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: **6.2.20**

Volume 20: Chambers Wharf appendices

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

Hard copy available in

Box **34** Folder **B**
January 2013

Thames Tideway Tunnel

Creating a cleaner, healthier River Thames

This page is intentionally blank

Thames Tideway Tunnel

Environmental Statement

List of contents

This page is intentionally blank

Thames Tideway Tunnel

Environmental Statement

Volume 20 Chambers Wharf site assessment

List of contents

Thames Tideway Tunnel
Thames Water Utilities Limited

Application for Development Consent

Application Reference Number: WWO10001

Environmental Statement

Doc Ref: **6.2.20**

Volume 20: Chambers Wharf appendices

Appendix A: Introduction

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

Hard copy available in

Box **34** Folder **B**
January 2013

Thames Tideway Tunnel

Creating a cleaner, healthier River Thames

This page is intentionally blank

Thames Tideway Tunnel

Environmental Statement

Volume 20 Chambers Wharf appendices

Appendix A: Introduction

List of contents

Page number

This page is intentionally blank

Appendix A: Introduction

A.1 Summary

A.1.1 This document presents the appendices that accompany the *Environmental Statement* Volume 20 Chambers Wharf 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.

This page is intentionally blank

Thames Tideway Tunnel
Thames Water Utilities Limited

Application for Development Consent

Application Reference Number: WWO10001

Environmental Statement

Doc Ref: **6.2.20**

Volume 20: Chambers Wharf appendices

Appendix B: Air quality and odour

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

Hard copy available in

Box **34** Folder **B**
January 2013

Thames Tideway Tunnel

Creating a cleaner, healthier River Thames

This page is intentionally blank

Thames Tideway Tunnel

Volume 20 Appendices: Chambers Wharf site assessment

Appendix B: Air quality and odour

List of contents

Page number

List of plates

Page number

List of tables

Page number

This page is intentionally blank

Appendix B: Air quality and odour

B.1 Model verification

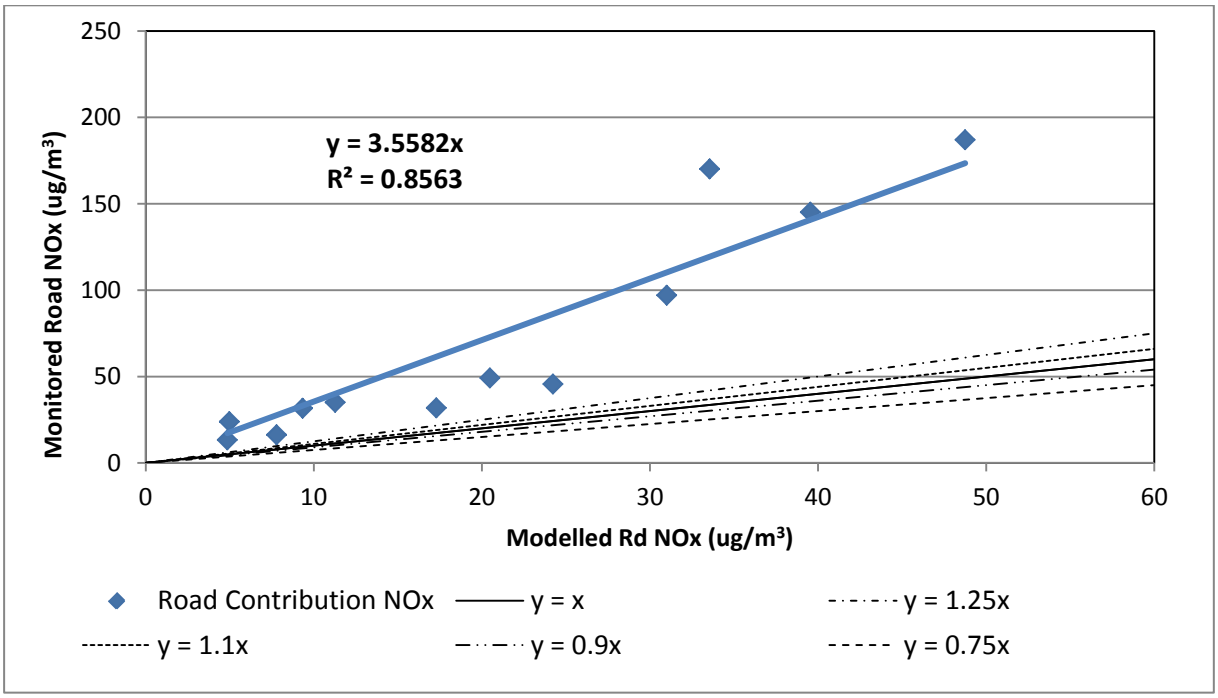
B.1.1 Modelled NO_2 concentrations have been plotted against monitored concentrations at twelve diffusion tube sites (STPM1-STPM5, CHWM1, CHWM3-CHWM5 and KSGM1-KSGM3) as shown in Vol 24 Figure 4.4.1 (see separate volume of figures).

B.1.2 This showed that the modelled results underestimated NO_2 concentrations by between 7% and 41%. 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.

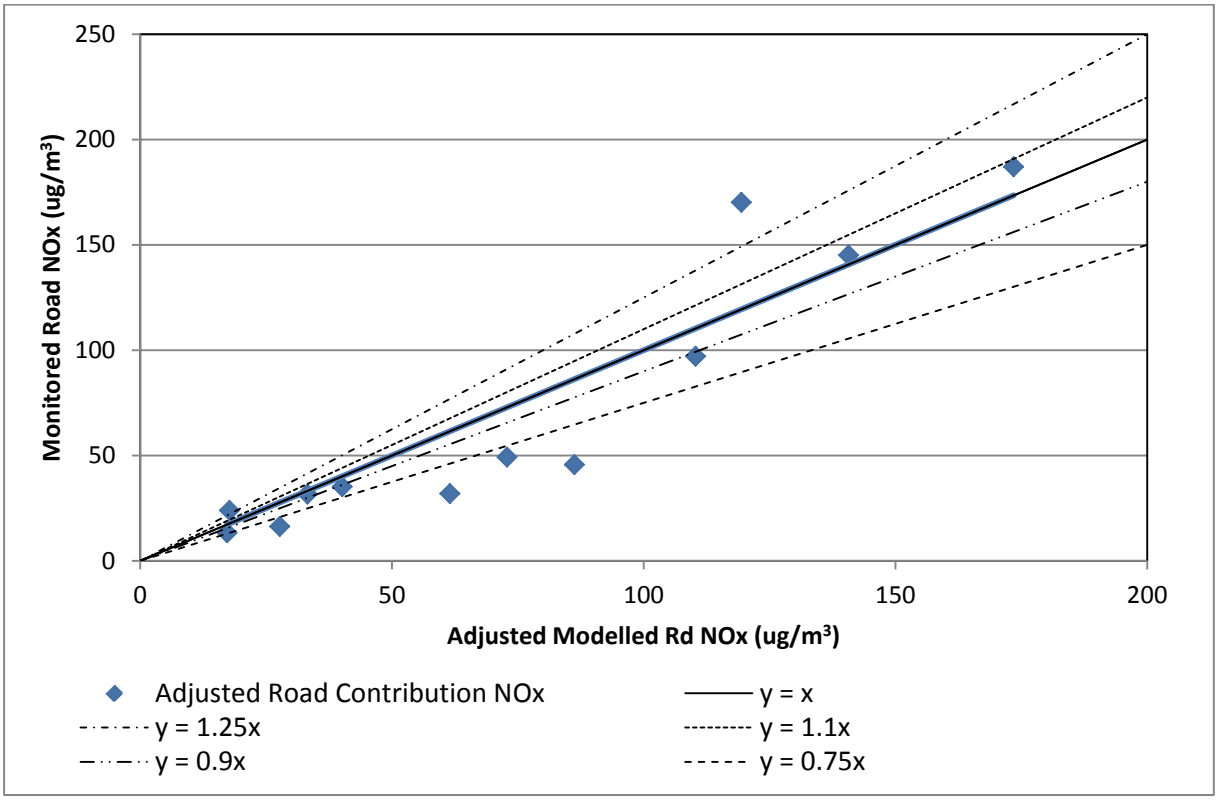
B.1.3 To derive the adjustment factor, modelled road NO_X concentrations were plotted against calculated monitored road NO_X concentrations (see Vol 20 Plate B.1 below). An adjustment factor of 3.56 was calculated for adjusting modelled roadside NO_X concentrations, in accordance with LAQM.TG(09)[1] and subsequently applied. This factor was also applied to the PM_{10} results as no local PM_{10} monitoring data were available for an area where traffic data were also available.

B.1.4 Applying the NO_X adjustment factor and then calculating NO_2 concentrations, as shown in Vol 20 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 20 Plate B.3, indicated that eight of the twelve modelled concentrations were within 10% of the measured value and that the other four were within 25% of the modelled value.

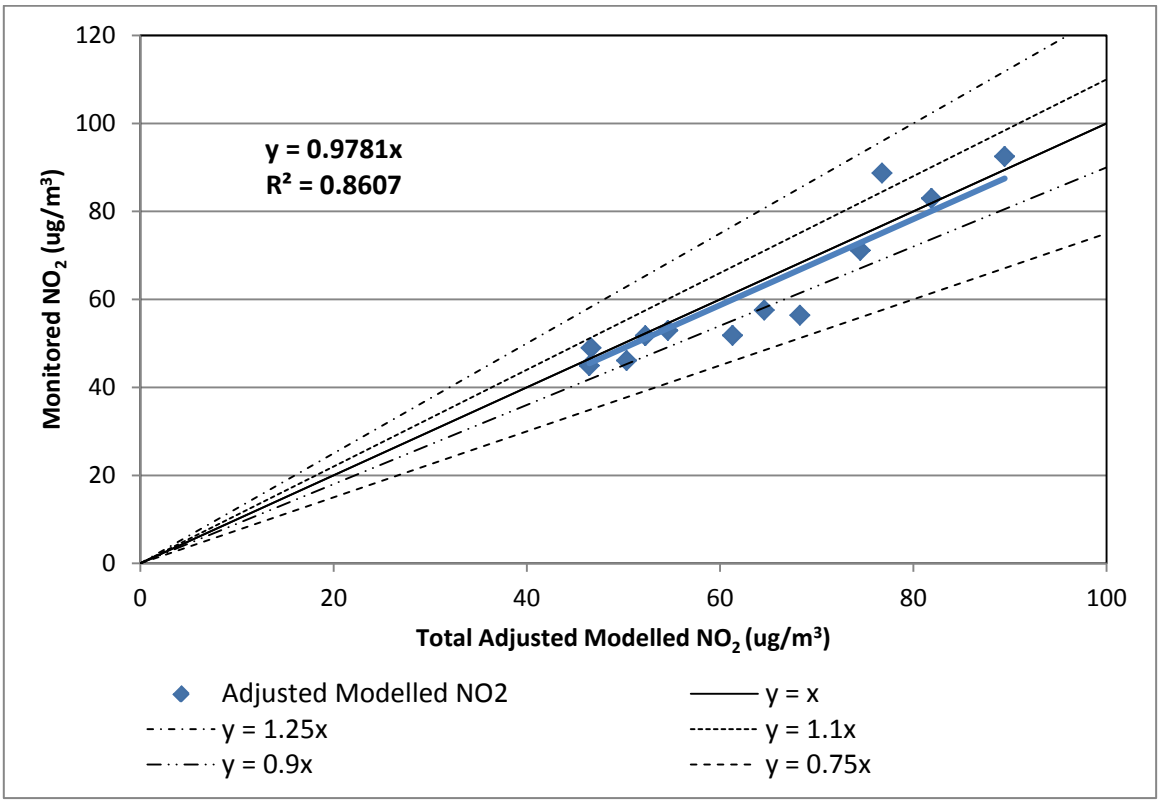
Vol 20 Plate B.1 Air quality - monitored road NO_x vs. modelled road NO_X



Vol 20 Plate B.2 Air quality – monitored road NO_X vs. adjusted modelled road NO_X



Vol 20 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 Chambers Wharf site are shown in Vol 20 Table B.1.

