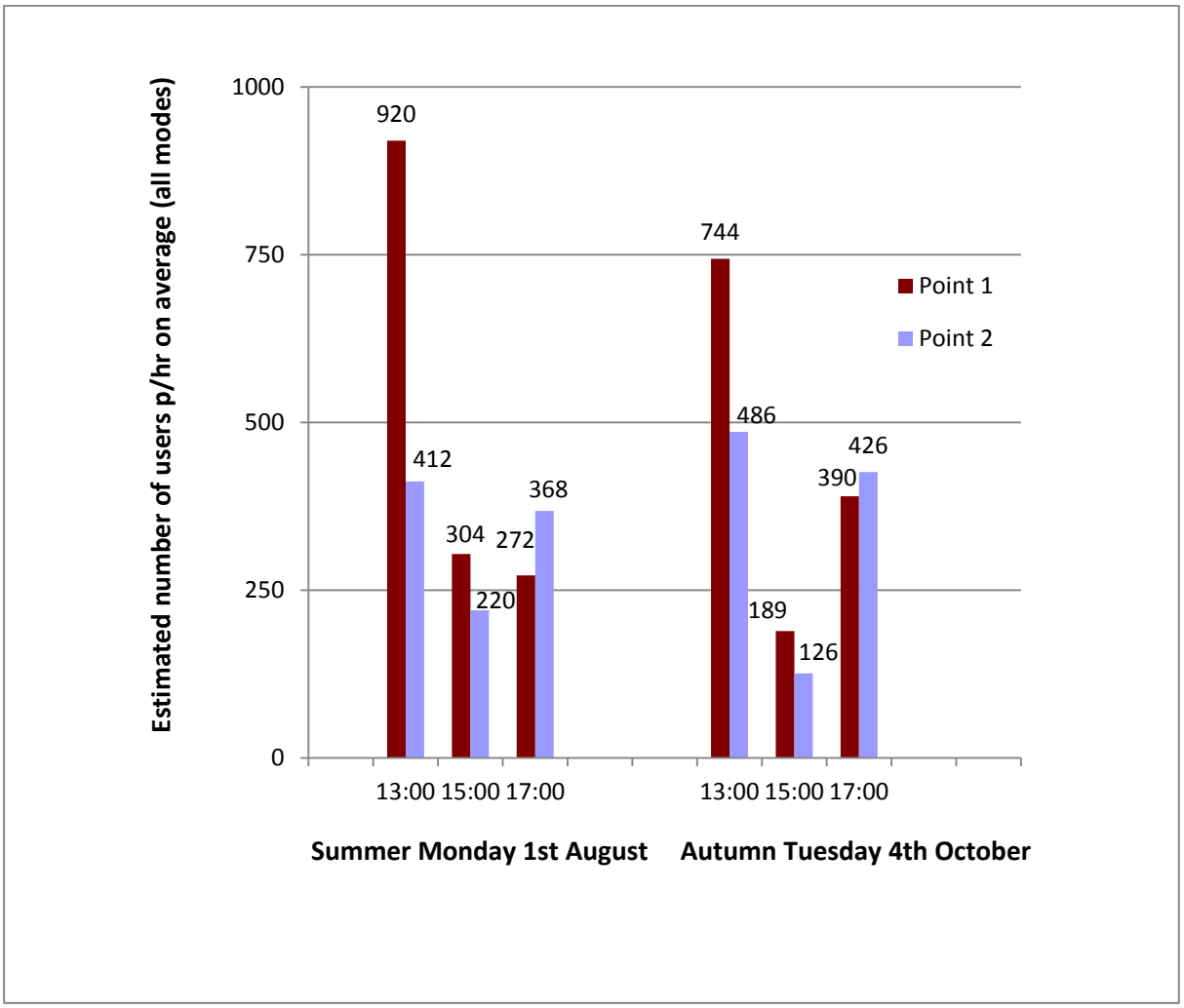
c. It appeared, again based on similar user characteristics to those noted above, that tourists made up a significant proportion of users.

d. Although over the course of the survey programme the majority of users (on average 75% to 80%) were white, usage by black and minority ethnic groups proportionately increased during mid-afternoon survey periods and at weekends.

e. Other characteristics relating to the type and ethnicity of user observed here were similar to those observed at point 1.

f. See Vol 18 Plate H.1andVol 18 Plate H.2 for further details.

Vol 18 Plate H.2 Socio-economics – Usage level of the Thames Path (averaged per hour) at survey points 1 and 2 (weekdays)

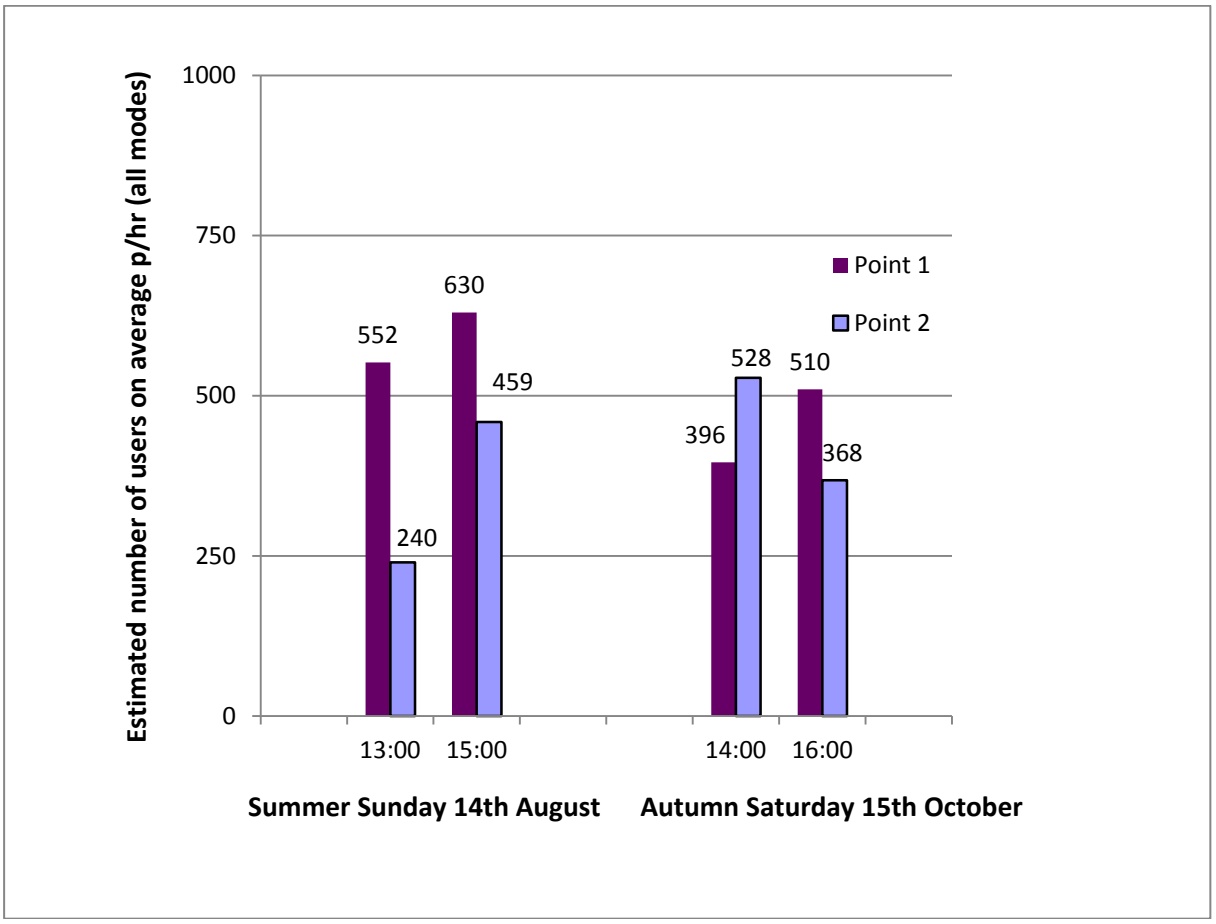


Other findings

a. Momentary observations of the Inner Temple Gardens, located to the north of the busy A3211, recorded that the Gardens were well used on the summer weekday lunchtime (the only time of day when the space is open to the general public). Lower usage levels were observed during autumn

b. As access to the Inner Temple Gardens is only from its northern corners, the vast majority of users remain in the northern half of the open space – well away from the road and the river foreshore.

Vol 18 Plate H.3 Socio-economics – Usage level of the Thames Path (averaged per hour) at survey points 1 and 2 (weekends)



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Thames Tideway Tunnel
Thames Water Utilities Limited

Application for Development Consent

Application Reference Number: WWO10001

Environmental Statement

Doc Ref: **6.2.18**

Volume 18 Blackfriars Bridge Foreshore appendices

Appendix I: Townscape and visual

APFP Regulations 2009: Regulation **5(2)(a)**

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Thames Tideway Tunnel

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Appendix I: Townscape and visual

I.1 Introduction

I.1.1 Construction and operational effects assessments at this site for this topic do not require the provision of any supporting information, so this appendix is intentionally empty.

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Thames Water Utilities Limited

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Appendix J: Transport

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Appendix J: Transport

J.1 Introduction

J.1.1 Construction and operational effects assessments at this site for this topic do not require the provision of any supporting information, so this appendix is intentionally empty.

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Thames Tideway Tunnel
Thames Water Utilities Limited

Application for Development Consent

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Volume 18 Blackfriars Bridge Foreshore appendices

Appendix K: Water resources - groundwater

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Appendix K: Water resources – groundwater

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Appendix K: Water resources – groundwater

K.1 Geology

K.1.2 A summary of the anticipated geological succession at the Blackfriars Bridge Foreshore site is shown in the Vol 18 Table K.1.

Vol 18 Table K.1 Groundwater - anticipated geological succession

Period	Series	Group	Formation
Quaternary	Holocene	Superficial Deposits	Made ground
			Alluvium
	Pleistocene		River Terrace Deposits
Palaeogene	Eocene	Thames	London Clay
			Harwich
	Palaeocene	Lambeth	Upper Shelly Beds
			Upper Mottled Beds
			Laminated Beds
			Lower Shelly Beds
			Mid-Lambeth Hiatus*
			Lower Mottled Beds
			Upnor
		No group	Thanet Sand
Cretaceous	Upper Cretaceous	White Chalk Subgroup	Seaford Chalk**

** Not a Formation but an important depositional feature*
*** Subdivided into the Haven Brow, Cuckmere and Belle Tout members.*

K.1.3 The superficial and solid geology in the vicinity of the site, as published by the British Geological Survey (BGS) (BGS, 2009)[1], is shown in Vol 18 Figure 13.4.1 and Vol 18 Figure 13.4.2 respectively (see separate volume of figures).

K.1.4 The ground investigation undertaken for the Thames Tideway Tunnel project has involved drilling boreholes both on the banks and within the main river channel for the purposes of understanding the geology and hydrogeology within the assessment area. The depths and thicknesses of the geological layers have been based on ground investigation boreholes located on site and up to 230m from the Blackfriars Bridge Foreshore site; these are boreholes SR1058, SR2047, SR2048, SR2049 and SR5011. The locations of boreholes around the site are shown in Vol 18 Figure

13.4.1 (see separate volume of figures). The depths and thicknesses of geological layers encountered are summarised in Vol 18 Table K.2.