Vol 20 Table B.1 Air quality - traffic data 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'	Tooley Street A200 W of Shad Thames	14835	6.7%	30	27.8	2.3%	15172	2	15182	6.7%
ATC 'Indirect'	Tanner Street S of Tooley Street	8810	8.6%	30	27.8	2.3%	9010	2	9034	8.6%
ATC 'direct'	Jamaica Road A200 E of Shad Thames	18408	16.1%	30	27.8	2.3%	18826	4	18873	16.1%
TfL Model	Abbey Street B202 S of Jamaica Road	13331	5.4%	20	12.6	2.3%	13633	0	14102	5.3%
ATC 'Indirect'	Jamaica Road A200 W of Bevington Street	31803	6.7%	30	27.8	2.3%	32525	4	32948	6.7%
TfL Model	St James's	13918	3.6%	20	11.0	2.3%	14234	0	14420	3.6%

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)
	Road S of Jamaica Road									
Speed Limit	Bevington Street N of Jamaica Road	4197	4.2%	30	30.0	2.3%	4292	34	4326	4.9%
Speed Limit	Scott Lidgett Crescent W of Bevington Street	1528	3.4%	30	30.0	2.3%	1563	0	1563	3.4%
Speed Limit	Scott Lidgett Crescent E of Bevington Street	1677	2.3%	30	30.0	2.3%	1715	0	1715	2.3%
Speed Limit	Bevington Street S of Chambers Street	1544	4.6%	30	30.0	2.3%	1579	34	1613	6.6%
Speed Limit	Chambers Street W of Bevington Street	1454	2.0%	30	30.0	2.3%	1487	34	1521	4.2%

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 'direct'	Jamaica Road A200 E of Bevington Street	28952	13.6%	30	23.9	2.3%	29609	38	30248	13.4%
Speed Limit	West Lane N of Jamaica Road	1060	4.6%	30	30.0	2.3%	1084	0	1084	4.6%
Speed Limit	Southwark Park Road S of Jamaica Road	10303	5.1%	20	20.0	2.3%	10537	0	10537	5.1%
ATC 'Indirect'	Jamaica Road A200 E of West Lane	44381	5.9%	30	23.9	2.3%	45388	38	46083	5.9%
ATC 'direct'	A100 Tower Bridge	34794	7.2%	20	15.3	2.3%	35583	2	35618	7.2%
ATC 'Indirect'	A200 Tooley Street	12345	8.7%	30	27.8	2.3%	12625	0	12634	8.7%
ATC 'Indirect'	A100 Tower Bridge (middle)	36495	6.6%	30	15.3	2.3%	37322	2	37401	6.6%
ATC 'Indirect'	A200 St Thomas Street	20070	7.2%	30	27.8	2.3%	20525	0	20534	7.2%

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'	A100 Tower Bridge (South)	34238	7.1%	30	15.3	2.3%	35015	2	35091	7.1%
ATC 'Indirect'	A200 Druid Street	9883	8.7%	30	27.8	2.3%	10108	0	10150	8.6%

** AADT – annual average daily traffic. ** CTC – classified traffic count. *** ATC - automatic traffic count.*

B.3 Barge emission factors

B.3.1 Emissions of NO_X and PM_{10} from the barges were calculated using the data shown in Vol 20 Table B.2 for the Chambers Wharf site.

Vol 20 Table B.2 Air quality - barge assessment model inputs

Parameter	Value	Units
Total barges	365	tugs/year
Time per barge*	20	minutes
NO_X base emission factor	10.2	g/kWhr
PM_{10} base emission factor	0.9	g/kWhr
Average barge engine size	613	kW
Manoeuvring and hotelling** load factor	0.2	No units
Total barge area***	5768	m^2
NO_X emissions per barge	6.0×10^{-05}	$g/s/m^2$
PM_{10} emissions per barge	5.3×10^{-06}	$g/s/m^2$

* Time that barge is at the site.
** Hotelling refers to when the barge is securely moored or anchored and is not loading or unloading cargo.
*** Area modelled for the mooring and manoeuvring of barges.

B.4 Construction plant emission factors

B.4.1 For the purpose of the assessment, the following listed equipment in Vol 20 Table B.3 has been modelled for the peak construction year at the Chambers Wharf site.

Vol 20 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	$1.5x10^{-07}$	$9.2x10^{-09}$
	Ground level behind hoarding	Generator - 200kVA	1	100	160	$4.5x10^{-07}$	$2.8x10^{-08}$
	Ground level behind hoarding	JCB with hydraulic breaker	1	50	67	$9.4x10^{-08}$	$5.9x10^{-09}$
	Ground level behind hoarding	Cutting equipment (diamond saw)	2	10	2.3	$3.3x10^{-09}$	$7.2x10^{-09}$
	Ground level behind hoarding	Telescopic handler / FLT**	1	30	60	$5.1x10^{-08}$	$3.2x10^{-09}$
	Ground level behind hoarding	Hiab*** lorry/crane	1	5	56	$7.9x10^{-09}$	$4.9x10^{-10}$
Main tunnel drive - Chambers Wharf to Abbey Mills	Ground level behind hoarding	150t crawler crane	1	50	240	$3.4x10^{-07}$	$2.1x10^{-08}$
	Ground level behind hoarding	Air compressor 600cfm*	2	50	224	$6.3x10^{-07}$	$3.9x10^{-08}$
	Ground level behind hoarding	Dumper	1	25	81	$5.7x10^{-08}$	$3.6x10^{-09}$

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	Emergency generator - 200kW	1	5	200	$2.8x10^{-08}$	$1.8x10^{-09}$
	Ground level behind hoarding	Loading shovel	2	30	325	$5.5x10^{-07}$	$3.4x10^{-08}$
	Ground level behind hoarding	Telehandler 5t	2	80	60	$2.7x10^{-07}$	$1.7x10^{-08}$
	Within tunnel	Locomotives	4	100	180	$4.7x10^{-05}$	$2.9x10^{-06}$

*Note: For the purposes of this assessment, the above listed equipment has been modelled for the peak construction year. The data assumes a 24-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).

This page is intentionally blank

Thames Tideway Tunnel
Thames Water Utilities Limited

Application for Development Consent

Application Reference Number: WWO10001

Environmental Statement

Doc Ref: **6.2.20**

Volume 20: Chambers Wharf appendices

Appendix C: Ecology - aquatic

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

Hard copy available in

Box **34** Folder **B**
January 2013

Thames Tideway Tunnel

Creating a cleaner, healthier River Thames

This page is intentionally blank

Thames Tideway Tunnel

Environmental Statement

Volume 20 Chambers Wharf appendices

Appendix C: Ecology - aquatic

List of contents

Page number

.

This page is intentionally blank

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.

This page is intentionally blank

Thames Tideway Tunnel
Thames Water Utilities Limited

Application for Development Consent

Application Reference Number: WWO10001

Environmental Statement

Doc Ref: **6.2.20**

Volume 20: Chambers Wharf appendices

Appendix D: Ecology - terrestrial

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

Hard copy available in

Box **34** Folder **B**
January 2013

Thames Tideway Tunnel

Creating a cleaner, healthier River Thames

This page is intentionally blank

Thames Tideway Tunnel

Environmental Statement

Volume 20 Chambers Wharf appendices

Appendix D: Ecology – terrestrial

List of contents

Page number

List of plates

Page number

List of tables

Page number

This page is intentionally blank

Appendix D: Ecology – terrestrial

D.1 Notable species survey report

Introduction

D.1.1 A Phase 1 Habitat Survey was carried out on 17 May 2011 at the Chambers Wharf site (Vol 20 Figure 6.4.1, separate volume of figures). Based on this, surveys for the following species have been undertaken:

a. bats;

b. wintering birds;

c. black redstarts (*Phoenicurus ochruros*); and

d. invasive plants.

D.1.2 The purpose of the surveys is to determine the presence or likely absence of these species at and around the site.

D.1.3 This report presents the survey findings. The survey area for each species is described with reference to the habitat types identified during the Phase 1 Habitat Survey as having potential for notable species (paras D.1.5 to D.1.13). The results from the surveys are then presented (paras D.1.14 to D.1.24). The final section provides an interpretation of the results (paras. D.1.25 to D.1.29). Figures referred to in this report are contained within Vol 20 Chambers Wharf Figures.

D.1.4 Information on legislation, policy and methodology can be found in Vol 2 of the *Environmental Statement*. Information on site context can be found in Section 3 of this volume.

Survey area

Bats

D.1.5 Bats are associated with a diverse range of habitats, including woodland, scrub, riparian habitats and buildings. They roost in trees and buildings where suitable features are present, and they commute along linear features such as hedgerows, watercourses and tree lines, and forage around vegetation such as scrub, hedgerows, grassland, trees and river corridors.

D.1.6 A two stage bat survey was carried out. The first survey was a remote recording (bat triggering) survey using remote Anabat™ recording devices. Based on the habitat types identified during the Phase 1 habitat survey, which comprise ephemeral and short perennial vegetation, scattered scrub and the adjacent River Thames, and their potential to support foraging, commuting or roosting bats, two locations were chosen for the installation of the remote recording devices (shown on Vol 20 Figure 6.4.2, separate volume of figures).

D.1.7 Location 1 is on the eastern boundary of the site. This location was selected to record potential bat activity associated with foraging and

commuting along the eastern boundary, adjacent to residential properties, and the River Thames.

D.1.8 Location 2 is towards the west of the site. This location was selected to record potential bat activity associated with foraging and commuting across the site and along the adjacent River Thames.

D.1.9 The bat activity recorded during the remote recording surveys triggered the need for an additional dawn survey (see Vol 2 Methodology for bat triggering criteria). Therefore, a second stage of bat surveying was undertaken, comprising one dawn survey visit by two ecologists to assess the usage of the site and immediate surrounds by bats.

Wintering Birds

D.1.10 Wintering birds are mainly associated with aquatic habitats such as intertidal mudflats and marshes, marginal vegetation and wetlands, which they use for resting and foraging. Some wintering bird species are also associated with terrestrial habitats such as scrub and grassland, which they use for roosting at high tide or foraging. The survey area, as shown in Vol 20 Figure 6.4.3 (separate volume of figures), includes the proposed development site and habitats in close proximity to the site that have potential for wintering birds such as the intertidal foreshore and the River Thames. The foreshore mainly consists of stones and silt.

Black Redstart

D.1.11 Black redstart nest on and within buildings and structures (mostly those that are derelict), and forage on sparsely-vegetated open areas. The derelict building on site was considered to have the potential to support nesting black redstarts. The survey area is shown in Vol 20 Figure 6.4.4 (separate volume of figures). The survey area includes those buildings, areas of hard standing and other features which lie in the immediate vicinity of Chambers Wharf and includes the section of foreshore and river which lie adjacent to the proposed development site.

Invasive Plants

D.1.12 Invasive plants that are listed on Schedule 9 of the Wildlife and Countryside Act 1981 (as amended) occur in a wide range of habitats, although they are more often associated with watercourses or wet areas, or within areas of disturbed ground, where material contaminated with seeds and rhizomes (sections of root that can re-grow), may have been imported into the area.

D.1.13 The invasive plants survey area, as shown on Vol 20 Figure 6.4.5 (separate volume of figures), comprises the proposed development site.

Results

D.1.14 In this section, the results of the desk study, notable species surveys and the invasive plant survey are presented. The results are then interpreted in pars. D.1.25 to D.1.29.

Desk Study

D.1.15 Species data recorded within 500m of the site from 2001 to 2011, as supplied by Greenspace Information for Greater London (GIGL), are summarised in Vol 20 Table D.1.