Vol 18 Table K.2 Groundwater - anticipated ground conditions

Formation	Top elevation* (mATD)**	Depth below river level (m)	Thickness (m)
Alluvium	96.50	0.00	1.50
River Terrace Deposits	95.00	1.50	2.00
London Clay			
B	93.00	3.50	3.00
A3ii	90.00	6.50	7.60
A3i	82.40	14.10	3.75
A2	78.65	17.85	11.81
Harwich Formation	66.84	29.66	0.32
Lambeth Group			
Sand Unit	66.52	29.98	2.50
UMB	64.02	32.48	4.50
LtB	59.52	36.98	0.75
LSB	58.77	37.73	0.55
LMB	58.22	38.28	3.67
UPN (Gv)	54.55	41.95	2.07
UPN	52.48	44.02	3.46
Thanet Sand	49.02	47.48	10.27
Seaford Chalk	38.75	57.75	Not proven

** Top elevation of over-water boreholes is approximately 4m below assumed ground level*
***mATD = metres above tunnel datum. A commonly used term for sub-surface construction projects, which defines height above a datum set at -100mAOD (above Ordnance Datum)*
At borehole SR1061A, used for groundwater level monitoring, the top of the Alluvium is at 98.2mATD

UMB–Upper Mottled Beds; LtB–Laminated Beds; LSB-Lower Shelly Beds; LMB-Lower Mottled Beds; UPN (Gv)-Upnor Formation (Gravel); UPN-Upnor Formation

K.1.5 The combined sewer overflow (CSO) drop shaft at the Blackfriars Bridge Foreshore site would extend down to approximately 51.28mATD and would pass through the Alluvium, River Terrace Deposits, London Clay Formation, Harwich Formation, Lambeth Group and into the Upnor Formation at the base of the Lambeth Group. The base slab would extend to approximately 46.28mATD and would be founded in the Thanet Sand Formation.

K.1.6 As assumed for the purpose of this assessment the invert level of the shaft would extend down between 7.4m and 13.9m to approximately 90.7mATD (at the downstream end) to 97.2mATD (at the upstream end) and into the London Clay Formation, units B and A3ii.

K.1.7 The Alluvium, comprising silty clay and clayey silt, with occasional scattered pebbles and granules is expected to be 1.5m thick at the Blackfriars Bridge Foreshore site.

K.1.8 The River Terrace Deposits are formed of extensive alluvial sand and gravel deposits laid down in river terraces a braided river system of approximately 5km width, in river terraces since the Anglian glaciation. The River Terrace Deposits are expected to be 2m thick at the Blackfriars Bridge Foreshore site

K.1.9 The London Clay is described by the BGS as “fine, sandy, silty clay/silty clay, glauconitic at base” (BGS, 2012)[2] and is comprised of stiff to very stiff clay at the Blackfriars Bridge Foreshore site. The London Clay is divided into sub-units referred from oldest to youngest as A to E, with some of these sub-units dividing further, for example A2, A3i-iii, B in decreasing age order. The London Clay Formation is expected to be 26.16m thick at the Blackfriars Bridge Foreshore site.

K.1.10 The Harwich Formation comprises of fine-grained glauconitic sand and rounded black flinty pebble beds, commonly deposited in a series of superimposed channels and is expected to be 0.32m thick at the Blackfriars Bridge Foreshore site.

K.1.11 A significant, consistently occurring, sand unit, up to 2.5m thick, has been encountered at the top of the Upper Mottled Beds, at the junction with the base of the London Clay and/or Harwich Formation.

K.1.12 The Upper Mottled Beds (UMB) of the Lambeth Group comprises silty clay and clay, generally un-bedded, fissured and blocky, with up to 50% silt and sand and are expected to be 4.5m thick at the Blackfriars Bridge Foreshore site.

K.1.13 The Laminated Beds (LtB) of the Lambeth Group comprise thinly interbedded fine to medium grained sand, silt and clay with shells, with sand lenses found locally and are expected to be 0.75m thick at the Blackfriars Bridge Foreshore site.

K.1.14 The Lower Shelly Beds (LSB) of the Lambeth Group comprises dark grey to black clay with abundant shells and are expected to be 0.55m thick at the Blackfriars Bridge Foreshore site.

K.1.15 The Lower Mottled Beds (LMB) of the Lambeth Group comprises silty clay and clay, generally un-bedded, fissured and blocky, with up to 50% silt and sand and are expected to be 3.67m thick at the Blackfriars Bridge Foreshore site.

K.1.16 The Upnor Formation (UPN) is a variably bioturbated fine- to medium-grained sand with glauconite, rounded flint pebbles and minor clay, with distinctive pebble beds at the base and top (UPN (Gv)). The Upnor Formation is expected to be 5.53m thick at the Blackfriars Bridge Foreshore site.

K.1.17 The Thanet Sand Formation is described by the BGS as “marine glauconitic clayey silts and fine sands, varying in thickness” (BGS, 2012) and only occurs in the London Basin (BGS, 2000)[3]. The Thanet Sand is expected to be 10.27m thick at the Blackfriars Bridge Foreshore site.

K.1.18 The Seaford Chalk is the upper unit of the White Chalk, comprising firm to soft non-nodular Chalk with flint beds. Thin marl seams are found in the lower 8m and absent higher up. A hard ground marks the top of the Seaford Chalk. The total thickness of the Seaford Chalk was not proven through the available ground investigation.

K.1.19 In terms of geological structure, it is noted that there is a series of N-S and SSW-NNE trending faults are identified between Battersea and Chelsea bridges – referred to as the Chelsea Embankment (Albert Bridge) Fault Zone - intersecting the tunnel alignment at near to the perpendicular (Royse, 2008 [4]. It is reported that there is up to 5m vertical displacement of strata over this zone (Royse, 2008), resulting in uplift of the top of the Lambeth Group deposits into the proposed tunnel invert on the east side of Albert Bridge and tunnel construction at Chelsea Embankment. The Blackfriars Bridge Foreshore site is to the east of this fault zone, however, there may be minor faulting and fractures local to the site, together with localised displacement. Faults may also enhance or impede groundwater movement.

K.2 Hydrogeology

K.2.2 A summary of the anticipated hydrogeological conditions at the Blackfriars Bridge Foreshore site is shown in Vol 18 Table K.3.

Vol 18 Table K.3 Groundwater - anticipated main hydrogeological units

Group	Formation	Hydrogeology
Superficial deposits	(Made ground) Alluvium	Hydraulic continuity with upper aquifer
	River Terrace Deposits	Upper aquifer
Thames	London Clay	Aquiclude*
	Harwich	Aquitard**
Lambeth	Sand Unit Upper Mottled Beds Laminated Beds Lower Shelly Beds -----Mid Lambeth Hiatus***---- Lower Mottled Beds Upnor	Aquitards/ aquifers
No group	Thanet Sand	Lower aquifer
White Chalk	Seaford Chalk	

Group	Formation	Hydrogeology
Subgroup		

** Aquiclude - a hydrogeological unit which, although porous and capable of storing water, does not transmit it at rates sufficient to furnish an appreciable supply for a well or spring (USGS, 1989)*[5].
*** Aquitard - a poorly-permeable geological formation that does not yield water freely, but may still transmit significant quantities of water to or from adjacent aquifers (EA, 2012)*[6].
**** Not a Formation but an important depositional feature.*

K.2.3 The Alluvium overlies the River Terrace Deposits or upper aquifer. The ground investigation boreholes drilled in the vicinity of the site show groundwater was encountered within the Alluvium, suggesting that this formation is in hydraulic continuity with the underlying River Terrace Deposits.

K.2.4 The upper aquifer (River Terrace Deposits) is defined by the Environment Agency (EA) as a secondary A aquifer. These deposits are described as "permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important source of base flow to rivers. These are generally aquifers formerly classified as minor aquifers"6.

K.2.5 The lower aquifer comprises the Upnor and the Thanet Sand formations (both classified as secondary aquifers by the EA), and the Chalk (classified as a principal aquifer by the EA). A principal aquifer is described by the EA as "layers of rock or drift deposits that have high intergranular and/or fracture permeability - meaning they usually provide a high level of water storage. They may support water supply and/or river base flow on a strategic scale. In most cases, principal aquifers are aquifers previously designated as major aquifer" (EA website, 2012).

K.2.6 The CSO drop shaft would pass through the upper aquifer and then the London Clay Formation (B, A3ii, A3i and A2 sub divisions). The London Clay Formation is generally acknowledged as an aquiclude between the upper and lower aquifers. Any groundwater present is likely to consist of localised seepages and/or minor flows. It is anticipated that below the River Terrace Deposits the shaft would be excavated in predominantly dry London Clay Formation with the exception of minor seepage at various horizons, namely silt or claystone horizons. In unit A3ii, the presence of fine sand laminea/lenses at this horizon, may act as horizontal conduits for migration of groundwater from a nearby source.

K.2.7 The CSO drop shaft would then pass through the Harwich Formation, which may form a minor aquifer unit where it is isolated from the lower aquifer (Chalk / Thanet Sands) by the Lambeth Group. There may be limited connection via erosive features to the lower aquifer.

K.2.8 The CSO drop shaft would also pass through the Lambeth Group, in which several confined groundwater layers are anticipated to be encountered. Groundwater inflows are expected during excavation within the Upper Shelly Beds (USB) with potentially small inflows and more significantly at sub-artesian pressures within the Laminated Beds (formerly part of the Woolwich Formation).

K.2.9 The base of the CSO drop shaft would extend into the top of the lower aquifer (the Upnor Formation) and the base slab would extend into the Thanet Sands. These units have been considered to be in hydraulic continuity with each other and with the underlying Seaford Chalk.

K.2.10 The hydrogeological properties of the Chalk (principal aquifer) are defined by its transmissivity [the ability of rock to transmit water and is a function of its permeability and aquifer thickness] and storativity [the amount of water which the aquifer releases per unit change in water level]. The Chalk in the area around Blackfriars Bridge Foreshore is expected to have a medium transmissivity value of between 20m^2/d and 200m^2/d (average of 90m^2/d). The storativity value is expected to be approximately 1 x10^{-4} (EA and ESI, 2010)[7].

K.3 Groundwater level monitoring

K.3.2 Groundwater level monitoring was undertaken at a number of ground investigation boreholes across the assessment area with a few exceptions. In addition, the EA has a regional network of monitoring boreholes, mainly within the lower aquifer, across London which records are available dating back over 50 years.

K.3.3 Information on groundwater levels for this assessment was collected from two ground investigation boreholes located up to 600m from the Blackfriars Bridge Foreshore site (PR1060 and SR1061A). These boreholes have response zones[i] and monitor groundwater levels in the Alluvium and in the Seaford Chalk. The response zone depths, the monitored strata and the frequency of monitoring are detailed in Vol 18 Table K.4. The manual dip and logger data collected from these monitoring boreholes is shown in Vol 18 Table K.5.

Vol 18 Table K.4 Groundwater - monitoring boreholes

Borehole	Response zone depths mATD	Strata	Monitoring
SR1061A	97.22 – 93.72	Alluvium	Irregular dips and logger data
PR1060	34.72 – 30.72	Seaford Chalk	Irregular dips and logger data
TQ28/119	Not available	Chalk	Sporadic dips until 2005, monthly dips 2005-2012

[i] Response zone - the section of a borehole that is open to the host strata (EA, 2006)

Vol 18 Table K.5 Groundwater – summary level data

Borehole	Period of record	Maximum Month Year		Minimum Month Year		Average over the period of record	
		mbgl	mATD	mbgl	mATD	mbgl	mATD
SR1061A	23/10/2009 – 19/04/2012	6.43 (Feb. 2010)	98.66 (Feb. 2010)	7.21 (Nov. 2011)	98.09 (Oct. 2011)	6.73	98.49
PR1060	15/10/2009 – 02/04/2012	43.87 (June 2011)	60.86 (June 2011)	46.22 (Sep. 2010)	58.51 (Sep. 2010)	44.97	59.76
TQ28/119	08/11/1950* – 29/03/2012	47.48 (May 2000)	65.12 (May 2000)	100.19 (March 1967)	12.41 (March 1967)	76.92	35.68

** Water level records exist from 1845 but are sporadic; minimum, maximum and average values are calculated based on readings from 1950 onwards.*

K.3.4 The recorded water levels in the Alluvium at SR1061A range from 98.09mATD to 98.66mATD. These water levels fluctuate above and below the top of the formation in this borehole at 98. 2mATD, suggesting that this formation is influenced by tidal fluctuations.

K.3.5 The recorded water levels (piezometric head[ii]) in the Chalk at PR1060 range from 58.51mATD to 60.86mATD. These water levels consistently remain above the top of the formation at 38.75mATD, indicating that this formation is fully saturated and confined by the overlying London Clay Formation and Lambeth Group.

K.3.6 A plot of groundwater levels within the Alluvium and Chalk in the vicinity of the site is shown in Vol 18 Figure 13.4.3 (see separate volume of figures). There is only one borehole in the upper aquifer near the site (SR1061A) and as such it is difficult to determine the direction of groundwater flow. However it is likely that the direction of groundwater movement is from north to south, towards the River Thames, in these shallow deposits.

K.3.7 The EA network does not include any monitoring boreholes sufficiently close by to provide representative water level in the upper aquifer at the site. However the nearest EA groundwater level monitoring borehole in the lower aquifer is called B.T. Faraday (station number TQ38/233A) located at TQ 3196 8097, approximately 0.5km to the east of the Blackfriars Bridge Foreshore site (see Vol 18 Figure 13.4.3 in separate volume of figures). A second EA groundwater level monitoring borehole (station number TQ28/119) located at TQ 2997 8050 lies approximately 1.2km to the west. Both these boreholes record groundwater levels in the Chalk aquifer. A groundwater level hydrograph from these regional

[ii] Piezometric head – the level or pressure head to which confined groundwater would rise to in a piezometer if it is open to the atmosphere.

observation boreholes and PR1060 is shown in Vol 18 Figure 13.4.4 (see separate volume of figures).

K.3.8 A long term trend of rising groundwater levels from the early 1970's to mid-2000's, reflecting the changes in abstractions such as reductions in groundwater abstractions in central London due to the closure of heavy industries. Since 2000 water levels have declined. The recent lowering of levels reflects increase use of groundwater in central London groundwater. The same trends are seen in EA observation boreholes that lie to the west (TQ28/119) and east (TQ38/233A) of the site. The Chalk piezometry at the site as recorded in PR1060 lies at an elevation between the two EA observation boreholes, and is in line with these records.

K.3.9 The EA have produced regional groundwater contour plots which display the groundwater flowing in an east to west direction across site (EA, 2011)[8].

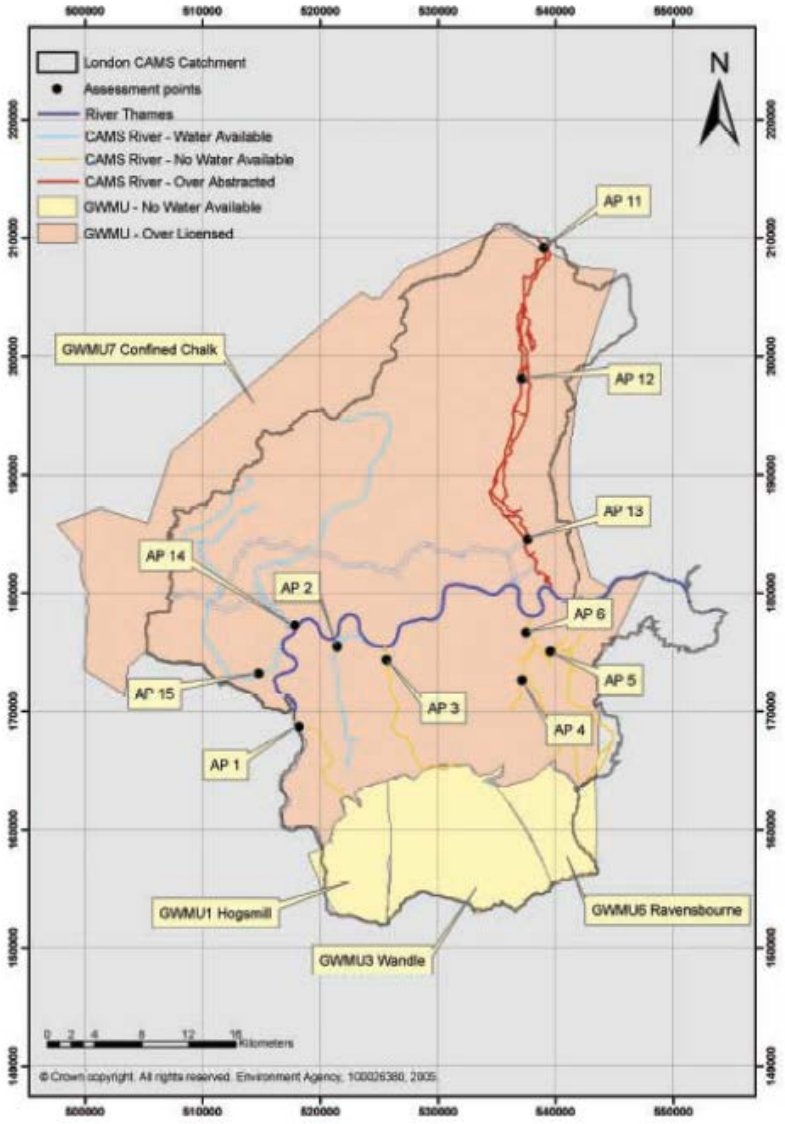
K.4 Groundwater abstractions and protected rights

Groundwater licensing policy

K.4.2 The London Catchment Abstraction Management Strategy (CAMS), (EA, 2006)[9] does not identify a condition status for the upper aquifer.

K.4.3 The EA identifies a condition status for the lower aquifer and defines a policy through its London CAMS, which restricts new abstractions in central, east and south London and further abstraction in areas approaching their sustainable limit9. The Blackfriars Bridge Foreshore site is located within the confined Chalk groundwater management unit GWM7, which is classified as being over-licensed (see Vol 18 Plate K.1) (EA, 2006). Within this area, there is a limit on the availability of groundwater resources such that large abstractions (>1-2Ml/d) would generally not be granted unless the applicant can demonstrate that the resources are available (EA, 2006). In addition, large abstractions may also have a time limit shorter than the London CAMS common end date of 2013 (EA, 2006).

Vol 18 Plate K.1 Groundwater - confined Chalk licensing



**Reproduced from EA, 2006*
Note: GWMU – groundwater management unit, AP – assessment point

K.4.4 The CAMS policy also states that, "every application would be assessed on its own merits, be subject to a detailed local hydrogeological assessment and require the submission of the necessary supporting justification and reports for a decision to be made on an individual scheme" (EA, 2006). A preliminary hydrogeological assessment, following guidance provided in the CAMS policy, is completed for the proposed development in Vol 18 Table K.6.

Vol 18 Table K.6 Groundwater - licensing assessment

No.	Question	Preliminary response
1.	Has there been any long-term (several years) downward trend in	The hydrograph in Vol 18 Figure 13.4.4 (see separate

No.	Question	Preliminary response
	the groundwater level in the vicinity of the application?	volume of figures) for an EA observation borehole close to the site shows the groundwater level increased from 1986 to 2000; displayed a downward trend from 2000 to 2004 and started to rise again in 2009.
2.	The groundwater level in relation to the base of the London Clay. If the groundwater level is near the base of the London Clay, then the EA would be unlikely to grant the abstraction licence. The EA would use discretion if there is a significant thickness of the Lambeth Group below the London Clay, but the aim is to manage abstraction to keep groundwater levels above the Thanet Sands.	The EA data confirms that groundwater levels in measured in the Chalk by the EA have risen from about 20mATD in the early 1970s to 65mATD in 2000, declining to about 57mATD since 2000. This corresponds with levels rising from within the Seaford Chalk in the late 1960s to a level corresponding with the lower units of the London Clay by 2000. The present position corresponds with a level within the upper Lambeth Group. Whilst there would be a need to depressurise the upper units of the lower aquifer, with dewatering the Upnor Beds and the top of the Thanet Sands.
3.	Any recent abstraction development in the same area. If groundwater levels have not yet responded to a recent change in abstraction, the EA may not grant further licences in that area.	No recent developments are known.
4.	Other proposals in the area that have been refused for water resource reasons in the last five years	No refusals known.
5.	Proximity of the proposal to an existing or proposed Artificial Recharge Scheme (ARS). Artificial Recharge scheme proposals would be treated as a special case as they involve the management of groundwater levels to provide additional resource to the scheme	No known ARS in the vicinity.

No.	Question	Preliminary response
	operator.	

K.4.5 The estimated average dewatering volume required at Blackfriars Bridge Foreshore site from the lower aquifer is approximately 440m^3/d, depending on the permeability of the ground and the impact of dewatering at nearby sites. These rates are above the most restrictive abstraction licensing limit set by the EA of 0.2Ml/d (200m^3/d) for Central and South London (EA, 2006). Therefore a detailed local assessment is likely to be required by the EA.

Licensed abstractions

K.4.6 The EA licenses abstraction from groundwater within London for all sources in excess of 20m^3/d. Groundwater abstractions within 1km of the site have been identified and are displayed in Vol 18 Figure 13.4.5. The locations of public water supply sources are not presented due to restriction on the display of this information.

K.4.7 There are no licensed groundwater abstractions from the River Terrace Deposits or upper aquifer located within 1km of the Blackfriars Bridge Foreshore site; however these are four licensed groundwater abstractions from the Chalk located within 1km of the site.

K.4.8 The nearest licensed groundwater abstraction from the Chalk or lower aquifer (28/39/39/0229) is held by Global Grange Ltd., is located <1km to the northeast of the Blackfriars Bridge Foreshore site and is used for drinking water purposes.

K.4.9 The next nearest licensed groundwater abstraction from the Chalk (28/39/42/0004) is held by Beetham Landmark London Ltd., is located approximately 0.4km to the south of the Blackfriars Bridge Foreshore site and is used for process water purposes.

K.4.10 The licensed groundwater abstraction 28/39/42/0069 from the Chalk is held by The South Bank Board Ltd., is located within one kilometre to the southwest of the Blackfriars Bridge Foreshore site and is used for industrial, commercial and public service purposes.

K.4.11 The licensed groundwater abstraction 28/39/42/0008 from the Chalk is held by Land Securities Ltd., is located approximately 0.7km to the northeast of the Blackfriars Bridge Foreshore site and is used for heat pump purposes.

K.4.12 Further details of these licensed abstractions within 1km radius are given in Vol 18 Table K.7.

Vol 18 Table K.7 Groundwater - licensed abstractions

Licence number	Licence holder	Purpose	Aquifer
28/39/39/0229	Global Grange Ltd.	Industrial, commercial and public services –	Chalk

Licence number	Licence holder	Purpose	Aquifer
		drinking water	
28/39/42/0004	(formerly) Beetham Landmark London Ltd.	Industrial, commercial and public services – process water	Chalk
28/39/42/0069	The South Bank Board Ltd.	Industrial, commercial and public services	Chalk
28/39/39/0008	Land Securities Group Plc	Heat pump & cooling	Chalk

K.4.13 There is one unlicensed groundwater abstraction (CL1) from the Chalk, located 0.3km to the north of the Blackfriars Bridge Foreshore site. This source is held by C. Hoare & Co., the usage is unknown and is shown on Vol 18 Figure 13.4.1 (see separate volume of figures).

K.5 Groundwater Source Protection Zones

K.5.2 The EA defines Source Protection Zones (SPZ) around all major public water supply abstractions sources and large licensed private abstractions in order to safeguard groundwater resources from potentially polluting activities.

K.5.3 The Blackfriars Bridge Foreshore site is not located within a modelled SPZ. The nearest modelled SPZ for a Chalk source lies at approximately 1.7km to the north.

K.6 Environmental designations

K.6.2 There are no environmental designations relevant to groundwater, such as SSSI, SAC and SNCIs within 1km of the Blackfriars Bridge Foreshore site.

K.7 Groundwater quality and land quality assessment

K.7.2 Historical land use mapping at the Blackfriars Bridge Foreshore site, reviewed as part of the land quality assessment, has identified no potential contamination sources (Vol 18 Section 8). Land quality may impact on groundwater quality through the creation or promotion of preferential pathways for existing contamination during construction of the proposed development.

K.7.3 The groundwater quality data presented in Vol 18 Table K.8 has been sourced from the ground investigation and monitoring works undertaken as part of the Thames Tideway Tunnel project and includes data from monitoring boreholes located off site and up to 670m away (SR1058, SR1061A and SR1062) (for locations see Vol 18 Figure 13.4.1 in separate volume of figures) and within the Made Ground, River Terrace Deposits and Chalk. Any exceedances of the UK drinking water standards (*The Water Supply Regulations, 2000*)[10] or relevant Environmental Quality

Standards (EQS) (*River Basin Districts Typology* ..., 2010)[11] are shaded in blue in this table.