Vol 20 Table D.1 Terrestrial ecology – species found within 500m of the site from 2001 – 2011

Common name	Species name (latin)	Species count
Birds		
Greylag goose	*Anser anser*	2
Peregrine falcon	*Falco peregrinus*	4
Black redstart	*Phoenicurus ochruros*	16
Common linnet	*Carduelis cannabina*	4
Common starling	*Sturnus vulgaris*	18
Fieldfare	*Turdus pilaris*	2
Hedge accentor	*Prunella modularis*	4
House sparrow	*Passer domesticus*	22
Song thrush	*Turdus philomelos*	2
Spotted flycatcher	*Muscicapa striata*	2
Invertebrates		
Stag beetle	*Lucanus cervus*	2

Bat surveys

Bat triggering (remote recording) surveys

D.1.16 The bat triggering (remote recording) surveys were undertaken between 10 and 12 June 2011 in suitable weather conditions (Vol 20 Table D.20).

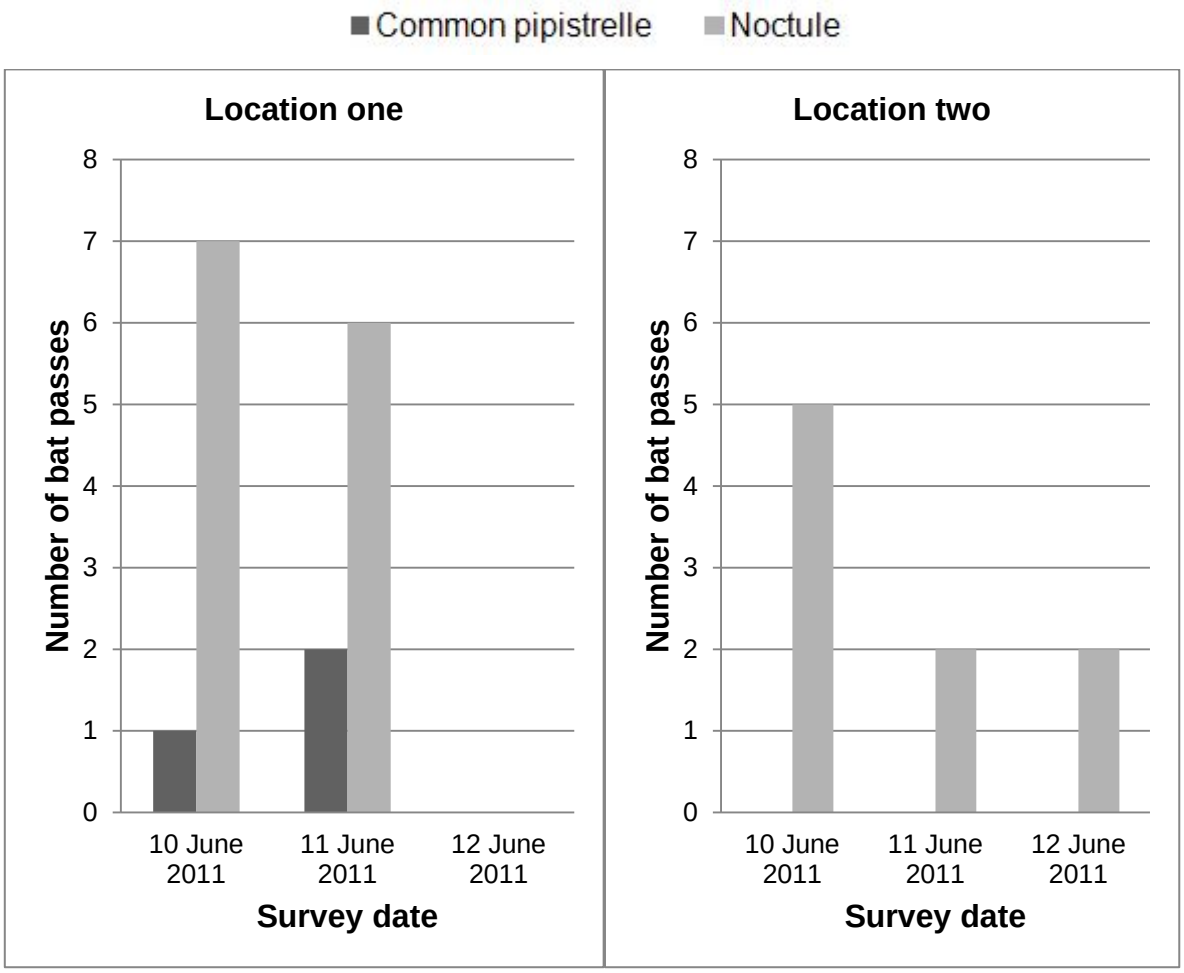
D.1.17 The remote recording surveys undertaken at Chambers Wharf recorded two species of bats using the site, common pipistrelle (*Pipistrellus pipistrellus*) and noctule (*Nyctalus noctula*). A maximum count of two common pipistrelle and seven noctule bat passes were recorded in any one night. Common pipistrelle were only recorded at location one and only on two occasions. Noctule bats were recorded at both locations on all but one night (Vol 20 Plate D.1). No bats were recorded close to sunset or sunrise, when bats typically leave and return to their roosts.

Vol 20 Table D.2 Terrestrial ecology – bat survey weather conditions

Survey visit	Weather conditions
10 June 2011	9^{o}C, gentle south-westerly wind, 100% cloud cover, dry

Survey visit	Weather conditions
11 June 2011	9°C, gentle west south-westerly wind, 25% cloud cover, dry
12 June 2011	8°C, no wind, 100% cloud cover, dry

Vol 20 Plate D.1 Terrestrial ecology – bat passes recorded during remote recording surveys at two locations at Chambers Wharf



Bat activity (dawn) surveys

D.1.18 As an uncommon species of bat (noctule) was recorded during the remote recording survey, the need for a bat activity (dawn) survey was triggered (based on bat triggering criteria in Vol 2 Section 6). The bat activity survey was undertaken on 8 July 2011 in suitable weather conditions (13°C, gentle southerly wind, 50% cloud cover). No bat activity was recorded during the dawn activity survey (Vol 20 Figure 6.4.2, separate volume of figures).

Wintering bird survey

D.1.19 A total of six surveys were undertaken at monthly intervals between October 2011 and March 2012 by an experienced ornithologist (bird specialist). The survey visits were undertaken in suitable weather conditions (Vol 20 Table D.3). The monthly counts for each species and

the total number of waterbirds recorded in each month are given in Vol 20 Table D.4.

D.1.20 A total of 12 waterbird[i] species were recorded on the foreshore on and adjacent to the site. Of these, eight species are of nature conservation importance and are included on the Birds of Conservation Concern 3 (RSPB, 2009)[1] Red or Amber List[ii] and/or UK and London BAP as priority species.

D.1.21 Gadwall (*Anas strepera*), mallard (*Anas platyrhynchos*), tufted duck (*Aythya fuligula*), black-headed gull (*Chroicocephalus ridibundus*), common gull (*Larus canus*), lesser black-backed gull (*Larus fuscus*), herring gull (*Larus argentatus*) and great black-backed gull (*Larus marinus*) were recorded foraging on inter-tidal mud and along the water's edge on and adjacent to the site. The majority of these were recorded to the west of the proposed development site, with small numbers recorded on the opposite foreshore on the River Thames and adjacent to the site to the east.

D.1.22 Small numbers of carrion crow (*Corvus corone*) (a terrestrial bird species) were recorded on the foreshore habitat on site during each of the survey visits.

Vol 20 Table D.3 Terrestrial ecology – wintering bird survey weather conditions

Survey visit	Weather conditions
11 October 2011	18^{o}C, light westerly wind, 75% cloud cover, dry
29 November 2011	10^{o}C, light southwesterly wind, 100% cloud cover, dry
14 December 2011	4^{o}C, calm, 20% cloud cover, dry
11 January 2012	9^{o}C, light southwesterly wind, 10% cloud cover, dry
9 February 2012	0^{o}C, light east northeasterly breeze, 100% cloud cover, dry

[i] A waterbird is a species which is listed in the Wetland Bird Survey (WeBS) methodology – British Trust for Ornithology, Royal Society for the Protection of Birds, Joint Nature Conservation Committee and Wildfowl and Wetlands Trust.

[ii] The conservation status of all regularly occurring British birds has been analysed in co-operation with the leading governmental and non-governmental conservation organisations, including the Royal Society for the Protection of Birds (RSPB), British Trust for Ornithology (BTO) and Birdlife International Birds of Conservation Concern 3 (RSPB, 2009). The basis of species ongoing population trends are assigned to one of three lists of Conservation Concern. These are the UK Red, Amber and Green lists. Although the lists confer no legal status in themselves, they are useful in evaluating the conservation significance of bird assemblages, and for assessing the potential significance of impacts and informing appropriate levels of mitigation with respect to bird populations. Birds of Conservation Concern (BoCC) Red List criteria for breeding birds are those which have experienced a severe decline of more than 50% of population and / or range over the last 25 years, as measured by the number of 10km squares occupied by breeding birds of the species concerned. Species listed as globally threatened by Birdlife International and those with a historical decline in the UK between 1800 and 1995 (without evidence of recovery) are also included. BoCC Amber List criteria for breeding birds are those which have experienced a moderate decline of between 25% and 49% of population and / or range over the last 25 years. Species of European conservation concern and those with a historical decline but which are currently recovering are also included.

Survey visit	Weather conditions
12 March 2012	5^{o}C, light westerly breeze, 100% cloud cover, dry

Vol 20 Table D.4 Terrestrial ecology – species and numbers recorded during wintering bird surveys undertaken once a month over a sixth month period

Species name	Latin name	Conservation designation[iii]	Monthly wintering waterbird counts					
			11 October 2011	29 November 2011	14 December 2011	11 January 2012	9 February 2012	12 March 2012
Gadwall	*Anas strepera*	Amber List	-	-	-	-	2	-
Cormorant	*Phalacrocorax carbo*	Green List	2	1	-	1	1	7
Greylag goose (feral)	*Anser anser*	Green List	-	8	-	-	-	-
Canada goose	*Branta canadensis*	Green List	2	1	1	1	-	4
Tufted duck	*Aythya fuligula*	Amber List	-	-	-	-	12	-
Mallard	*Anas platyrhynchos*	Amber List	14	5	13	20	29	5
Coot	*Fulica atra*	Green List	-	1	1	-	4	1
Black-headed gull	*Chroicocephalus ridibundus*	Amber List	15	49	65	87	40	10
Common gull	*Larus canus*	Amber List	-	1	5	1	1	-
Lesser black-	*Larus fuscus*	Amber List	3	3	3	3	2	1

[iii] A species that is listed in the following publications:

Batten, L.A., Bibby, C.J., Clement, P., Elliot, G.D. & Porter, R.F. (1990). *Red Data Birds in Britain*. T. & A.D. Poyser, London.

Commission of the European Communities (1979). Council Directive 79/409/EEC on the Conservation of Wild Birds. *Official Journal of European Communities, L103*.

Holliday, M & Rare Breeding Bird Panel (2011). Rare Breeding Birds in the United Kingdom in 2009. *British Birds*, 104, 9, 476-537.

Royal Society for the Protection Birds (2009). *Birds of Conservation Concern 3*. RSPB, Sandy.

United Kingdom Biodiversity Action Plan Steering Group (2011). *United Kingdom Biodiversity Action Plan* http://jncc.defra.gov.uk/page-5163 [10.11].