K.7.4 The data shows only one exceedance of the relevant standards within the River Terrace Deposits at SR1062 (located approximately 670m from the site) with respect to sulphate.

K.7.5 The EA monitors groundwater quality at number of points across London. The nearest EA monitoring is at Dolphin Square, which lies approximately 3km away to the southwest of the Blackfriars Bridge Foreshore. The data here shows exceedances of the UK drinking water standard within the Chalk with respect to ammonia, pesticides, herbicides, heavy metals, sulphate, potassium, polycyclic aromatic hydrocarbons (PAH's) and benzene. PAH's may be formed during a range of human activities, including incomplete combustion of carbon-based fuels and other industrial processes (EA, 2010)[12]. In addition, PAH's are considered to be Priority Hazardous Substances under the Water Framework Directive (Commission of the EU Communities, 2009)[13].

K.7.6 The land quality data from the ground investigation boreholes used in the groundwater quality assessment show exceedances of the human health screening values (EA, 2009)[14] (soil guideline values designed to be protective of human health) within the River Terrace Deposits with respect to sulphate and exceedances within the Made Ground with respect to heavy metals and hydrocarbons. Further detail is provided in the land quality assessment (see Vol 18 Appendix F).

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Vol 18 Table K.8 Groundwater– groundwater quality results

Source of data*				SI	SI	TT	TT	TT	TT	TT	SI
Name				SR1058	SR1061A	SR1061A	SR1061A	SR1061A	SR1061A	SR1061A	SR1062
Hydrogeological unit**				SCK	MG	ALV	ALV	ALV	ALV	ALV	RTD
Distance from site	EQS Criteria			153m	602m	602m	602m	602m	602m	602m	673m
Chemical	Value	Units	Source	2009	2009	29/9/2011	17/11/2011	31/1/2012	19/4/2012	17/5/2012	2009
1,1 - Dichloroethane	10	ug/l	WFD 2010	-	-	<0.09	-	-	-	-	-
1,1 - Dichloroethene	30	ug/l	WHO 2004	-	-	<0.12	-	-	-	-	-
1,1,1 - Trichloroethane	100	ug/l	SW Regs 98	-	-	<0.1	<0.08	<0.08	-	< 0.08	-
1,1,2 - Trichloroethane	400	ug/l	SW Regs 98	-	-	<0.2	<0.2	<0.2	-	< 0.2	-
1,2 - Dichloroethane {Ethylene Dichloride}	3	ug/l	WS Regs 20	-	-	<0.12	<0.12	<0.12	-	< 0.12	-
1,2 - Dichloroethene (Trans)	30	ug/l	WHO 2004	-	-	<0.12	-	-	-	-	-
2 - Chlorophenol	50	ug/l	WFD 2010	-	-	<0.05	-	-	-	-	-
2 - Methylphenol {O-Cresol}	-	ug/l	None	-	-	<0.05	-	-	-	-	-
2,3 - Dimethylphenol {2,3-Xylenol}	-	ug/l	None	-	-	<0.05	-	-	<0.0500	-	-
2,3,5,6 - Tetrachloroaminobenzene {2,...Aniline}	-	ug/l	None	-	-	<0.00500	-	-	<0.00500	-	-
2,3,6 - TBA {2,3,6-Trichlorobenzoic Acid}{Cas Rn 50-31-7}	-	ug/l	None	-	-	<0.01600	-	-	-	-	-
2,4 - Dichlorophenol	20	ug/l	WFD 2010	-	-	-	-	-	-	-	<0.25
2,4 - Dimethylphenol {2,4-Xylenol}	-	ug/l	None	-	-	<0.05	-	-	-	-	<0.25
2,4,5 - Trichlorophenol	-	ug/l	None	-	-	<0.05	-	-	-	-	-
2,4,6 - Trichlorophenol	-	ug/l	None	-	-	<0.05	-	-	-	-	<0.25
2,4-D {2,4-Dichlorophenoxyacetic acid}	0.1	ug/l	DWS 2010	-	-	<0.01100	-	-	-	-	-
2,4-DB {4-(2,4-dichlorophenoxy)butyric acid}	0.1	ug/l	DWS 2010	-	-	<0.01000	-	-	-	-	-
2,6 - Dichlorophenol	-	ug/l	None	-	-	<0.05	-	-	-	-	<0.25
2,6 - Dimethylphenol {2,6 Xylenol}	-	ug/l	None	-	-	<0.05	-	-	<0.0500	-	-
3 - Chlorophenol	-	ug/l	None	-	-	<0.05	-	-	-	-	-
3 - Methylphenol {M-Cresol}	-	ug/l	None	-	-	<0.05	-	-	-	-	-
3,4 - Dimethylphenol {3,4 Xylenol}	-	ug/l	None	-	-	<0.05	-	-	<0.0500	-	-
3,5 - Dimethylphenol {3,5-Xylenol}	-	ug/l	None	-	-	<0.05	-	-	-	-	-
4 - Chloro - 3- Methylphenol {P-Chloro-M-Cresol}	40	ug/l	WFD 2010	-	-	<0.05	-	-	-	-	<0.25
4 - Chlorophenol	-	ug/l	None	-	-	<0.05	-	-	-	-	-
4-Methylphenol {para-Cresol}	-	ug/l	None	-	-	<0.05	-	-	<0.0500	-	-
Acenaphthene	-	ug/l	None	-	-	-	-	-	-	-	<0.01
Acenaphthylene	-	ug/l	None	-	-	-	-	-	-	-	<0.01
Acenapthene	-	ug/l	None	-	-	0.01	-	-	0.02	-	-
Acenapthylene	-	ug/l	None	-	-	<0.01	-	-	<0.01	-	-
Aldicarb	0.1	ug/l	DWS 2010	-	-	<0.01	-	-	-	-	-
Aldicarb Sulphone	-	ug/l	None	-	-	<0.01000	-	-	-	-	-
Aldrin	0.03	ug/l	DWS 2010	-	-	<0.00300	-	-	-	-	-
Aliphatics >C10-C12	-	ug/l	None	-	-	-	-	-	-	-	270
Aliphatics >C12-C16 (Aqueous)	-	ug/l	None	-	-	-	-	-	-	-	330
Aliphatics >C16-C21 (Aqueous)	-	ug/l	None	-	-	-	-	-	-	-	<1
Aliphatics >C21-C35 (Aqueous)	-	ug/l	None	-	-	-	-	-	-	-	<1
Aliphatics >C6-C8	-	ug/l	None	-	-	-	-	-	-	-	<0.1
Aliphatics >C8-C10	-	ug/l	None	-	-	-	-	-	-	-	<0.1
Aliphatics C5-C6	-	ug/l	None	-	-	-	-	-	-	-	<0.1
Alkalinity (Carbonate)	-	mg/l as CaCO3	None	-	-	<4	<4	-	-	-	-
Alkalinity Ph 4.5 - As CaCO3	-	mg/l as CaCO3	None	-	-	238	242	228	-	218	460

Source of data*				SI	SI	TT	TT	TT	TT	TT	SI
Name				SR1058	SR1061A	SR1061A	SR1061A	SR1061A	SR1061A	SR1061A	SR1062
Hydrogeological unit**				SCK	MG	ALV	ALV	ALV	ALV	ALV	RTD
Distance from site	EQS Criteria			153m	602m	602m	602m	602m	602m	602m	673m
Chemical	Value	Units	Source	2009	2009	29/9/2011	17/11/2011	31/1/2012	19/4/2012	17/5/2012	2009
Aluminium Dissolved	200	ug/l as Al	DWS 2010	-	-	180	-	-	1.4	-	-
Aluminium Total	200	ug/l as Al	DWS 2010	-	-	210	92	0.98	-	0.64	-
Ammonia - As N	0.39	mg/l as N	WS Regs 20	-	-	2.9	2.9	2.9	-	1.71	-
Ammoniacal nitrogen	-	mg/l	None	-	-	-	-	-	-	-	6.6
Anions	-	meq/l	None	-	-	8.503	-	-	-	-	-
Anthracene	0.1	ug/l	SW WFD	-	-	<0.1	-	-	<0.01	-	<0.01
Antimony Total	5	ug/l	DWS 2010	-	-	0.5	-	-	1.8	-	-
Aromatics >C7-C8	50	ug/l	WFD 2010	-	-	-	-	-	-	-	<0.1
Aromatics >EC10-EC12	-	ug/l	None	-	-	-	-	-	-	-	17
Aromatics >EC12-EC16 (Aqueous)	-	ug/l	None	-	-	-	-	-	-	-	22
Aromatics >EC16-EC21 (Aqueous)	-	ug/l	None	-	-	-	-	-	-	-	5
Aromatics >EC21-EC35 (Aqueous)	-	ug/l	None	-	-	-	-	-	-	-	8
Aromatics >EC8-EC10	-	ug/l	None	-	-	-	-	-	-	-	<0.1
Aromatics C6-C7	1	ug/l	DWS 2010	-	-	-	-	-	-	-	<0.1
Arsenic Total	10	ug/l as As	DWS 2010	-	-	2.9	<1	2.6	-	3.3	5
Asulam	-	ug/l	None	-	-	<0.01	-	-	-	-	-
Atrazine { }	0.1	ug/l	DWS 2010	-	-	<0.00300	<0.00300	<0.00300	-	<0.00800	-
Atrazine Desethyl {De-Ethyl Atrazine}	-	ug/l	None	-	-	<0.05	-	-	-	-	-
Atrazine Desisopropyl	-	ug/l	None	-	-	<0.05	-	-	-	-	-
Azinphos-Ethyl	-	ug/l	None	-	-	<0.00700	-	-	-	-	-
Azinphos-Methyl	0.1	ug/l	DWS 2010	-	-	<0.00900	-	-	-	-	-
Barium Dissolved	100	ug/l as Ba	SW Regs 96	-	-	60	-	-	79	-	-
Barium Total	100	ug/l as Ba	SW Regs 96	-	-	61	-	-	82	-	-
Benazolin	-	ug/l	None	-	-	<0.00900	-	-	-	-	-
Bendiocarb	-	ug/l	None	-	-	<0.00900	-	-	-	-	-
Bentazone	0.1	ug/l	DWS 2010	-	-	<0.00800	<0.00800	<0.00800	-	<0.00800	-
Benz[a]-Anthracene	-	ug/l	None	-	-	<0.01	-	-	0.02	-	-
Benzene	1	ug/l	DWS 2010	-	-	0.1	<0.07	<0.07	<0.07	< 0.07	<1
Benzene (1,2,3 Trichlorobenzene)	-	ug/l	None	-	-	<0.17	-	-	-	-	-
Benzene (1,2,4 Trichlorobenzene)	-	ug/l	None	-	-	<0.15	-	-	-	-	-
Benzene (1,3,5 Trichlorobenzene)	-	ug/l	None	-	-	<0.16	-	-	-	-	-
Benzene (Ethylbenzene)	20	ug/l	FW List II	-	-	0.14	-	-	<0.06	-	-
Benzo (a) anthracene	-	ug/l	None	-	-	-	-	-	-	-	<0.01
Benzo[a]Pyrene	0.01	ug/l	DWS 2010	-	-	<0.01	<0.00500	0.02800	0.03	0.03370	<0.01
Benzo[b]Fluoranthene	0.03	ug/l	WFD D 10	-	-	<0.01	-	-	0.04	-	<0.01
Benzo[g,h,i]Perylene	0.002	ug/l	WFD D 10	-	-	<0.01	-	-	0.02	-	<0.01
Benzo[k]Fluoranthene	0.03	ug/l	WFD D 10	-	-	<0.01	-	-	0.01	-	<0.01
Beryllium Total	0	ug/l as Be	GW Regs 98	-	-	<3	-	-	-	-	-
Bifenthrin	-	ug/l	None	-	-	0.01200	-	-	<0.00500	-	-
Boron Dissolved	1000	ug/l as B	DWS 2010	-	-	736	-	-	830	-	-
Boron Total	1000	ug/l as B	DWS 2010	-	-	630	860	780	-	0.72	560
Bromate	10	ug/l as BrO3	DWS 2010	-	-	<0.5	<0.5	<0.5	-	< 0.5	-
Bromide ion	2	ug/l as Br	FW List II	-	-	293	-	-	-	-	-
Bromodichloromethane	100	ug/l	WS Regs 20	-	-	<0.4	-	-	-	-	-
Bromoform	100	ug/l	WS Regs 20	-	-	<0.7	-	-	-	-	-
Bromoxynil	0.1	ug/l	DWS 2010	-	-	<0.01000	-	-	-	-	-
Bupirimate	-	ug/l	None	-	-	<0.00500	-	-	-	-	-

Source of data*				SI	SI	TT	TT	TT	TT	TT	SI
Name				SR1058	SR1061A	SR1061A	SR1061A	SR1061A	SR1061A	SR1061A	SR1062
Hydrogeological unit**				SCK	MG	ALV	ALV	ALV	ALV	ALV	RTD
Distance from site	EQS Criteria			153m	602m	602m	602m	602m	602m	602m	673m
Chemical	Value	Units	Source	2009	2009	29/9/2011	17/11/2011	31/1/2012	19/4/2012	17/5/2012	2009
Cadmium Dissolved	5	ug/l as Cd	DWS 2010	-	-	<1.5	-	-	-	-	-
Cadmium Total	5	ug/l as Cd	DWS 2010	-	-	<1.5	<1.5	<1.5	<1.5	< 1.5	<2
Calcium Dissolved	250	mg/l as Ca	DWS 2010	-	-	38	-	-	-	-	-
Calcium Total	250	mg/l as Ca	DWS 2010	-	-	41	39	43	-	41	-
Carbaryl	-	ug/l	None	-	-	<0.01	-	-	-	-	-
Carbendazim / Benomyl	0.1	ug/l	FW List II	-	-	<0.00300	<0.00300	<0.00300	-	0.00500	-
Carbetamide	-	ug/l	None	-	-	<0.00600	<0.00600	<0.00600	-	<0.01000	-
Carbofuran	0.1	ug/l	DWS 2010	-	-	<0.01	-	-	-	-	-
Carbon Dioxide	-	ug/l	None	-	-	6140	-	-	11200	-	-
Carbon Organic Dissolved	-	mg/l as C	None	-	-	3.41	-	-	2.6	-	-
Carbon tetrachloride	3	ug/l	DWS 2010	-	-	<0.07	<0.07	<0.07	-	< 0.070	-
Carbophenothion	-	ug/l	None	-	-	<0.01300	-	-	-	-	-
Cations	-	meq/l	None	-	-	8.236	-	-	-	-	-
Chlordane (cis)	0.1	ug/l	DWS 2010	-	-	<0.00500	-	-	-	-	-
Chlordane Trans	0.1	ug/l	DWS 2010	-	-	<0.00500	-	-	-	-	-
Chlorfenvinphos	0.1	ug/l	DWS 2010	-	-	<0.00900	<0.00900	<0.00900	-	<0.00900	-
Chloridazon	-	ug/l	None	-	-	<0.01	-	-	-	-	-
Chloride	250	mg/l as Cl	DWS 2010	-	-	91.1	96.4	95.3	-	89.3	210
Chlormequat	-	ug/l	None	-	-	<0.05	-	-	-	-	-
Chlorodibromomethane	-	ug/l	None	-	-	<0.5	-	-	-	-	-
Chloroform	100	ug/l	WS Regs 20	-	-	<0.6	<0.6	<0.6	-	< 0.600	-
Chloroxuron	-	ug/l	None	-	-	<0.01	-	-	-	-	-
Chlorpropham	-	ug/l	None	-	-	<0.03600	-	-	-	-	-
Chlorpyrifos	0.03	ug/l	WFD 2010	-	-	<0.00700	-	-	-	-	-
Chlorpyriphos-Methyl	-	ug/l	None	-	-	<0.06	-	-	-	-	-
Chlorthalonil	-	ug/l	None	-	-	<0.01800	-	-	-	-	-
Chlortoluron	2	ug/l	FW List II	-	-	<0.00400	<0.00400	<0.00400	-	<0.01000	-
Chromium Dissolved	50	ug/l as Cr	DWS 2010	-	-	7	-	-	14	-	-
Chromium Total	50	ug/l as Cr	DWS 2010	-	-	10	8	8	-	11	<5
Chrysene	-	ug/l	None	<0.01	-	<0.01	-	-	0.01	-	<0.01
cis-1-2-Dichloroethene	-	ug/l	None	-	-	<0.12	-	-	-	-	-
Clopyralid	-	ug/l	None	-	-	<0.01900	<0.01900	<0.01900	-	<0.01900	-
Cobalt - As Co	0	ug/l	GW Regs 98	-	-	<5	-	-	-	-	-
Conductivity @ 20°C	2500	uS/cm	WS Regs 20	-	-	-	-	-	-	-	2080
Copper Dissolved	2000	ug/l as Cu	DWS 2010	-	-	<5.5	-	-	-	-	-
Copper Total	2000	ug/l as Cu	DWS 2010	-	-	<5.5	<5.5	12	-	16	10
Coumaphos	0.1	ug/l	DWS 2010	-	-	<0.00500	-	-	0.00720	-	-
Cresols	-	ug/l	None	-	-	-	-	-	-	-	<0.25
Cyanazine	0.1	ug/l	DWS 2010	-	-	<0.00700	<0.00700	<0.00700	-	<0.00800	-
Cyanide (Free)	50	ug/l as CN	DWS 2010	-	-	-	-	-	-	-	<20
Cyanide (Total)	50	ug/l as CN	DWS 2010	-	-	<1	-	-	-	-	<40
Cyfluthrin	0.1	ug/l	DWS 2010	-	-	<0.005	-	-	-	-	-
Cypermethrin	0.0001	ug/l	WFD 2010	-	-	0.01	<0.1	<0.1	-	< 0.100	-
Cypermethrin ID	-	Code	None	-	-	-	-	-	<5.00	-	-
Dalapon	-	ug/l	None	-	-	<0.05000	<0.05000	<0.05000	-	<0.05000	-
DDD (OP)	0.1	ug/l	DWS 2010	-	-	<0.01000	-	-	-	-	-
DDD (PP)	0.1	ug/l	DWS 2010	-	-	<0.01000	-	-	-	-	-

Source of data*				SI	SI	TT	TT	TT	TT	TT	SI
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Hydrogeological unit**				SCK	MG	ALV	ALV	ALV	ALV	ALV	RTD
Distance from site	EQS Criteria			153m	602m	602m	602m	602m	602m	602m	673m
Chemical	Value	Units	Source	2009	2009	29/9/2011	17/11/2011	31/1/2012	19/4/2012	17/5/2012	2009
DDE (OP)	0.1	ug/l	DWS 2010	-	-	<0.01000	-	-	-	-	-
DDE (PP)	0.1	ug/l	DWS 2010	-	-	<0.01000	-	-	-	-	-
DDT (OP)	0.1	ug/l	DWS 2010	-	-	<0.01000	-	-	-	-	-
DDT (PP)	0.1	ug/l	DWS 2010	-	-	<0.01000	-	-	-	-	-
Deltamethrin	-	ug/l	None	-	-	<2	-	-	-	-	-
Diazinon	0.1	ug/l	DWS 2010	-	-	<0.00900	<0.00900	<0.00900	-	<0.00900	-
Dibenz-[A,H]-Anthracene	-	ug/l	None	-	-	<0.01	-	-	<0.01	-	<0.01
Dicamba {3,6-Dichloro(O-Methoxybenzoic Acid)}	-	ug/l	None	-	-	<0.01300	-	-	-	-	-
Dichlobenil	-	ug/l	None	-	-	<0.02500	-	-	-	-	-
Dichlor(2,4+2,5)phenols	-	ug/l	None	-	-	<0.05	-	-	-	-	-
Dichloromethane	20	ug/l	WFD 2010	-	-	<3	<3	<3	-	< 3.0	-
Dichlorprop	0.1	ug/l	DWS 2010	-	-	<0.01100	<0.01100	<0.01100	-	<0.01100	-
Dichlorvos	0.1	ug/l	DWS 2010	-	-	<0.00900	-	-	-	-	-
Dieldrin	0.03	ug/l	DWS 2010	-	-	<0.00300	-	-	-	-	-
Diflurobenzuron	-	ug/l	None	-	-	<0.02000	-	-	-	-	-
Dimethoate	-	ug/l	None	-	-	<0.01500	-	-	-	-	-
Diuron	0.1	ug/l	DWS 2010	-	-	<0.00500	<0.00500	0.00900	-	<0.01000	-
Endosulphan Alpha	0.1	ug/l	DWS 2010	-	-	<0.00500	-	-	-	-	-
Endosulphan Beta	0.1	ug/l	DWS 2010	-	-	<0.00500	-	-	-	-	-
Endrin	0.1	ug/l	DWS 2010	-	-	<0.00300	-	-	-	-	-
Enterococci (Species)	-	Nr/100ml	None	-	-	0	-	-	20	-	-
Escherichia coli (Confirmed)	0	Nr/100ml	WS Regs 20	-	-	0	-	-	1	-	-
Ethiofencarb	-	ug/l	None	-	-	<0.01	-	-	-	-	-
Ethion	-	ug/l	None	-	-	<0.3	-	-	-	-	-
Ethofumesate	-	ug/l	None	-	-	<0.01	-	-	<0.01	-	-
Ethyl Tertiary Butyl Ether (ETBE)	-	ug/l	None	-	-	<5	-	-	-	-	-
Ethylbenzene	-	ug/l	None	-	-	-	-	-	-	-	<1
Fenchlorphos {Ronnel.}	0.1	ug/l	DWS 2010	-	-	<0.00500	-	-	-	-	-
Fenitrothion	0.1	ug/l	DWS 2010	-	-	<0.00900	-	-	-	-	-
Fenoprop	0.1	ug/l	DWS 2010	-	-	<0.01000	-	-	-	-	-
Fenpropimorph	-	ug/l	None	-	-	<0.00600	-	-	-	-	-
Fenthion	-	ug/l	None	-	-	<0.01100	-	-	-	-	-
Fenuron	-	ug/l	None	-	-	0.12	-	-	<0.01	-	-
Flumethrin	-	ug/l	None	-	-	<0.00500	-	-	-	-	-
Fluoranthene	0.2	ug/l	EEC MAC	-	-	<0.01	-	-	0.03	-	0.03
Fluorene	-	ug/l	None	-	-	<0.01	-	-	<0.01	-	<0.01
Fluoride	1.5	mg/l as F	DWS 2010	-	-	0.4	0.53	0.7	-	0.547	-
Fluroxypyr	-	ug/l	None	-	-	<0.01000	-	-	-	-	-
Flutriafol	-	ug/l	None	-	-	<0.00700	-	-	-	-	-
Fonofos	-	ug/l	None	-	-	<0.00500	-	-	-	-	-
Glyphosate	-	ug/l	None	-	-	<0.01400	<0.01400	<0.01400	-	<0.01400	-
Hardness Total - As CaCO3	-	mg/l as CaCO3	None	-	-	140	-	-	170	-	-
Heptachlor	0.03	ug/l	DWS 2010	-	-	<0.00300	-	-	-	-	-
Hexachloro 1,3 Butadiene	0.1	ug/l	WFD 2010	-	-	<0.01000	-	-	-	-	-
Hexachlorobenzene	0.01	ug/l	WFD 2010	-	-	<0.00100	-	-	-	-	-
Hexachlorocyclohexane (alpha)	0.1	ug/l	DWS 2010	-	-	<0.01000	-	-	-	-	-