Species name	Latin name	Conservation designation[iii]	Monthly wintering waterbird counts					
			11 October 2011	29 November 2011	14 December 2011	11 January 2012	9 February 2012	12 March 2012
backed gull								
Herring gull	*Larus argentatus*	Red List UK BAP Priority List	7	5	8	14	9	-
Great black-backed gull	*Larus marinus*	Amber List	1	-	-	-	1	-

Black redstart surveys

D.1.23 Five back redstart survey visits were undertaken between May and July 2011 by an experienced ornithologist (bird specialist) in suitable weather conditions (Vol 20 Table D.5). The two July visits are outside of the optimum survey period for black redstart. However, surveys can be undertaken during July as breeding usually continues into this month (Brown and Grice 2005)[2]. The other three visits were undertaken during the peak breeding period for black redstart in May and June. Therefore, if black redstart were breeding on or near the site, then this would have been recorded with the survey effort undertaken. Consequently, two survey visits in July are not considered to limit the results of the survey. No black redstarts were recorded within the survey area during any of the survey visits.

Vol 20 Table D.5 Terrestrial ecology – weather conditions for black redstart surveys

Date	Weather conditions
20 May 2011	11°C, light westerly breeze, 25% cloud cover, dry
14 June 2011	10°C, light westerly breeze, 100% cloud cover, dry
21 June 2011	15°C, light south-westerly breeze, 100% cloud cover, dry
8 July 2011	13°C, light south-westerly breeze, 50% cloud cover, dry
14 July 2011	13°C, light west north-westerly breeze, 50% cloud cover, dry

Invasive plants survey

D.1.24 An invasive plant survey was undertaken by an experienced ecologist on 2 September 2011. One invasive plant species, Japanese knotweed (*Fallopia japonica)*, was recorded during the survey in the centre of the site. The location of this species is shown in Vol 20 Figure 6.4.5 (separate volume of figures), with corresponding description given in Vol 20 Table D.6.

Vol 20 Table D.6 Terrestrial ecology – invasive species

Common and scientific name	Location/description	National grid reference	Stand size
Japanese Knotweed *(Fallopia japonica)*	One young plant found growing within the centre of the site.	TQ3433579758	0.5m x 0.5m

Interpretation

Bats

D.1.25 The survey results suggest that levels of bat activity across the site are limited to commuting of small numbers of common pipistrelle bats. This activity is considered likely to be associated with the commuting of bats along the River Thames. The lack of vegetation on site will limit the use of the site for foraging.

D.1.26 The number of noctule bat passes was relatively high compared to surveys of other proposed Thames Tideway Tunnel development sites. However, none of the passes were recorded close to dusk or dawn, which indicates that bats use the site for commuting rather than roosting either on site or in close proximity to the Chambers Wharf site. The site is unlikely to be used as a foraging resource due to the likely absence of invertebrates on site (due to lack of semi-natural habitat).

Wintering birds

D.1.27 Out of the 12 waterbird species that were recorded within the survey area to date, eight are of nature conservation importance and are included in the Birds of Conservation Concern Red or Amber List and/or are UK BAP Priority Species: gadwall, mallard, tufted duck, black-headed gull, common gull, lesser black-backed gull, herring gull and great black-backed gull. The foreshore on and adjacent to the site is mainly used for foraging.

Black redstart

D.1.28 The five surveys were undertaken over a period of approximately seven weeks at a time of year when back redstarts are most likely to be recorded if present. The lack of black redstart observations indicates that the species does not currently utilise the proposed development site or immediate surrounds for foraging or breeding. While there are many opportunities for black redstart to nest and forage in London, not all these locations are occupied by this species. This is mainly due to the rarity of black redstart in the UK and in London (Holling and Rare Breeding Birds Panel, 2005)[3].

Invasive plants

D.1.29 Japanese knotweed, a Schedule 9 (Wildlife and Countryside Act 1981) listed invasive plant species, was recorded within the site boundary. Control of this plant species will need to be addressed to meet legislative requirements prior to works commencing (it is illegal to cause these plants to spread or grow in the wild).

References

[1] Royal Society for the Protection Birds. *Birds of Conservation Concern 3*. RSPB, Sandy (2009).

[2] Brown, A., Grice, P. *Birds in England*. T & A D Poyser Ltd (2005).

[3] Holling and Rare Breeding Birds Panel. *Rare breeding birds in the United Kingdom in 2008*. Mark Holling and the Rare Breeding Birds Panel (2008).

This page is intentionally blank

Thames Tideway Tunnel
Thames Water Utilities Limited

Application for Development Consent

Application Reference Number: WWO10001

Environmental Statement

Doc Ref: **6.2.20**

Volume 20: Chambers Wharf appendices

Appendix E: Historic environment

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

Hard copy available in

Box **34** Folder **B**
January 2013

Thames Tideway Tunnel

Creating a cleaner, healthier River Thames

This page is intentionally blank

Thames Tideway Tunnel

Environmental Statement

Volume 20 Chambers Wharf appendices

Appendix E: Historic environment

List of contents

Page number

List of plates

Page number

List of tables

Page number

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 20 Table E.1 below, with their location shown on the historic environment features map (Vol 20 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 and 2, egg, **HEA 1A–1Z**, **2A**. References to assets outside the site but within the assessment area begin with 3 and continue onwards, e.g., **HEA 3**, **4**, **5**.

Vol 20 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/ NGR ref
1A	Chambers Wharf, Chambers Street. Museum of London Archaeology Service (MOLAS); archaeological watching brief (2006); archaeological evaluation and standing structure survey (2008). An archaeological watching brief was conducted by MoLAS in 2006 to monitor and record ten geotechnical test pits, eight of which were located within the site, landward of the river wall. Of the ten pits, only two reached natural gravel (both were located within the site) at 5mbgl (metres below ground level). Three further pits, also excavated to 5m deep, revealed a sequence of waterlain clays, sand and silt with peaty lenses and in the case of the latter two (neither of which were within the site) a substantial in situ peat horizon at the base of the pits, which may be of Late Bronze date (1200–800 BC). The pits situated in the northern side of the site revealed late post-medieval structures and deposits, mainly of 19th century date, prior to cessation of further investigation, due to the presence of perched water. An archaeological evaluation was carried out on land to the south of Chambers Street in 2008. Seven trenches were excavated, all immediately to the south of, and outside of, the site, two of which revealed the truncation of archaeological deposits. Five trenches located archaeological features dating from the 17th to the 20th	CHJ06

HEA Ref no.	Description	Site code/ GLHER ref/ List Entry Number/ NGR ref
	centuries. A series of north-south drainage ditches or channels were excavated, probably used to drain the then open land, creating firmer, drier land on which construction could be carried out. The ditches were revetted with timber structures. Evidence of consolidation dumps to provide building foundations were also recorded. Later timber structures, built into the partially filled drainage channels, included a timber-framed building of probable 18th–19th century date, and a privy building. Standing structure recording was also carried out on the site in 2008. The oldest structural remains were to the east where the substantial remains of an 18th to19th-century warehouse were visible along Loftie Street. Further 19th century wall fragments were noted in other areas of the site, incorporated into the 20th century buildings. During the 1930s large cold storage warehouses were built, including a dock along the Thames riverbank. Later additions to Chambers Wharf were made in the 1950s. All buildings surveyed at the time have subsequently been demolished. Related sites: FSW01 (**HEA 1B**) and BCB01 (**HEA 6**)	
1B	Southwark Foreshore. University College London Institute of Archaeology (1993); Thames Archaeology Service (TAS) (1992); LARF; Museum of London Archaeology Service (MoLAS) foreshore survey (1995 and 2008); Thames Discovery Programme (TDP) ongoing survey since 2009. UCLIA/LARF Bermondsey foreshore survey (1993): A variety of prehistoric material was found at the 'dead low' water line on the foreshore in front of Chambers Wharf. This included a flint core of Mesolithic type, a macehead possibly Neolithic, pottery of likely Earlier Neolithic date, a sherd of Late Neolithic Peterborough Ware, a barbed and tanged arrowhead, which may also be of Neolithic date, and the bronze chape from a scabbard. Burnt flint, molluscs, and human bone were also found. It was thought that this material may have been derived from erosion of in situ bedded horizons. Traces of a timber revetment or structure, at 97.5m ATD to 96.9m ATD on the foreshore at the upstream end of Chambers Wharf, were previously thought to be of prehistoric date, but are now dated to the medieval or post-medieval periods.	BMF93 FSW01

HEA Ref no.	Description	Site code/ GLHER ref/ List Entry Number/ NGR ref
	TAS 1990s surveys: A photographic record of the foreshore and visible features was made, comprising views of the foreshore and nearby waterfront; detailed images of a number of features. These include a windlass re-used as part of a structure at the water's edge, numerous timbers, and a panel which may be part of a barge, a clinker-built floor frame, mooring blocks and posts beneath the existing jetty. MoLAS 1996: A foreshore survey of the area immediately upstream of Chambers Wharf was carried out. TDP ongoing foreshore survey (2009–present): Ongoing foreshore surveys have been carried out incorporating the stretch opposite Chambers Wharf, resulting in the identification of prehistoric features, post-medieval shipyard and re-used ship and boat timbers. The later foreshore survey observed features during the original survey of the site and the area of foreshore both in front of and underneath the jetty was mapped. A number of new features were also recorded. See also **HEA 1D–1M**; **1O–1Z**; **2A–2F**; **2H** and **2I**; which detail further finds discovered within the site (survey code FSW01) as part of this survey. Related sites: CHJ06 (**HEA 1A**)	
1C	To the north of Chambers street. Medieval fish trap, dam, embankment, land reclamation; post-medieval ship timber; Bronze Age peat and alluvium and lithic implement: Noted on the GLHER.	MLO75370
1D	Post-medieval nautical timbers. Re-used in A175. Recorded by the TAS in the 1990s and surveyed as part of a foreshore survey carried out in 2008.	FSW01 A176
1E	Post-medieval mooring block. Recorded by the TAS in the 1990s and surveyed as part of a foreshore survey carried out in 2008.	FSW01 A166
1F	Post-medieval artefact scatter. Nails associated with A148. Sawn timber, drilled timber, remains of a stone surface and make up layer. Recorded by the TAS in the 1990s and re-recorded as part of a foreshore survey carried out in 2008.	FSW01 A171
1G	Post-medieval nautical timber. Recorded by the TAS in the 1990s and re-recorded as part of a foreshore survey carried out in 2008.	FSW01 A163

HEA Ref no.	Description	Site code/ GLHER ref/ List Entry Number/ NGR ref
1H	Post-medieval structure. Probably stairs or a causeway. Timber revetment in form of 2 posts and plank. Nautical post-medieval clinker built floor-frame. Recorded by the TAS in the 1990s and re-recorded as part of a foreshore survey carried out in 2008.	FSW01 A162
1I	Post-medieval artefact scatter. Probably shipworking scatter/shipyard. Recorded by the TAS in the 1990s and surveyed as part of a foreshore survey carried out in 2008.	FSW01 A130
1J	Post-medieval structure. Rectangular box with central divide, possibly vessel engine box. Recorded by the TAS in the 1990s and re-recorded as part of a foreshore survey carried out in 2008.	FSW01 A133
1K	Thames foreshore A post-medieval iron wheel (possibly a cart or ship's wheel) identified on the foreshore as part of the site visit.	---
1L	Unclassified post-medieval timber structure. Recorded by the TAS in the 1990s, however, not visible during a foreshore survey carried out by the TDP in 2008.	FSW01 A136
1M	Unassigned post-medieval feature, possibly shipworking scatter/ shipyard. Recorded by the TAS in the 1990s and surveyed as a group of vertical timbers by the TDP in 2008.	FSW01 A137
1N	Thames channel The approximate location of a Roman brooch, two post-medieval toys (unspecified), and a post-medieval plaque, recorded by the Portable Antiquities Scheme (PAS).	LON-622234 LON-34AAB1; LON-348B90; LON-945312
1O	Post-medieval tree trunk with bark, possibly a ship-working scatter. Recorded by the TAS in the 1990s but not visible during a foreshore survey carried out by the TDP in 2008. Possibly washed away.	FSW01 A131
1P	Post-medieval timber, tree trunk cut, probably shipworking scatter. Recorded by the TAS in the 1990s but not visible during a foreshore survey carried out by the TDP in 2008. Possibly washed away.	FSW01 A132
1Q	Post-medieval group of timbers, probably shipworking scatter, shipyard. Recorded by the TAS in the 1990s and	FSW01 A128