Source of data*				SI	SI	TT	TT	TT	TT	TT	SI
Name				SR1058	SR1061A	SR1061A	SR1061A	SR1061A	SR1061A	SR1061A	SR1062
Hydrogeological unit**				SCK	MG	ALV	ALV	ALV	ALV	ALV	RTD
Distance from site	EQS Criteria			153m	602m	602m	602m	602m	602m	602m	673m
Chemical	Value	Units	Source	2009	2009	29/9/2011	17/11/2011	31/1/2012	19/4/2012	17/5/2012	2009
Hexachlorocyclohexane (beta)	0.1	ug/l	DWS 2010	-	-	<0.01000	-	-	-	-	-
Hexachlorocyclohexane (delta)	0.1	ug/l	DWS 2010	-	-	<0.01000	-	-	-	-	-
Hexachlorocyclohexane (gamma)	0.1	ug/l	DWS 2010	-	-	<0.01000	-	-	-	-	-
Indeno-[1,2,3-Cd]-Pyrene	0.002	ug/l	WFD D 10	-	-	<0.01	-	-	0.01	-	<0.01
Iodide Ion	-	ug/l as I	None	-	-	42	-	-	25	-	-
Iodofenphos	-	ug/l	None	-	-	<0.06	-	-	-	-	-
Ionic Balance (Anions/Cations)	-	%	None	-	-	-1.6	-	-	-	-	-
Ioxynil	0.1	ug/l	DWS 2010	-	-	<0.00800	-	-	-	-	-
Iprodione	-	ug/l	None	-	-	<0.01300	-	-	-	-	-
Irgarol 1051	-	ug/l	None	-	-	<0.00500	-	-	<0.00500	-	-
Iron Dissolved	200	ug/l as Fe	DWS 2010	-	-	2300	-	-	4.3	-	-
Iron Total	200	ug/l as Fe	DWS 2010	-	-	2200	-	-	4.3	-	-
Isodrin	0.1	ug/l	DWS 2010	-	-	<0.00300	-	-	-	-	-
Isoproturon (Diip1,3Dithiolan-2-Ylidenemalonate)	0.1	ug/l	DWS 2010	-	-	<0.00300	<0.00300	<0.00300	-	<0.00800	-
Lambda Cyhalothrin	-	ug/l	None	-	-	<0.01	-	-	<5.00	-	-
Lead Dissolved	10	ug/l	WS Regs 20	-	-	<5	-	-	-	-	-
Lead Total	10	ug/l	WS Regs 20	-	-	<5	<5	7	-	12	<4
Linuron	0.1	ug/l	DWS 2010	-	-	<0.00500	-	-	-	-	-
Lithium Dissolved	-	ug/l as Li	None	-	-	<0.6	-	-	0.0029	-	-
Lithium Total	-	ug/l as Li	None	-	-	<0.6	-	-	0.0036	-	-
Magnesium Dissolved	50	mg/l as Mg	EEC MAC	-	-	9.3	-	-	13	-	-
Magnesium Total	50	mg/l as Mg	EEC MAC	-	-	9.2	11	11	-	11	24
Malathion	0.1	ug/l	DWS 2010	-	-	<0.00600	-	-	-	-	-
Manganese Dissolved	50	ug/l as Mn	DWS 2010	-	-	100	-	-	0.11	-	-
Manganese Total	50	ug/l as Mn	DWS 2010	-	-	110	-	-	0.12	-	-
MCPA {2-methyl-4-chlorophenoxyacetic acid }	0.1	ug/l	DWS 2010	-	-	<0.00900	<0.00900	<0.00900	-	<0.00900	-
MCPB	10	ug/l	WHO 2004	-	-	<0.01100	-	-	-	-	-
Mecoprop { }	0.1	ug/l	DWS 2010	-	-	<0.01000	<0.01000	<0.01000	-	<0.01000	-
Mercury Total	1	ug/l Hg	WS Regs 20	-	-	0.009	0.015	0.002	-	< 0.002	<0.05
Metalaxyl	-	ug/l	None	-	-	<0.01	-	-	-	-	-
Metazachlor	-	ug/l	None	-	-	<0.01	<0	<0	-	< 0	-
Methabenzthiazuron	-	ug/l	None	-	-	<0.00300	-	-	-	-	-
Methane	-	ug/l	None	-	-	<10	-	-	<10.0	-	-
Methiocarb	-	ug/l	None	-	-	<0.005	-	-	-	-	-
Methomyl	-	ug/l	None	-	-	<0.01	-	-	-	-	-
Methoxychlor	0.1	ug/l	DWS 2010	-	-	<0.01000	-	-	-	-	-
Metoxuron	-	ug/l	None	-	-	<0.00500	-	-	-	-	-
Metsulfuron - Methyl	-	ug/l	None	-	-	<0.01	-	-	-	-	-
Mevinphos	0.1	ug/l	DWS 2010	-	-	<0.01400	-	-	-	-	-
Molybdenum Total	0	ug/l	GW Regs 98	-	-	21	-	-	<5	-	-
Monolinuron	-	ug/l	None	-	-	<0.00600	-	-	-	-	-
Monuron	-	ug/l	None	-	-	<0.01	-	-	-	-	-
MTBE {Methyl Tert-Butyl Ether}	-	ug/l	None	-	-	<0.13	-	-	-	-	<1
Multi Residual Scan	-	ug/l	None	-	-	-	-	-	-	<0.10000	-
Naphthalene	1.2	ug/l	WFD D 10	-	-	0.04	-	-	0.84	-	<0.01
Napropamide	-	ug/l	None	-	-	<0.01	-	-	-	-	-
Neburon	-	ug/l	None	-	-	<0.01	-	-	-	-	-

Source of data*				SI	SI	TT	TT	TT	TT	TT	SI
Name				SR1058	SR1061A	SR1061A	SR1061A	SR1061A	SR1061A	SR1061A	SR1062
Hydrogeological unit**				SCK	MG	ALV	ALV	ALV	ALV	ALV	RTD
Distance from site	EQS Criteria			153m	602m	602m	602m	602m	602m	602m	673m
Chemical	Value	Units	Source	2009	2009	29/9/2011	17/11/2011	31/1/2012	19/4/2012	17/5/2012	2009
Nickel Total	20	ug/l as Ni	DWS 2010	-	-	<4	<4	<4	-	< 4	<10
Nitrate - N	11.3	mg/l as N	WS Regs 20	-	-	<0.043	<0.043	<0.043	-	< 0.068	<0.1
Nitrite - N	0.03	mg/l as N	WS Regs 20	-	-	<0.002	-	-	-	-	-
Nitrogen Total Oxidised	11.3	mg/l as N	WS Regs 20	-	-	<0.05	-	-	<0.081	-	-
Orthophosphate	-	mg/l as P	None	-	-	0.38	-	-	0.27	-	-
Oxamyl	-	ug/l	None	-	-	<0.00500	-	-	<0.00500	-	-
PAHs Total	0.1	ug/l	DWS 2010	-	-	0.05	-	-	1.08	-	-
Parathion (Parathion-ethyl)	1	ug/l	SW Regs 96	-	-	<0.00900	-	-	-	-	-
Parathion (Parathion-methyl)	1	ug/l	SW Regs 96	-	-	<0.01000	-	-	-	-	-
PCB Congener 028	0.1	ug/l	DWS 2010	-	-	<0.01	-	-	-	-	-
PCB Congener 052	0.1	ug/l	DWS 2010	-	-	<0.01	-	-	-	-	-
PCB Congener 101	0.1	ug/l	DWS 2010	-	-	<0.01	-	-	-	-	-
PCB Congener 105	0.1	ug/l	DWS 2010	-	-	<0.01	-	-	-	-	-
PCB Congener 118	0.1	ug/l	DWS 2010	-	-	<0.01	-	-	-	-	-
PCB Congener 138	0.1	ug/l	DWS 2010	-	-	<0.01	-	-	-	-	-
PCB Congener 153	0.1	ug/l	DWS 2010	-	-	<0.01	-	-	-	-	-
PCB Congener 156	0.1	ug/l	DWS 2010	-	-	<0.01	-	-	-	-	-
PCB Congener 180	0.1	ug/l	DWS 2010	-	-	<0.01	-	-	-	-	-
Pendimethalin	0.1	ug/l	DWS 2010	-	-	<0.00700	-	-	-	-	-
Permethrin (Cis + Trans)	0.01	ug/l	WFD D 10	-	-	-	<0.10000	<0.10000	-	-	-
pH	10	pH units	DWS 2010	-	-	7.25	-	-	-	-	7.4
Phenanthrene	-	ug/l	None	-	-	<0.01	-	-	0.02	-	0.01
Phenol	0.5	ug/l	EEC MAC	-	-	<1	-	-	-	-	<0.25
Phenol (Pentachlorophenol (PCP))	-	ug/l	None	-	-	<0.00900	0.01500	<0.00900	-	<0.00900	-
Phenols Total For SWAD (7 Compounds)	-	ug/l	None	-	-	-	12.0	26.0	-	<2,500,000.0	-
Pichloram	-	ug/l	None	-	-	<0.00900	-	-	-	-	-
Pirimephos (Pirimephos-methyl)	-	ug/l	None	-	-	<0.00300	-	-	-	-	-
Pirimicarb	1	ug/l	FW List II	-	-	<0.00300	-	-	-	-	-
Polynuclear Aromatic Hydrocarbons (Total)	0.1	ug/l	DWS 2010	-	-	-	-	-	-	-	<0.2
Potassium Dissolved	-	mg/l as K	None	-	-	14	-	-	13	-	-
Potassium Total	-	mg/l as K	None	-	-	14	13	12	-	11	-
Prochloraz	4	ug/l	FW List II	-	-	<0.01	-	-	-	-	-
Promethryn	-	ug/l	None	-	-	<0.00300	-	-	-	-	-
Propachlor	-	ug/l	None	-	-	<0.00800	-	-	-	-	-
Propazine	0.1	ug/l	DWS 2010	-	-	<0.00400	<0.00400	<0.00400	-	<0.00500	-
Propetamphos	0.1	ug/l	DWS 2010	-	-	<0.00500	<0.00500	<0.00500	-	<0.00500	-
Propoxur	-	ug/l	None	-	-	<0.00500	-	-	-	-	-
Propyzamide	-	ug/l	None	-	-	<0.00600	-	-	-	-	-
Pyrene	-	ug/l	None	-	-	<0.01	-	-	0.03	-	<0.01
Qualitative Scan (Volatiles By GCMS) NP	-	Text	None	-	-	-	-	-	-	-	-
Selenium	10	ug/l as Se	DWS 2010	-	-	<0.4	-	-	<0.4	-	<3
Silicate Reactive Dissolved - As SiO2	-	mg/l	None	-	-	13	-	-	15	-	-
Silver Total	0	ug/l	GW Regs 98	-	-	<0.8	-	-	-	-	-
Simazine	0.1	ug/l	DWS 2010	-	-	<0.00900	<0.00900	<0.00900	-	<0.00400	-
Sodium Dissolved	200	mg/l as Na	DWS 2010	-	-	110	-	-	-	-	-
Sodium Total	200	mg/l as Na	DWS 2010	-	-	110	120	110	-	100	130
Strontium Dissolved	-	ug/l as Sr	None	-	-	460	-	-	0.68	-	-