HEA Ref no.	Description	Site code/ GLHER ref/ List Entry Number/ NGR ref
	surveyed as part of a foreshore survey carried out in 2008.	
1R	Gravel deposit. Raised bed of gravel and tufa with iron. Possibly a prehistoric land surface. Recorded by the TAS in the 1990s and surveyed (further upstream) as part of a foreshore survey carried out by the TDP in 2008.	FSW01 A127
1S	Undated timber structure and unclassified vertical timber stakes, possibly prehistoric and of multiple phases. Recorded by the TAS in the 1990s and surveyed as part of a foreshore survey carried out by the TDP in 2008.	FSW01 A123
1T	Unclassified timber feature comprising small verticals. Possibly prehistoric. Recorded by the TAS in the 1990s, however, not visible during a foreshore survey carried out by the TDP in 2008. Possibly removed by barge scour.	FSW01 A122
1U	Post-medieval mooring block. Timber anchor point or anchor. Recorded by the TAS in the 1990s but not visible during a foreshore survey carried out by the TDP in 2008. Possibly lying beneath a temporarily moored barge.	FSW01 A126
1V	Post-medieval structure comprising timber verticals at shore level. Recorded by the TAS in the 1990s but not visible during a foreshore survey carried out by the TDP in 2008. Possibly removed by barge scour.	FSW01 A121
1W	Post-medieval structure, probably mooring feature comprising square timber, and timber probably representing shipworking scatter, or potential prehistoric forest remains. Recorded by the TAS in the 1990s but not visible during a foreshore survey carried out by the TDP in 2008. Possibly lying beneath barge which was temporarily moored at the time of the survey.	FSW01 A124
1X	Unspecified and undated timber drain. Recorded by TAS in the 1990s.	FSW01 A304
1Y	Post-medieval consolidated ground. Recorded by the TAS in the 1990s but, not visible during a foreshore survey carried out by the TDP in 2008.	FSW01 A120
1Z	Undated unclassified timber structure. Recorded by the TAS in the 1990s but not visible during a foreshore survey carried out by the TDP in 2008. Exact location uncertain.	FSW01 A119
2A	Thames foreshore An early Iron Age dagger in a wooden sheath is described in London and Middlesex Archaeological Society (vol. 55) as	5343; 1797 (approx)

HEA Ref no.	Description	Site code/ GLHER ref/ List Entry Number/ NGR ref
	having been discovered by chance on the foreshore in front of Chambers Wharf in 2003. Both the dagger and sheath were in a reasonable state of preservation. A late Iron Age coin had previously been discovered here in 2002. Half of a post-medieval skeleton and an early post-medieval fish trap were discovered close by. This is also the approximate findspot of eleven sherds of Neolithic pottery recovered from the foreshore by individual collectors in 2001 and 2002. At least three vessels appeared to be represented by the sherds.	
2B	Void – Number not used	-
2C	Void – Number not used	-
2D	Post-medieval nautical timbers. Worked with bolts. Recorded by the TAS in the 1990s and surveyed as part of a foreshore survey carried out in 2008.	FSW01 A113
2E	Post-medieval nautical timber plank. Recorded by the TAS in the 1990s and surveyed as part of a foreshore survey carried out in 2008.	FSW01 A114
2F	Post-medieval consolidation timber structure comprising two vertical timbers. Recorded by the TAS in the 1990s and surveyed as part of a foreshore survey carried out by the TDP in 2008.	FSW01 A111
2G	Thames foreshore The approximate findspot of a discoidal Neolithic flint scraper. Discovered on the foreshore a few metres downstream of sherds of Neolithic pottery (see **HEA 2R** above) in the 1990s.	5343; 1797 (approx)
2H	Post-medieval structure, probably riverfront defence comprising timber and revetment fragment. Recorded by the TAS in the 1990s, however, not visible during a foreshore survey carried out by the TDP in 2008. Perhaps buried by sand deposits.	FSW01 A167
2I	Post-medieval mooring bollard, with graffiti. Recorded by the TAS in the 1990s and re-recorded as part of a foreshore survey carried out in 2008.	FSW01 A165
2J	Jamaica Road (a Wharf off this road). A Bronze Age dagger is recorded on the GLHER	MLO26884 114023
2K	Thames foreshore. Post-medieval structure noted on the GLHER.	MLO70452 092500

HEA Ref no.	Description	Site code/ GLHER ref/ List Entry Number/ NGR ref
2L	Thames foreshore Unclassified deposit noted on the GLHER.	MLO70454 092501
2M	Post-medieval nail and timber scatter. Recorded by TAS in the 1990s.	FSW01 A310
2N	Thames foreshore Animal bone, probably cattle, identified on the foreshore during the MOLA Thames Tideway Tunnel site visit.	---
2O	Mid-20th century jetty extending from the riverside wall northwards over the foreshore, comprising a concrete deck on concrete piled foundations.	5343; 1797
3	The (former) George Public House, George Row, Bermondsey 2003 Gifford and Partners (GAP)/Pre-Construct Archaeology (PCA) evaluation A sequence of naturally laid deposits above former bars and eyots, and in former natural channels, was recorded. One of these deposits was a band of peat dating to the Neolithic and Iron Age periods. The sequence was sealed by a ground consolidation dump, dating to the 19th century	GPB03
4	Riverside School. Grade II listed. Formerly known as: Farncombe Street School Board School. School Board school. Dated 1874, by MP Manning of Gale and Manning. Brick in English bond with stone dressings; roofs of slate.	1385525
5	Bermondsey Wall West, 53 George Row (corner of). 1996 PCA evaluation An apparently undisturbed sequence of alluvium and post-medieval dumped consolidation was recorded, the top of the alluvium at 102m ATD. The naturally-deposited alluvium included a peat deposit 0.45m thick occurring at 100.5m ATD. Alluvial deposits were truncated by a massive channel or pit, probably formed through erosion or other natural processes. In the early post-medieval period the channel was initially filled by alluvially-based deposits, and then purposely backfilled in the 17th or (more probably) 18th century, creating a ground surface at 102.7m ATD. A timber drain apparently running into the channel and a deep 19th century walled drain probably reflect the use of the channel for drainage. This feature is reflected by a 'dip' in Flockton Street immediately	BWT96

HEA Ref no.	Description	Site code/ GLHER ref/ List Entry Number/ NGR ref
	to the east of the site.	
6	Bermondsey Wall West (land at), Chambers Street. 2001 PCA evaluation; excavation; watching brief. Natural alluvial silts with probable Bronze Age peat bands were recorded in a channel. A small assemblage of burnt and struck flint is probably associated with low scale human activity in the area. Medieval activity in the form of postholes probably part of a fish trap or weir and a possible medieval barge bed was recorded. The channel was later dammed with timber beams, tiebacks and wattling, retaining an infill of redeposited clay and using this as part of a foundation for an embankment. The ground was later levelled and built over in the 17th and 18th centuries and associated with the development of wharfage in the area. The site was then levelled and truncated by 19th century and modern industrial and docking activity.	BCB01
7	St Michael's Catholic College, John Felton Road. 2008 MOLA evaluation Auguring indicated the existence of one or more palaeochannels, where natural sand and gravel were overlain by alluvial silts. Higher sandy ground suggests the presence of an eyot (gravel island) in the area. A pit containing Roman pottery was recorded. Alluvial silts were overlain by 17th–19th century deposits. A late 17th or early 18th century, timber-reinforced ditch, and a series of 18th century cuts may relate to a fish pond shown on an 18th century map. These features were truncated by 18th and 19th century brick foundations, superseded by brick and concrete foundations of 19th and 20th century industrial buildings.	JFNO8
8	Odessa Wharf, Bermondsey Wall West. 1995 MOLAS evaluation The earliest recorded layer was alluvium, above which was a thick modern reclamation dump behind the river wall. Into the alluvium were set two parallel timber revetments, possibly part of a water channel or of shoring for the construction of an adjacent 19th or 20th century brick wall, abutted by a similar, but north-south aligned wall, extending towards the river. These walls may have formed part of an earlier building foundation or were perhaps tie-backs associated with the river wall.	ODW95
9	Cherry Garden Project, Bermondsey Wall East.	CG87

HEA Ref no.	Description	Site code/ GLHER ref/ List Entry Number/ NGR ref
	1987 Department of Greater London Archaeology excavation Several pits and deposits on the surface of the natural containing Iron Age pottery and flint flakes. Concentrated in a small area of higher ground were a Roman ditch and other features as well as three cremation burials. A clay-filled channel was found to contain a large Saxon timber resting against a wattle structure, possibly the remains of a revetment. Post-medieval features included a number of pits of mostly 18th century date and containing large groups of domestic pottery	
10	Springall's Wharf, Bermondsey Wall West. 1991 DGLA evaluation Remains of a timber waterfront covered by c. 3.5m depth of post-medieval deposits. Evidence of an inlet from the River Thames was also found.	SPW91
11	St James's Estate, St James's Road. 1990 DGLA excavation Natural waterlain clays and peats in part destroyed by 19th century industrial intrusion, and in places sealed by a thick layer of brick rubble and sand which was probably related to the construction of the nearby Surrey Canal.	SJR90
12	Adlarde's Wharf 1996 PCA evaluation, excavation, watching brief The surface of natural alluvial deposits was at 100.2m ATD. A chalk dump, revetted with large secured timbers, was interpreted as part of the medieval embankment or associated defences which are thought to be represented by the line of Bermondsey Wall West. A sequence of waterfronts and associated land reclamation. Timber revetments probably represent the early post-medieval development of the site. Earliest phase of waterfront dating to the early 17th century. A total of 24 individual timber revetments and a brick-built wall were recorded, the timber being primarily re-used and derived from boats and ships. Cartographic evidence identified individual properties uncovered during the excavation dating back to at least the 17th century. For much of the early period development took place on a piecemeal property-by-property basis, so that at any one time the contemporary waterfront consisted of several different phases of revetment.	BWW96

HEA Ref no.	Description	Site code/ GLHER ref/ List Entry Number/ NGR ref
	Other notable features included a timber building, a c. 15th century clinker boat, a crane-base, a slipway, three timber drains, two timber platforms and a cobbled surface. The fills between the revetments included two dumps from different phases of pottery kiln waste, including kiln furniture and structural evidence.	
13	Post-medieval causeway, timber and stone, fountain stairs. Recorded by the TAS in the 1990s.	FSW01 A101
14	Gridiron (post-medieval timbers for large sea going vessels) consisting of re-used nautical timbers, including near complete rudders, rudder stock, keelson, deck beams etc. Recorded by the TAS in the 1990s.	FSW01 A103
15	Post-Medieval timbers. Large block, possibly mooring post or work bench. Recorded by the TAS in the 1990s.	FSW01 A104
16	Post-medieval gridiron. Apparently an earlier phase of A103. Consisting of re-used nautical timbers, including near complete rudders, keel. Recorded by the TAS in the 1990s.	FSW01 A105
17	Post-medieval structure. Several timbers possibly associated with, but not part of, gridiron A105. Recorded by the TAS in the 1990s.	FSW01 A106
18	Thames foreshore The location of two prehistoric tree stumps, recorded by TAS in 2001.	FSW01 A307/A308
19	Post-medieval gridiron. Apparently later than A103. Little exposed. Covered by gravel. Recorded by the TAS in the 1990s.	FSW01 A108
20	Drain. Modern concrete outfall of ancient channel. Recorded by the TAS in the 1990s.	FSW01 A109
21	Post-medieval timber. Partly worked tree trunk, vertical, with bark. Possibly shipworking scatter/ shipyard. Recorded by the TAS in the 1990s but not visible during a foreshore survey carried out by the TDP in 2008. Possibly washed away.	FSW01 A134
22	Post-medieval timber. Possible shipworking scatter/ shipyard. Recorded by the TAS in the 1990s but not visible during a foreshore survey carried out by the TDP in 2008.	FSW01 A138
23	Tree root with bark, possibly remnants of prehistoric forest. Recorded by the TAS in the 1990s and re-recorded as a	FSW01 A139