Source of data*				SI	SI	TT	TT	TT	TT	TT	SI
Name				SR1058	SR1061A	SR1061A	SR1061A	SR1061A	SR1061A	SR1061A	SR1062
Hydrogeological unit**				SCK	MG	ALV	ALV	ALV	ALV	ALV	RTD
Distance from site	EQS Criteria			153m	602m	602m	602m	602m	602m	602m	673m
Chemical	Value	Units	Source	2009	2009	29/9/2011	17/11/2011	31/1/2012	19/4/2012	17/5/2012	2009
Strontium Total	-	ug/l as Sr	None	-	-	490	-	-	0.71	-	-
Sulphate	250	mg/l as SO4	DWS 2010	-	-	56.4	58.7	69	-	62.7	350
Sulphide	-	ug/l	None	-	-	<30.0	-	-	82.0	-	12
Tecnazene	0.1	ug/l	DWS 2010	-	-	<0.01000	-	-	-	-	-
Terbutryn	0.1	ug/l	DWS 2010	-	-	<0.00300	<0.00300	<0.00300	-	<0.00500	-
Tertiary Amyl Methyl Ether (TAME)	-	ug/l	None	-	-	<5	-	-	-	-	-
Tetrachloroethane	10	ug/l	DWS 2010	-	-	<0.11	-	-	-	-	-
Tetrachloroethylene	-	ug/l	None	-	-	<0.09	<0.09	<0.09	-	< 0.09	-
Tetrachlorothioanisole	-	ug/l	None	-	-	0.00600	-	-	<0.00500	-	-
Thallium Total	0	ug/l as Tl	GW Regs 98	-	-	<0.3	-	-	-	-	-
Tin Total	0	ug/l as Sn	GW Regs 98	-	-	<5	-	-	6	-	-
Titanium	0	ug/l as Ti	GW Regs 98	-	-	16	-	-	0.021	-	-
Toluene (Methylbenzene)	50	ug/l	WFD 2010	-	-	0.7	-	-	<0.55	-	<1
Total Aliphatic TPH	-	ug/l	None								600
Total Aromatic TPH	-	ug/l	None								51
Total Chemical Oxygen Demand	-	mg/l	None								200
Total Petroleum Hydrocarbons (TPH)	-	ug/l	None		24000						
Total Petroleum Hydrocarbons 10-20 (TPH)	-	ug/l	None		19000						
Total Petroleum Hydrocarbons 20-30 (TPH)	-	ug/l	None		83						
Triazophos	0.1	ug/l	DWS 2010			<0.00800					
Trichloroethene (Trichloroethylene)	10	ug/l	DWS 2010			<0.07	<0.07	<0.07		< 0.07	
Trichlorophenoxyacetic Acid (2,4,5)	-	ug/l	None			<0.01500					
Triclopyr	-	ug/l	None			<0.01500					
Trietazine	-	ug/l	None			<0.00600	<0.00600	<0.00600		<0.00800	
Trifluralin	0.1	ug/l	DWS 2010			<0.01000	<0.01000	<0.01000		<0.01000	
Turbidity	1	FTU	WS Regs 20				8.59	9.74		13.1	
Uranium	0	ug/l as U	GW Regs 98			0.16			0.2		
Vanadium	0	ug/l as V	GW Regs 98			<5					
Xylene (Meta & Para){1,3+1,4-Dimethylbenzene}	30	ug/l	WFD 2010			0.3	0.1	0.13	<0.180	< 0.09	<1
Xylene (ortho)	30	ug/l	SW Regs 98			0.23			<0.09		
Zinc Dissolved	50	ug/l as Zn	DWS 2010			<5					
Zinc Total	50	ug/l as Zn	DWS 2010			<5	7	35		61	7

Notes:

xx	GAC1 exceedance
' - '	Not tested
' < '	Less than MDL

** Origin of data: SI – Groundwater quality data collected during site investigation works by Thames Tideway Tunnel project (2009-2011), TT – Groundwater quality data collected during ongoing monitoring works by Thames Tideway Tunnel project (2009-2012)*

*** Hydrogeological unit: SCK – Seaford Chalk, MG – Made Ground, RTD – River Terrace Deposits*

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K.8 Groundwater status

K.8.2 The EC Water Framework Directive (WFD) requires the status of groundwater management units (groundwater bodies) within each river basin to be determined as 'good' or 'poor' by 2015. For groundwater there are two separate classifications for groundwater bodies; chemical status and quantitative status. The WFD aims to achieve good status by 2015, or, where this is not possible and subject to the criteria set out in the Directive, the WFD aims to achieve good status by 2021 or 2027.

K.8.3 The Thames River Basin Management Plan (RBMP) (EA, 2009)[15] shows that the Lambeth Group, Thanet Sands and Chalk Formation in the area of the Blackfriars Bridge Foreshore site are designated as the Greenwich Chalk and Tertiaries groundwater body.

K.8.4 The baseline assessment for groundwater status classification for the Greenwich Chalk and Tertiaries shows poor quantitative status with respect to impact on surface waters and saline intrusions, good quantitative status with respect to groundwater dependent terrestrial ecosystems and resource balance for 2009. The baseline assessment also shows poor chemical status with respect to saline intrusions and drinking water protected area status and good chemical status with respect to general chemical assessment, groundwater dependent terrestrial ecosystems and impact on surface water chemical/ ecological status.

K.8.5 The predicted quantitative and chemical quality was poor for 2015 due to treatment or improvement being disproportionately expensive or technically infeasible.

K.8.6 The baseline assessment for groundwater status classification for the nearby Lower Thames Gravels is good quantitative status and poor quality status for 2009. The predicted chemical quality was poor for 2015 due to treatment or improvement being disproportionately expensive or technically infeasible.

K.8.7 Only eight out of forty-six groundwater bodies within the Thames River basin district are at good status overall; this is not expected to change by 2015 (EA, 2009)[15].

K.8.8 The Thames Tideway Tunnel project would prevent deterioration of the current and predicted status of groundwater and would adhere to the key actions identified in the RBMP to achieve good status by 2021 or 2027, as follows (EA, 2009):

a. The control of pollution to groundwater that may arise from any development which takes place on land.

b. Prevent input of nitrates to groundwater body.

c. Prevent inputs to and mitigate potential mobilisation of copper, other metals and hazardous substances in groundwater.

d. Prevent and mitigate potential inflow of river water to groundwater due to dewatering/ abstraction by implementing working methods to protect

surface and groundwater from impacts, including changes to flow, by producing site-specific water management plans and by monitoring where required.

e. Prevent direct discharges of pollutants to groundwater.

K.9 Data sources

K.9.2 A list of data used for the Blackfriars Bridge Foreshore assessment is given in Vol 18 Table K.9.

Vol 18 Table K.9 Groundwater - desk based baseline data sources

Source	Data	Date received	Notes
BGS	British Geological Survey (BGS) 1:50,000 scale digital geological data	February 2009	
EA	Licensed groundwater abstraction boreholes, their ownership and purpose	December 2010, February 2011 and March 2012	Licensed abstraction rates, aquifer, and status (active or dormant)
LB's*	Unlicensed groundwater abstraction boreholes and their details	June 2009	Contacted 14 London Boroughs along tunnel alignment
EA	Designated source protection zones (SPZ)	December 2010	
EA	Groundwater level records for EA observation boreholes	September 2009, June 2011, December 2011 and October 2012	
EA	Groundwater quality results for EA observation boreholes	August 2009 and May 2011	
EA	Ground Source Heat Pump (GSHP) schemes and their details	December 2010 and March 2012	
Thames Tideway Tunnel project	Ground Investigation (2009) borehole logs, construction details, monitoring regime and available water level records and water quality	Last updated September 2012	Final ES

Source	Data	Date received	Notes
	results from 2009 to 2012		
Thames Tideway Tunnel project	Groundwater monitoring strategy	Draft strategy Feb 2012	
Thames Tideway Tunnel project	Land quality data	February 2011	
Individual licence holders	Letters sent out to 30 licence holders	December 2011 (last updated 15th October 2012)	

** LBs – London Borough*

References

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[9] Environment Agency. *The London Catchment Abstraction Management Strategy* (CAMS). Final Strategy Document (2006). Available at: http://publications.environment-agency.gov.uk/PDF/GETH0406BKRM-E-E.pdf.

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[12] Environment Agency. *REACH Annex XVII Restrictions Polycyclic-aromatic Hydrocarbons (PAHs) Guidance Note Part 1* (October 2010). Available at: http://www.environment-agency.gov.uk/static/documents/Business/Part_1_PAH_Guidance_Note.pdf.

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[14] Environment Agency. *Soil Guideline Value Reports* (2009). Available at: http://www.environment-agency.gov.uk/research/planning/64015.aspx.

[15] Environment Agency. *River Basin Management Plan, Thames River Basin District* (December 2009). Available at: http://publications.environment-agency.gov.uk/PDF/GETH0910BSWA-E-E.pdf.

Thames Tideway Tunnel
Thames Water Utilities Limited

Application for Development Consent

Application Reference Number: WWO10001

Environmental Statement

Doc Ref: **6.2.18**

Volume 18 Blackfriars Bridge Foreshore appendices

Appendix L: Water resources - surface water

APFP Regulations 2009: Regulation **5(2)(a)**

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Thames Tideway Tunnel

Creating a cleaner, healthier River Thames

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Thames Tideway Tunnel

Environmental Statement

Volume 18 Blackfriars Bridge Foreshore appendices

Appendix L: Water resources – surface water

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Appendix L: Water resources – surface water

L.1 Introduction

L.1.1 Construction and operational effects assessments at this site for this topic do not require the provision of any supporting information, so this appendix is intentionally empty.

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Thames Tideway Tunnel
Thames Water Utilities Limited

Application for Development Consent

Application Reference Number: WWO10001

Environmental Statement

Doc Ref: **6.2.18**

Volume 18 Blackfriars Bridge Foreshore appendices

Appendix M: Water resources - flood risk

APFP Regulations 2009: Regulation **5(2)(a)**

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Creating a cleaner, healthier River Thames

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Thames Tideway Tunnel

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Appendix M: Water resources – flood risk

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Appendix M: Water resources – flood risk

M.1 Policy considerations

M.1.1 The relevant planning document that would be used to assess the proposals is the National Policy Statement (NPS) for Waste Water (Defra, 2012)[1] which was published in February 2012.

M.1.2 The Waste Water NPS considers the Thames Tideway Tunnel project as 'nationally significant waste water infrastructure.'

M.1.3 General policy documents (eg, NPS) have been reviewed within Volume 2 Environmental assessment methodology. A summary of local and regional policy relevant to flood risk at Blackfriars Bridge Foreshore is provided below.

Local policy

Strategic Flood Risk Assessment

M.1.4 The Blackfriars Bridge Foreshore site lies within the City of London. The City of London Corporation produced a Level 1 Strategic Flood Risk Assessment (SFRA) (Mouchel Parkman, 2007)[2]. This outlines the main flood sources to the site.

M.1.5 The site is located in the tidal Thames and identified as Flood Zone 3b as Functional Floodplain, which is currently undefended.

M.1.6 The City of London SFRA confirms that the Thames Tidal Defence network (the River Thames tidal flood defence walls and the Thames Barrier) reduces the annual probability of flooding from the River Thames in the City to less than 0.1%. The risk of tidal flooding to the City is therefore residual associated with a breach in, or overtopping of the flood defences.

M.1.7 According to the SFRA:

a. The site is within the Environment Agency (EA) Flood Zone 3b and is currently undefended

b. The primary source of flooding is tidal from the River Thames

c. Flood defences protect the adjacent land behind the foreshore. However, this area would be subject to a residual risk of flooding from overtopping or breaching of the defences

d. There are two canalised rivers incorporated into the sewer network in the City of London, one of which outfalls beneath Blackfriars Bridge

e. The site is in an area of critical sewer flooding

f. The existing flood defences in the vicinity are in good condition.

M.1.8 The SFRA promotes the use of Sustainable Drainage Systems (SuDS) suitable to specific site locations within the City of London, depending on underlying geology.

Surface Water Management Plan

M.1.9 The City of London, in partnership with the Greater London Authority (GLA), Thames Water and the EA produced a Surface Water Management Plan (SWMP) (GLA, 2011)[3] as part of the Drain London project. The SWMP sets out the preferred surface water management strategy for the borough.

M.1.10 According to the SWMP:

a. The site lies within the Thames Embankment (Group 3_007) Critical Drainage Area (CDA)[i]

b. An identified flow path for the 1% AEP[ii] + 30% climate change rainfall event lies to the north of the western section of the site, with flood depths ranging between 0.1-0.5m

c. The surface water flood hazard rating ranges from moderate (danger for some) to extreme (danger for all)

d. 1-5 sewer flood incidents have been recorded within the vicinity of the site.

Regional policy

Thames Estuary 2100

M.1.11 Blackfriars Bridge Foreshore site lies within the London City Policy Unit which has been assigned flood risk management policy 'P5'within the Thames Estuary 2100 (TE2100) Plan (EA, 2012)[4], meaning that further action will be taken to reduce flood risk beyond that required to keep pace with climate change.

M.1.12 The TE2100 Plan identifies the local sources of flood risk at this location as including:

a. tidal flooding from the River Thames

b. pluvial (heavy rainfall) and urban drainage sources

c. a risk of groundwater flooding from superficial strata which is possibly connected to high water levels in the Thames.

M.1.13 Flood mitigation from these sources include:

a. the Thames Barrier and secondary tidal defences along the Thames frontage (both making up the Thames Tidal Defences)

b. combined sewer overflows (CSOs) for mitigation of urban drainage

c. flood forecasting and warning.