HEA Ref no.	Description	Site code/ GLHER ref/ List Entry Number/ NGR ref
	possible in situ peat deposit during a foreshore survey carried out by the TDP in 2008.	
(24)	The site of 38 and 40 Bermondsey Wall West. Former Grade II listed buildings, recently delisted and demolished (not shown on historic features map).	---
25	48 Farncombe Street. Grade II listed. Former office. Dated 1822. For the sewer pumping station (now demolished). Stock brick with stone dressings, shallow stone frieze, cornice and blocking course. Two-storey wedge-shaped corner building with 3-bay front. An early sewerage building, predating the present system, begun in 1858. Dates from first phase of dock expansion.	1385524
26	Chambers Wharf. Grade II listed. Warehouse, c.1865–70. Stock brick with hipped slate roof behind coped parapet. 5 storeys, 3 bays. Street elevation has central ground-floor wagon entrance with hatch rank above, flanked by gauged brick, segmental-arched windows on all but ground floors.	1376584
27	East Lane Stairs. Grade II listed River stairs appearing as such on Horwood's map of 1799 and the OS of 1872; possibly the same as "East Stairs" on Roque's map of 1746. Stone-flagged hardstanding, now broken up.	1376586
28	St. Saviour's House, 21 Bermondsey Wall West, 60 George Row 2000 PCA watching brief Natural strata were not observed during the monitoring of excavations for beam slots, drain runs and a foundation trench. Made ground, a brushwood surface of post-medieval to 18th century date, and the remains of foundations dating to the 19th and 20th centuries were recorded.	BYA00
29	Post-medieval barge bed. Concrete sandbag construction. Recorded by the TAS in the 1990s.	FSW01 A156
30	Post-medieval crane. Attached to waterfront building. Recorded by the TAS in the 1990s.	FSW01 A179
31	Post-medieval artefact scatter, industrial. Sugar refinery wares, pot. Recorded by the TAS in the 1990s and recorded as part of a foreshore survey carried out by the TDP in 2008.	FSW01 A158

HEA Ref no.	Description	Site code/ GLHER ref/ List Entry Number/ NGR ref
32	Post-medieval structure, possibly barge bed. Metal and timber revetment. Recorded by the TAS in the 1990s and recorded as part of a foreshore survey carried out by the TDP in 2008.	FSW01 A159
33	Post-medieval mooring block. Vertical round wood post with metal ring. Recorded by the TAS in the 1990s but not visible during a foreshore survey carried out by the TDP in 2008.	FSW01 A160
34	Post-medieval mooring block and timber dolphin. Recorded by the TAS in the 1990s and observed (not recorded) as part of a foreshore survey carried out by the TDP in 2008.	FSW01 A161
35	33, Bermondsey Wall West. Grade II listed. Granary, later London Grist Mills, 1866. Stock brick with hipped slate roof with skylights, partly surmounted by timber clerestory, possibly for housing a pneumatic grain intake, seen from river behind plain parapet with coping.	1376585
36	Odessa Wharf. Post-medieval wall and revetment.	MLO66684 092223
37	Bermondsey Wall West. Post-medieval wharf, waterfront and undated watercourse.	MLO58644
38	Chambers Street. Roman (Samian) pottery and coins dated to the reigns of the emperors Claudius (AD 41–54) and Vespasian (AD 69–79) were discovered by chance in 1845 during sewer construction. The description states that these were found in the vicinity of the former New Church Street, which ran a considerable distance to the south of Chambers Street. It is likely that the finds actually came from an area of higher gravel, further to the south.	MLO8405 090660
39	67, George Row. Grade II listed. A workshop now restored as offices dating to c.1830-40. Stock brick; recent slate mansard with dormers behind rebuilt brick parapet with spaced brick strings and stone coping. 2 storeys and attic, 6 bays with rounded corners.	1385546
40	Thames channel The approximate location of a post-medieval coin, recorded by the PAS.	LON-6B4A04
41	Thames channel The approximate location of a medieval candlestick, recorded by the PAS.	LON-623C24

HEA Ref no.	Description	Site code/ GLHER ref/ List Entry Number/ NGR ref
42	Thames channel The approximate location of a post-medieval token, a post-medieval toy, and a post-medieval button, recorded by the PAS.	LON-823905; LON-6E60D6; LON-6A8723
43	Thames channel The approximate location of a post-medieval token and a Roman coin recorded by the PAS.	LON-F789C0; LON-7F7DC7; LON-023EC4
44	Thames channel The approximate location of a post-medieval coin, two post-medieval tokens, and a medieval token, recorded by the PAS.	SUR-8C9A66; LON-F28823; LON-E05090; LON-231AF5
45	Thames channel The approximate location of a two post-medieval tokens and a post-medieval key, recorded by the PAS.	LON-C14850; LON-F0D841; LON-F0FEA4
46	Thames channel The approximate location of a post-medieval weight and token; and a medieval dice, recorded by the PAS.	LON-9F2D14; LON-8FA666; LON-47FE93
47	Thames channel The approximate location of a post-medieval pin, knife and coin, recorded by the PAS.	SUR-8C2B04; SUR-EE98C6; SUR-EB3CC4
48	Post-medieval mooring block. Stone with metal ring. Recorded by the TAS in the 1990s and recorded again as	FSW01 A164

HEA Ref no.	Description	Site code/ GLHER ref/ List Entry Number/ NGR ref
	part of a foreshore survey carried out by the TDP in 2008.	
49	Unclassified timber structure in aggradation. Recorded by the TDP post-2009.	FSW01 A305
50	Undated anchor chain. Recorded by the TDP post-2009.	FSW01 A303
51	An undated anchor chain. Recorded by the TDP post-2009.	FSW01 A302
52	Post-medieval Delftware kiln scatter. Recorded by the TAS in the 1990s.	FSW01 A143
53	An undated barge fragment. Recorded by the TAS in the 1990s.	FSW01 A142
54	Thames foreshore The location of an unclassified structure, comprising horizontal and vertical timbers. Recorded by the TDP post-2009.	FSW01 A309
55	An undated anchor point which include re-used timbers. Recorded by the TAS in the 1990s.	FSW01 A146
56	Thames foreshore The approximate findspot of a body sherd of later Neolithic Grooved Ware pottery, discovered on the foreshore in 2004. A small fragment of human cranium (skull) bone was also discovered in this approximate location in 2003. (The date of the skull bone is not known.)	534180; 179870

E.2 Site location, topography and geology

Site location

E.2.1 The site falls within the historic parish of Bermondsey and lay within the county of Surrey prior to being absorbed into the administration of London Borough of Southwark.

Topography

E.2.2 The land-based part of the site and the surrounding area is relatively flat. Ground levels on Chambers Wharf lie at c. 102.6m ATD in the southwestern corner of the site and at c. 103.4m at the southeastern corner, rising to c. 104.0m ATD across the northern end of the site. Within the site, projecting c. 18m from (to the north of) the line of the river wall, is a piled 20th century deck. The pile foundations of this structure are driven

into the foreshore within the site. The high edge of the foreshore in the northern part of the site drops down to 100.0m ATD. The foreshore at low tide lies at c. 97.7–97.8m ATD.

Geology

E.2.3 The site lies entirely on the alluvial floodplain of the Thames (British Geological Survey, *Drift Geology sheet 256*)[1], 150m to the west of the northern tip of a high area of sands known as the Bermondsey Eyot.

E.2.4 Extensive archaeological and geoarchaeological investigations in the assessment area have confirmed the underlying geology as comprising alluvial silts overlying a number of similar but smaller largely sand islands or 'eyots' separated by a complex network of channels (Sidell et al., 2010)[2]. These sandbanks or eyots would have been formed during the latter stages of the Pleistocene when the Thames was a high-energy braided river system, rather than a single channel. In this environment the irregular topography of high and low gravel areas were sculpted through rapid channel migration (see Vol 20 Plate E.1). As the climate changed at the end of the Pleistocene (up to 10,000 BP) the river energy decreased and sand instead of gravel was deposited within the channels and over the higher gravels. As the Holocene progressed (i.e. from 10,000 BP), the river channels stabilised, many were abandoned by the river, and some incised the underlying gravels. As a consequence, areas of high sand-covered gravels (eyots) were left elevated and exposed, forming a dry-land surface suitable for occupation. The lower ground, including that on which the site is located, to the northwest of the Bermondsey Eyot, would have formed a network of streams, pools and wetlands for much of the early to mid-Holocene. Within these lower-lying areas fluvially deposited sands and silts accumulated with peats and organic clays developing along the channel margins (Vol 20 Plate E.2).

E.2.5 Eyots were utilised from the Mesolithic onward (Ridgeway, 1999)[3]. Drier land appears to have existed across the site at least until the Neolithic period, and possibly later. By the Roman period, evidence from maximum mean tidal head measurements indicate that only land over 101.0m ATD would have lain above the tidal range (e.g. **HEA 9**, to the east of the site) and also possibly within the site (see E.2.7 below) (Sidell et al., 2010)[4]. It is thought that the consequent 'ponding back' of the Thames through the upstream migration of the tidal head was the cause of the increase in the wetland areas around the margins of the high ground. Lower river levels during the later Roman period caused some drying out of the wetlands and mudflats.

E.2.6 Palaeochannels, separating eyots of higher ground have been identified at several nearby sites. In 2006–2008, Museum of London Archaeology (MOLA) carried out investigations at St. Michael's Catholic College, immediately to the south of the site (**HEA 7**). Geoarchaeological auger holes and monitoring of test pits revealed a palaeochannel (ancient river or stream channel) containing alluvial silts and peats to the northwest and areas of higher ground, with the top of the underlying gravels shown at 96.5m ATD, overlain by sands in which soils had developed to the southeast (Vol 20 Plate E.2). Truncated alluvial silty clays survived as

high as 100.9m ATD, overlain by made ground to a maximum of 103.7m ATD.

E.2.7 A recent geotechnical borehole, monitored close to the southern boundary of the site suggests that the buried topography of the site rises northwards. Thus, the palaeochannel recorded at St. Michael's Catholic College (**HEA 7**) separates an eyot, on which the site is possibly located, from the main Bermondsey Eyot, c. 25m to the south of the site. The borehole recorded Pleistocene gravel at c. 99m ATD overlain by black gritty silt, which could represent a prehistoric soil formation, comprising fine-grained deposits, at c. 100m ATD. This potentially prehistoric land surface was sealed by 2.0m of soft alluvial clay within which a firm layer is likely to represent an episode of soil formation and drying out. This layer, recorded at c. 101.5m ATD, probably corresponds to the late Roman land surface recorded to the south of Chambers Street (this is shown as Deposit 7 in Vol 20 Plate E.2).

E.2.8 One vibro core (VC6573) was taken within the north-eastern part of the site and another (VC6579) approximately 15m beyond the northern boundary of the site. The vibro cores record the surface of the London Clay at approximately 93.0m ATD within the north-east of the site, sloping down to 92.0m ATD outside of the site. The London Clay is 0.3m to 0.4m of foreshore deposits with anthropogenic inclusions of brick, glass and ash.

E.3 Past archaeological investigations within the assessment area

E.3.1 The foreshore within and beyond the site was surveyed by Richard Hill, of University College London Institute of Archaeology (UCLIA), in 1993 (Hill, 1996)[5]. The aim of the survey was to ascertain archaeological potential through the mapping, recording and interpretation of archaeological features on the foreshore. The survey uncovered large numbers of prehistoric flint flakes and cores, exposed sections of a prehistoric peat horizon, containing plant (possibly forest) remains, and numerous post-medieval features and deposits associated with maritime activity. The survey identified the potential for in situ prehistoric activity, and possibly a settlement, on the foreshore.

E.3.2 The 'Alpha Survey', carried out by the Thames Archaeological Survey (TAS) in the 1990s, identified and recorded a considerable number of finds and features within the site (**HEA 1B–1Z** and **2A–2N**), several of which had previously been recorded by UCLIA. These comprised prehistoric features and remains associated with a post-medieval shipyard, re-used ship and boat timbers at Chambers Wharf, prehistoric silts and peat, and post-medieval riverfront flood defences. The Thames Discovery Programme (TDP) has subsequently undertaken, and is continuing to undertake, a survey of the foreshore within and beyond the site. Features recorded more recently (2011) include further prehistoric deposits, along with post-medieval nautical and industrial features and associated deposits.

E.3.3 In addition to the foreshore surveys, MOLA carried out an archaeological watching brief (**HEA 1A**) to monitor and record ten geotechnical test pits, eight of which were located within the site, landward of the river wall. Three pits revealed a sequence of waterlain clays, sand and silt with peaty lenses and two, (neither of which were within the site), revealed an in situ peat horizon which may be of Late Bronze date (1,200–800 BC). The pits situated in the northern side of the site revealed late post-medieval structures and deposits, mainly of 19th century date. An archaeological evaluation was also carried out in the wider area of the site, involving the excavation of seven trenches, which were located immediately to the south of (outside of) the site boundary. Five trenches recorded post-medieval drainage ditches and two timber structures, dating from the 17th to the 20th centuries.

E.3.4 Standing building recording was also carried out within the site in 2008 (**HEA 1A**).The oldest structural remains were in the east of the site, where the substantial remains of an 18th–19th century warehouse were visible along Loftie Street. Further 19th century wall fragments were noted in other areas of the site, incorporated into the 20th century buildings. During the 1930s large cold storage warehouses were built, including a dock along the Thames riverbank. Later additions to Chambers Wharf were made in the 1950s. All structures recorded within the site during the survey were subsequently demolished.

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 During the early prehistoric period, the Thames comprised braided river channels crossing a broad floodplain. Gravel eyots, such as the Bermondsey and Horselydown eyots close to the site, were located within these channels and were increasingly subject to flooding and alluvial sedimentation as sea levels rose. The mixed marshy and dry land of this part of the Thames valley would have been especially favoured for settlement as providing a predictable source of food from hunting and fishing and water, as well as a means of transport and communication. Archaeological evidence recovered from the site suggests eyots were utilised from the Mesolithic onward, with seasonal occupation giving way to agricultural activity over time (Ridgeway, 1999)[6]. It is possible that prehistoric flint scatters and mounds of burnt flint may be encountered adjacent to the palaeochannel that appears to have extended beyond the

southern part of the site. Drier land appears to have existed across the site until at least the Neolithic period. This corresponds with the significant evidence for Neolithic occupation recovered from the foreshore in the northern part of site. Prehistoric flintwork, dating from the Mesolithic to the Bronze Age, is frequently recovered from the stretch of foreshore in which the site lies (Cotton and Green, 2004)[7].

E.4.3 Early prehistoric finds from the site include a large number of Mesolithic and Neolithic artefacts recovered from the foreshore during the 1990s TAS survey (**HEA 1B**). These include Mesolithic worked flint; a macehead worked from a naturally perforated stone, which may be Neolithic in date; flint-tempered pottery probably of earlier Neolithic date; a sherd of Late Neolithic Peterborough Ware and a barbed and tanged arrowhead, which may also be of Neolithic date. Burnt flint, molluscs, and human bone were also found. Eleven sherds of Neolithic pottery were also recovered from the foreshore on the site in 2001–2002 (**HEA 2A**), and appear to be represent three separate vessels, two of which were decorated with finger-tip and nail impressions (Cotton and Green, 2004)[8]. A Neolithic flint scraper (**HEA 2G**) was also discovered a few metres downstream of the pottery sherds in 2001 (Cotton and Green, 2004)[9]. A further sherd from the body of a later Neolithic 'Grooved Ware' pot (**HEA 56**) was discovered on the foreshore c. 90m to the west of the site.

E.4.4 It is highly likely that this material will have been derived from ongoing foreshore erosion of archaeological deposits including a pit or pits cut into in situ prehistoric soil horizons, which may extend southwards into the well preserved foreshore sequence beneath the jetty in the northern part of the site. Such deposits may represent activity on an eyot that appears to have been inundated in the later prehistoric period. Prior to this the eyot would have comprised dry land. The surrounding marshland would have provided important natural resources and was probably exploited for a broad range of activities including grazing, fishing, fowling, salt making, exploitation of sources of craft materials (willows, reeds and rushes) and pottery manufacture (Rippon, 2000)[10].

E.4.5 Substantial peat horizons were recorded within two test pits excavated as part of an investigation at Chambers Wharf in 2008 (**HEA 1A**), immediately to the southwest (outside of) the site. The peat deposits were dated to the late Bronze Age (2,000–800 BC). Intact prehistoric horizons were recorded by the TAS comprising peat layers and tree roots (**HEA 23**), immediately adjacent to the northwestern boundary of the site. The peat horizons contained plant remains, including plant seeds, alder and hazel. Finds recovered from within the peat include numerous struck flint blades and cores, along with large quantities of burnt flint (Hill, 1996)[11]. A past investigation at George Row (**HEA 3**), c. 115m to the south of the site, also revealed a sequence of naturally laid deposits above former natural channels, one of which comprised a band of peat dating from the Neolithic to the Iron Age. The peat horizons are likely to extend beneath both the site and the southern part of the current foreshore, becoming increasingly eroded towards the modern channel.

E.4.6 During the Bronze Age, the site was likely to have become a wetland, or perhaps estuarine area, as a result of rising sea levels. Within the site, Bronze Age activity is limited to individual finds recorded on the foreshore: a Bronze Age dagger (**HEA 2J**) and part of a scabbard (**HEA 1B**). Bronze Age peat layers containing lithic implements were also recorded within the site (**HEA 1C**) and c. 20m to the west (**HEA 6**). Investigations in Southwark, beyond the assessment area, have produced further evidence of activity on low-lying areas around the periphery of the eyots (Heard, 1996)[12]. These include a Bronze Age cooking pit and cultivation soil at Phoenix Wharf, 450m to the west of the site (Museum of London site code PHW88)[13] and characteristic cultivation marks made by a prehistoric plough (ard) at Wolseley Street, 270m west of the site (Museum of London site code WOY94)[14].

E.4.7 Later prehistoric remains discovered from the Thames estuary in the vicinity of, but outside, the site, include remains of wooden boats, fish traps, wharves and trackways, dating from the Bronze Age onwards. In areas of Southwark where eyots rose above marshy terrain, wooden trackways and platforms were built to cross wet areas. Evidence of trackways, leading across the marshes, has been found at Bramcote Grove, c. 1.5km to the south-west. Wetland and the river channels are thought to have been a focus of ritual activity, and the probable origin of many of the prehistoric metal objects found along the Thames.

E.4.8 Rising water levels continued into the Iron Age, for which remains are scarce on sites within similar topographic locations. A chance find of an early Iron Age dagger in a wooden sheath was made on the foreshore in front of Chambers Wharf (**HEA 2A**) within the site. A late Iron Age coin had previously been discovered within the same approximate location in 2002. It is likely that these finds were redeposited on the foreshore having been eroded from their original context by river action. Iron Age pottery and flint flakes from pits and deposits at Cherry Gardens Pier, 100m east of the site, indicate in situ occupation on an area of higher gravels on the edge of the Bermondsey Eyot (**HEA 9**). Evidence for Iron Age occupation was also recorded on the Horselydown Eyot, c. 500m to the west of the site at 283 and 271–281 Tooley Street, and on the northern edge of Bermondsey Eyot, 500m southwest of the site at Abbey Street/Neckinger. Given this local settlement activity, it is possible that associated evidence for Iron Age exploitation of the intertidal area, such as timber platforms at the water's edge, similar to those known from the Bankside Channel (pers comm.)[15] might be found within clayey deposits on the site.

E.4.9 Two timber structures (**HEA 1S** and **1T**), were identified on the foreshore within the site as part of the 1990s TAS survey. Both are undated but potentially prehistoric, and comprise vertical timber stakes. The timbers of one structure (**HEA 1S**) indicate multiple construction phases. The presence of potential timber structures within the site indicates that it may have been the location of a prehistoric settlement (Eliott Wragg pers. comm.). Four prehistoric trees have recently been identified by the TDP on the foreshore within the assessment area (Vol 20 Plate E.3 and Vol 20 Plate E.4), along with peat horizons (Vol 20 Plate E.5 and Vol 20 Plate E.6). One pair of tree stumps have been identified c. 35m to the east of

the site (**HEA 18**); however, precise dates and locations for the remaining features are not currently available.

E.4.10 Intact prehistoric land surfaces have been, and are continuing to be, recorded eroding out from beneath the current foreshore surface. In addition to dry land occupation, later prehistoric use and exploitation of the wetlands near the river channels may have occurred and could be represented by the presence of trackways, platforms or other timber structures used to access and cross the wetlands. Such structures may be encountered within deeper alluvial deposits.

Roman period (AD 43–410)

E.4.11 Following the Roman invasion and conquest of AD 43, an important Roman town developed at London (Londinium), which later became the capital of the province. A bridge led across the Thames from Londinium to the largest of the gravel islands on the South Bank, to a settlement in the Borough area of modern Southwark. It was thought that the Roman settlement in Southwark was small small-scale, and focussed around the approach to London Bridge (present day Borough High Street) but excavations in recent years have revealed remains of a large settlement that was probably viewed as an extension of Roman London (Cowan et al. 2009)[16]. The site lay about 1.3km east of the Roman settlement in north Southwark. It also lay 1.2km to the northeast of Watling Street, a major Roman road that connected London and Canterbury (Margary, 1967)[17]. The projected line of Watling Street ran roughly parallel to and between Great Dover Street and Tabard Street and then along Old Kent Road (Mackinder, 2000)[18].

E.4.12 During the later Roman period river levels fell, causing drier land surfaces to encroach across the former intertidal mud. Such a Roman land surface was recorded immediately to the south of the site at St. Michael's Catholic College (**HEA 7**) (see Vol 20 Plate E.2) and evidence from a geotechnical borehole near the southern boundary of the site suggests similar evidence might exist within the site. Although only a limited number of finds dating to this period have come from the assessment area, they suggest dry ground existed beyond the nearby Bermondsey and Horsleydown eyots. The Portable Antiquities Scheme (PAS) database records a Roman brooch on the foreshore within the site (**HEA 1N**), and a coin discovered on the foreshore c. 50m to the east (**HEA 43**). Samian pottery (a type of glossy, red-brown pottery which was mass produced as tableware) and coins, dated to the reigns of the emperors Claudius (AD 41–54) and Vespasian (AD 69–79) (**HEA 38**) are recorded on the GLHER as having been discovered by chance in 1845 during sewer construction immediately to the south of the site. However, the description states that these were found in the vicinity of the former New Church Street, which ran a considerable distance to the south of the site. It is likely that the finds actually came from an area of higher gravel at a further distance to the south of the site.

E.4.13 In 1987, archaeological excavations at the Cherry Garden Project, c. 100m east of the site (**HEA 9**) located two Roman ditches and three cremation burials within a small area of higher ground. As Roman law

forbade burial within settlements, cemeteries were usually sited alongside roads, and Roman burials have been found alongside Watling Street 1.3km to the southwest of the site (Heard, 1999)[19]. An investigation at St Michael's Catholic College, immediately to the southwest of the site, revealed Roman pottery fragments and possibly a pit (**HEA 7**). Here too, the remains were located on slightly higher ground, possibly the northern edge of the main Bermondsey Eyot, or an adjacent subsidiary island or sandbank. There is thus Roman occupation and associated activity within the general vicinity of the site.