M.1.14 The TE2100 Plan seeks to promote, where possible, defence improvements that ensure views are maintained and impacts to river access/views are minimised. Where defence raising in the future to manage the consequences of climate change is not possible, secondary

[i] An area susceptible to surface water flooding.

[ii] A rainfall event with a 1% AEP has a one in 100 year probability of occurring

defences and floodplain management should be introduced. In the Plan there is also the vision to increase flood risk awareness within the area.

M.1.15 There is an acknowledgement in the TE2100 Plan that there are long lengths of natural eroding foreshore at Blackfriars.

London Regional Flood Risk Appraisal

M.1.16 For the reach between Hammersmith Bridge and the Thames Barrier (City Reach) the London Regional Flood Risk Appraisal (RFRA) (GLA, 2009)[5] encourages small scale set back of development from the river walls where possible. The aim of this is to enable modification, raising and maintenance in a sustainable, environmentally acceptable and cost effective way. Development should be designed in such a way as to take opportunities to reduce flood risk and include resilience.

M.1.17 There is particular concern surrounding confluences of tributaries into the tidal Thames and the interactions between tidal and fluvial flows in the future due to climate change. This should be taken into consideration during the re-development process.

M.1.18 The RFRA indicates that SuDS should be included within developments to reduce surface water discharge.

References

[1] Department of Environment, Food and Rural Affairs (Defra), *National Planning Policy for Waste Water.* (February 2012)

[2] Mouchel Parkman. *City of London Strategic Flood Risk Assessment*. (August 2007).

[3] Greater London Authority. *City of London Surface Water Management Plan Final Report*. (July 2011).

[4] Environment Agency. Thames Estuary 2100 Flood Risk Management Plan. (November 2012)

[5] Greater London Authority . *London Regional Flood Risk Appraisal*. (October 2009).

Thames Tideway Tunnel
Thames Water Utilities Limited

Application for Development Consent

Application Reference Number: WWO10001

Environmental Statement

Doc Ref: **6.2.18**

Volume 18 Blackfriars Bridge Foreshore appendices

Appendix N: Development schedule

APFP Regulations 2009: Regulation **5(2)(a)**

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Thames Tideway Tunnel

Creating a cleaner, healthier River Thames

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Thames Tideway Tunnel

Environmental Statement

Volume 18 Blackfriars Bridge Foreshore appendices

Appendix N: Development schedule

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Appendix N: Development schedule

N.1 Summary

N.1.1 The assessments undertaken for this site take account of other relevant development projects within the vicinity of the site which are under construction, permitted but not yet implemented or submitted but not yet determined. In order to identify the relevant developments for consideration, the Planning Inspectorate, local planning authorities and the Greater London Authority have been consulted on the methodology (see Volume 2) and asked to assist in identifying and verifying the development projects included in the assessment. A schedule is provided in Vol 18 Table N.1 of the resulting development projects, a description of what is proposed and assumptions on phasing. Longer term development projects may be included under both base case, with construction preceding that of the Thames Tideway Tunnel site, and cumulative with construction or operation occurring at the same time as a given Thames Tideway Tunnel site.

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Vol 18 Table N.1 Development schedule for Blackfriars Bridge Foreshore

Category types:

a. Under construction

b. Permitted but not yet implemented

c. Submitted but not yet determined

Development within 1km (IPC or Mayoral referral unless otherwise noted)	Dist from site (closest point)	Development description			Category type (based on 'current' status)	Year specific assumptions			Source of assumption information / Notes	Base case or cumulative dev?
		Appl. No.	Developer	Description		2017 (Site Year 1 of construction)	2018 (peak construction traffic year)	2023 (Year 1 of operation)		
Puddle Dock Mermaid Theatre Note: not Mayoral referral scheme but included as possible sensitive receptor for consideration.	100m north	09/00321/ FULEIA	Heatherfield Limited	Erection of a new building to provide a seven storey hotel (Class C1) 26,990sq.m.	C	100% complete & operational	100% complete & operational	100% complete & operational	Professional judgement	Base case (all years)
1-16 Blackfriars Road	Approx 260m south	12-AP-1784	St George South London Ltd	Erection of three buildings (a 50 storey tower plus basement levels to a maximum height 170m Above Ordnance Datum (AOD), a 6 storey building - 'The Rennie Street Building', and a 4 storey building - 'The Podium Building') which together provide a mixed use development totalling 74,905sqm gross external area comprising: 11,267sqm of Class C1 use (hotel); 52,674sqm of Class C3 use (up to 274 flats); 1,316sqm of retail uses (Class A1 to A5); and 9,648sqm of basement, ancillary plant, servicing and car parking with associated public open space and landscaping.	C	Under construction	100% complete and operational	100% complete and operational	ES Volume 1 states that the construction programme would be 48 months but gives no indication of start/completion dates. On the basis that the application is not yet approved and the four year construction period, it is assumed that the development would be still under construction in Site Year 1 of construction but complete and operational by the peak year of construction.	**2017**: Cumulative **2018 & 2023**: Base case
231-241 Blackfriars Road	Approx 400m south	10-AP-3372	Great Ropemaker Partnership (GE) Ltd	Erection of a 20 storey building with basement (maximum 89m AOD) to provide 29,198sqm of office floorspace and 455sqm of ground floor retail floorspace (Class A1/A2/A3/A4), with plant, rear servicing area and cycle parking.	B	100% complete and operational	100% complete and operational	100% complete and operational	No information is available from the planning application documentation on phasing or dates. On the basis that the application has been permitted, it has been assumed that it will be built by 2017.	Base case (all years)
Bankside 4, Holland Street	Approx 400m south	11-AP-0912	GC Bankside LLP	Minor material amendments to approved scheme dated 12.1.2011 with ref 10-AP-3259 (Variation of condition 8 for alterations during the course of construction of approved scheme granted planning permission on 19.6.07 with ref 06-AP-1481 (for demolition of existing	A	100% complete & operational	100% complete & operational	100% complete & operational		

Development within 1km (IPC or Mayoral referral unless otherwise noted)	Dist from site (closest point)	Development description			Category type (based on 'current' status)	Year specific assumptions			Source of assumption information / Notes	Base case or cumulative dev?
		Appl. No.	Developer	Description		2017 (Site Year 1 of construction)	2018 (peak construction traffic year)	2023 (Year 1 of operation)		
				buildings and the erection of five buildings, one six storey, two 12 storey, one 18 storey and one 24 storey, each with two basement levels to provide 229 residential units on the upper floors) with retail Class A1, A2 and A3 use at ground floor with landscaping and other ancillary works). The amendments involve: The change of use of Block E [six storey building] from residential to offices; Minor changes to the design of Block E, including a reduction in height by 0.8m; The removal of 6 studio units on floors 1 to 6 in Block D [12 storey building]; A change in residential tenure of the shared equity units on floors 1 to 6 in Block D to market sale. (The changes result in the removal of all on-site affordable housing and a reduction in the total number of residential units on site by 16); and A series of changes to the legal agreement, relating to the timings for the delivery of the off-site affordable housing, together with modifications to the search area for the sites on which to deliver the housing.					Assumptions made on basis that ES (July 2006) specifies a construction period of three years. As application was granted in 2011, it is a reasonable assumption that it will be complete by Site Year 1 of construction.	Base case (all years)
Tate Modern	Approx 500m south	09-AP-0039	The Board of Trustees of the Tate Gallery	Erection of an 11 level (70.4m AOD) 24,786 sqm (gross external area) extension to Tate Modern to comprise Class D1 (non residential institution) use including display and exhibition spaces, performance spaces, education and learning facilities together with ancillary offices, catering, retail and other facilities, landscaping, external lighting, servicing, vehicle and cycle parking and associated works including works to the public highway and necessary demolition of outbuildings, annexes and structures.	A	100% complete & operational	100% complete & operational	100% complete & operational	Application documents. Phase 1 to be built and open by 2012 Phase 2 to be built and open by 2016	Base case (all years)
20 Blackfriars Road	Approx 500m south	07/AP/0301	Beetham Organisation	At 20 Blackfriars Road, the proposal is for mixed-use development providing approximately 25,000 sq.m. of office floorspace and 286 residential units, with ancillary retail and community uses, and a new public square. The development involves two towers of 23 and 42 storeys.	B	100% complete & operational	100% complete & operational	100% complete & operational	Granted by Southwark. Mayor disapproved. Secretary of State determined it – and accepted it. No information available regarding construction duration for this development. Assume that complete by Site Year 1 of construction.	Base case (all years)
Wedge House, 32-40 Blackfriars Road	Approx 500m south	10-AP-2707	Derwent London Plc	Redevelopment of land and buildings to provide an eleven storey commercial building with basement, comprising office use (Use Class B1) and retail on ground floor (Use Class A) with ancillary plant and servicing, works of hard and soft landscaping, alterations to existing vehicular and pedestrian access.	B	100% complete & operational	100% complete & operational	100% complete & operational	Application documentation gives no indication of construction timescales. On the basis that the development is approved, it is assume that the development would be complete and operational by Site Year 1 of construction.	Base case (all years)

Development within 1km (IPC or Mayoral referral unless otherwise noted)	Dist from site (closest point)	Development description			Category type (based on 'current' status)	Year specific assumptions			Source of assumption information / Notes	Base case or cumulative dev?
		Appl. No.	Developer	Description		2017 (Site Year 1 of construction)	2018 (peak construction traffic year)	2023 (Year 1 of operation)		
30 Old Bailey	Approx 500m north	07/00382/ FULEIA	City of London Real Property Company Ltd	Erection of a new building for mixed use purposes comprising office (Class B1) and retail (Class A1/A3) uses; creation of new publicly accessible space; reconfigured vehicular access and pedestrian routes, together with associated works including landscaping and the provision of parking, servicing and plant areas. 57,172sqm (615,170sq.feet).	B	100% complete & operational	100% complete & operational	100% complete & operational	Programmed to be complete by Site Year 1 of construction. Information on completion dates obtained from: http://www.constructionenquirer.com/2011/06/03/land-securities-to-start-375000-sq-ft-old-bailey-offices/	Base case (all years)
Land bounded by Upper Ground and Doon St (adjacent to Cornwall Rd)	Approx 550m southwest	05/03498/ FUL	Coin Street Community Builders	Redevelopment of site to provide a 8,292sq m multi purpose community sports centre and swimming pool, 902 sq m retail/commercial/restaurant/bar floorspace (use classes A1, A2, A3 and A4), 329 residential units and underground parking for 56 cars contained within a 43 storey tower measuring 144.3m in height and a part 7, part 8 storey block with roof terraces and courtyard.	A	100% complete and operational	100% complete and operational	100% complete and operational	Information provided by LB Lambeth. Works expected to take three years. Possible 2012/2013 start date so assume completion by 2016.	Base case (all years)
Elizabeth House	Approx 820m southwest	12/01327/ FUL	Elizabeth House GP LLC	Demolition of all buildings and structures on the site, including removal of the high level footbridge over York Road, and redevelopment to provide two new buildings of part 29 and part 14 storeys (north building) and 11 storeys (south building) respectively with a part one/part two level common basement to provide 132,127sqm of floorspace (GEA), comprising B1 offices (88,649sqm), C3 residential (comprising 142 units), areas of flexible Use Classes A1- A5 and B1 at ground level and ancillary parking and servicing space; works of hard and soft landscaping to Cab Road and Mepham Street, the provision of a new access to Waterloo Station on West Road and associated works; works of hard and soft landscaping and the provision of a single storey structure providing car lifts and Class A use on West Road; works of hard landscaping to York Road and Leake Street; plant and other associated infrastructure and works.	B	Under construction	100% complete & operational	100% complete & operational	Assumptions made on basis that ES (Volume 1, Chapter 6) specifies a construction period of 46 months commencing in Sept 2012 and finishing in latter half of 2016.	Base case (all years)
London Eye Pier Extension	Approx 930m southwest	11/03292/ FUL	EDF Energy London Eye	Proposal for a Pier extension to the south of the existing London Eye Millennium Pier.	B	100% complete & operational	100% complete & operational	100% complete & operational	Information provided by LB Lambeth. Likely to be completed by 2013.	Base case (all years)

Note: phasing and site layout information has been sourced from local authority planning portals unless otherwise indicated.

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