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

E.4.14 Following the withdrawal of the Roman army from England in the early 5th century AD, the Roman city was apparently abandoned, at least initially, and the main early to mid Saxon settlement of Lundenwic shifted westwards to what is now Covent Garden and the Strand, 2km northwest of the site. In AD 866, in response to threats from Viking invaders, King Alfred moved the town back within the walls of the Roman city, establishing Lundenburh as the medieval city of London.

E.4.15 The name Bermondsey is thought to be from the Saxon name Beormund, perhaps the Saxon lord of the area, and 'ea', or 'eye', an 'island'. Documentary evidence suggests that a Minster church stood in the area of Bermondsey Square, c. 1km southwest of the site, in the early 8th century. This may have been a precursor of the later Benedictine Bermondsey monastery (Blair, 1991)[20].

E.4.16 The main settlement in the area during this time would have been at Southwark, 1.5km to the northwest of the site, probably with a secondary nucleus on the Bermondsey Eyot. Southwark is first mentioned in AD 910–920, when it is included in the Burghal Hideage, a document listing all burhs (fortified settlements). Southwark, or 'Suthringa Geweorc', means 'fortification of the men of the southern province'. It was probably constructed to defend the southern bridgehead following the resettlement of the Roman city and the re-establishment of the bridge crossing, and may have been built on the orders of King Alfred (Malden, 1912)[21].The exact extent of the burh is uncertain. It probably occupied much of the northern end of the main eyot beside the bridgehead.

E.4.17 The site would have been intertidal marshland prone to regular flooding. It may have been used for rough grazing, and it is possible that fishtraps were constructed here, as have been recorded at similar locations along the River Thames. Evidence dating to this period within the assessment area comprises a clay-filled channel with a large Saxon timber resting against a wattle structure, possibly the remains of a revetment, recorded 100m to the east of the site at Cherry Garden Pier (**HEA 9**). This suggests Saxon activity via river management and land reclamation in the site vicinity.

Later medieval period (AD 1066–1485)

E.4.18 The manor (estate) of Bermondsey, within which the site lies, was held before the Conquest (AD 1066) by Earl Harold, and by in AD 1086 by William the Conqueror. In AD 1089, the Monastery at Bermondsey was

founded c. 1km to the southwest of the site, and became one of the main centres of Cluniac influence in the country (Steele and Sloane 1997)[22].

E.4.19 The main Southwark settlement is described in Domesday Book (1086) as having at least a dozen houses, a dock, trading shore, fishery and a Minster (Knight, 2000)[23]. Although settlement developed eastward along the bank of the Thames it is unlikely to have extended as far as the site.

E.4.20 It is likely that widespread marshland drainage and reclamation took place in the later medieval period. This took the form of drainage channels and embankments that served as sea walls around parcels of land. The purpose would have been primarily economic, to provide good-quality grazing for livestock and fertile land for crops. Although it is unlikely to have been a systematic river wall, this reclamation could well have occurred within the site. These river defences had mixed success, and breaches appear to have occurred occasionally. In 1230, the Annals of Bermondsey mention the repairs of the Breach of Rotherhithe, and in 1294 and 1304 there is reference to flooding around Bermondsey (Malden, 1912)[24].

E.4.21 It appears that during this period Bermondsey and Rotherhithe (until recently, Rotherhithe or 'Redriff' was often used as the name for the riverfront as far upstream as St Saviour's Dock) had already begun to function as a centre for shipbuilding and maritime industry; in 1355 Edward III set sail from Rotherhithe for France with 40 ships, and several of the vessels were fitted out there (Rankin, 1998)[25].

E.4.22 In the TAS survey of the 1990s, a later medieval or post-medieval timber revetment or structure was recorded at 96.9–97.5m ATD on the foreshore within the site (**HEA 1B**), along with a fishtrap, dam and embankment (**HEA 1C**). At Adlarde's Wharf, c. 70m west of the site, a medieval embankment and associated defences were recorded (**HEA 12**). Postholes, perhaps part of a fishtrap, and a possible barge bed were recorded at Bermondsey Wall (**HEA 6**), c.10m west of the site. The PAS database records finds from the foreshore dating to this period, including a candlestick, c. 200m east of the site (**HEA 41**), a token, c. 300m north of the site (**HEA 44**), and a dice (**HEA 46**), c. 450m to the northeast.

E.4.23 Throughout the later medieval period, the site was located away from the settled area on reclaimed land. This had probably been done to create an area in which to carry out maritime industry, leading eventually to the construction of a more unified, if piecemeal, river wall. By the medieval and post-medieval periods, prehistoric channels had developed into tidal creeks, where estuarine silts and clays were deposited in a salt marsh or mudflat environment, with overbank flooding sealing much of the higher ground with alluvial deposits. Riverside or channel edge structures such as drains, revetments, bridges, jetties, wharfs, boats or fishtraps relating to the historic period may occur within the alluvial clays and channel fills.

Post-medieval period (AD 1485–present)

E.4.24 The post-medieval growth of Bermondsey was primarily due to the great expansion in maritime activity from the late 16th century onwards. In 1592 the shipbuilders of 'Redriff' (Rotherhithe), having been excluded from

membership of the Free Shipwrights of the City, applied for a charter. This was eventually granted in 1612 under the title of *The Master, Wardens and commonalty of the Art or Mystery of Shipwrights of Redriff in the County of Surrey.* The charter described the vessels that could be built as 'Ships, Carvels, Hoys, Pinnaces, Ketches, Lighters, Boats, Barges and Wherries'. The first warship which has been identified as being built at 'Rederif' was the *Taunton* of 48 guns, built for the Commonwealth in 1654 in the area of what later became known as Fountain Dock, c. 55m to the east of the site. This yard was in operation from at least as early as 1647. The waterfront was occupied by small docks and yards for shipbuilders and breakers, and buildings for associated trades such as rope makers, mast makers, caulkers, coopers and anchor smiths (Cohen, 2008)[26]. The land to the south, beyond the riverfront, remained open fields and market gardens until the 19th century.

E.4.25 Foreshore surveys on the site by the TAS, MoLAS and, more recently, the TDP, attest to intensive maritime activity, in particular, shipbuilding and ship-breaking. At least three phases of gridiron (a structure on which ships/hulks were settled to keep hulls clear of water whilst salvage/repair work was carried out), comprising re-used vessel timbers, were recorded (**HEA 14, 16** and **19**), along with other vessel remains and assemblages comprising nail and timber scatters (**HEA 1B, 1C, 1D, 1F, 1G, 1M, 1O–1Q, 2D, 2E, 2M, 21** and **22**) (Vol 20 Plate E.7 and Vol 20 Plate E.8). Consolidated ground, mooring blocks and anchors associated with these activities have also been recorded. The construction and reconstruction of revetments continued throughout this period, and several post-medieval revetment structures (**HEA 1H, 1V, 1W, 2F, 17** and **49**) have also been identified. Further, similar post-medieval remains, the exact locations and extent of which have not yet been determined, have been identified on the foreshore within the site as part of recent TDP surveys.

E.4.26 Faithorne and Newcourt's map of 1658 (Vol 20 Plate E.9) is a pictorial map and not particularly accurate. This and subsequent 17th–19th century historic maps show the river wall along Bermondsey Wall West (formerly Rotherhithe Road), which crosses the site with riverside wharves and the industrial use of the foreshore to the north and again within the site. The area inland was largely open, used for rope yards for the shipbuilding industry (Vol 20 Plate E.10). During the 18th and 19th centuries development in the form of buildings increased (Vol 20 Plate E.12 and Vol 20 Plate E.13). A sequence of waterfronts and associated land reclamation, including a total of 24 individual timber revetments dating from the early 17th century were uncovered as part of an excavation at Adlarde's Wharf (**HEA 12**), c. 65m to the west of the site. The remains of a timber building and a 15th century 'clinker' boat (the hulls of which are constructed using overlapping planks of wood) was also discovered as part of the excavation. An early post-medieval fish trap and half of a human skeleton, dating to c. 1650–1800, were recorded on the foreshore by the TAS within the site, close to finds of an Iron Age dagger and coin (**HEA 2A**).

E.4.27 Morgan's map of 1682 (Vol 20 Plate E.10) is more detailed than Faithorne and Newcourt's. Where previously the river frontage within the site was

shown as densely built up, Morgan's map indicates that only about half of the river frontage was occupied by buildings and fewer buildings were located to the south of Rotherhithe Road. It is very likely that the gaps between buildings on the riverfront were used as timber storage areas for shipbuilding and breaking. Two rope walks are clearly shown on the map, indicating large-scale shipbuilding and/or chandlering activity. Morgan labels the 'stairs' down to the river on the west and east sides of (just outside) the site as 'East Stairs' ('East Lane Stairs' on later maps) and Three Mariners Stairs' respectively. The map shows a number of culverted open channels to the west of the site, leading to the Thames from the River Neckinger, and illustrates increased water management of the former marshland in this period.

E.4.28 Five out of seven archaeological evaluation trenches on land to the south of Chambers Street (**HEA 1A**; outside the site) revealed a series of north-south ditches or channels, dated to the 17th century. These were probably used to drain areas of open land to the south of the site, creating firmer, drier land on which building work could be carried out. The ditches were revetted with timber structures. Evidence of consolidation dumps to provide building foundations were also recorded. A previous investigation at Bermondsey Wall West (**HEA 5**), c. 65m to the west of the site, records a 'massive' channel or pit, probably formed by natural erosion which was backfilled in the 17th or 18th century, creating a ground surface. A timber drain (and subsequent 19th century drain) demonstrates the use of a natural feature for drainage in this period.

E.4.29 A Delftware kiln scatter (**HEA 52**) was recorded by the TAS on the foreshore c. 115m to the west of the site. (Delftware was a type of tin-glazed pottery which began to be produced in the Netherlands in the late 16th century and had become widely popular across Europe by the 17th and 18th centuries). Dumps comprising kiln waste, including kiln furniture, was also discovered between the remains of revetments at Adlarde's Wharf (**HEA 12**), c. 65m to the west of the site. The Delftware industry was extensive in Southwark (and along the south bank of the Thames) and is, for example, reflected in Pottery Street to the east of the site.

E.4.30 Rocque's map of 1746 (Vol 20 Plate E.11) shows increasing occupation within the assessment area, extending back from the river frontage. The road immediately behind the river frontage running east-west through the site is labelled as 'Rotherhithe or Redriff Wall'. A number of the buildings previously shown fronting the road on the northwestern side of the site appear to have been demolished and replaced by a timber yard, labelled 'Timber Wharf'. The majority of the area to the south of the site is shown comprising of market gardens and orchards, associated with buildings fronting on to the roads. A timber-–framed building and timber privy building, dated to the 18th–19th century were recorded immediately to the south of the site (**HEA 1A**), built into partially filled 17th century drainage ditches.

E.4.31 Horwood's map of 1799 (Vol 20 Plate E.12) shows increasing development. The river front within the site is now occupied by larger buildings, probably industrial warehouses. A number of new buildings are

shown within the southern part of the site, including 'Hucks Cooperage' (barrel making) in the southeast. The map shows a large rectilinear 'fishpond' intruding upon the site from the south. Although it is labelled as a fishpond, its shape and size suggest that it is almost certainly a mast pond for the local shipbuilding industry (used to season timbers by sinking them to the bottom of the pond and then drying them slowly to prevent splitting).

E.4.32 Wealthier residents had mainly left the area by the mid 19th century. The district along the waterside had an industrial character, heavily populated by workers, who typically slept four or five persons to one room (Malden, 1912)[27].

E.4.33 The Ordnance Survey (OS) 1st edition 25" scale map of 1862–95 (Vol 20 Plate E.13) shows the buildings on site in more detail. Some land reclamation had occurred along the waterfront since 1799, and most of the northern part of the site is now shown lying within the foreshore, whilst the southern part is shown located on the adjacent embankment. The former Rotherhithe Road is now labelled as Bermondsey Wall. The foreshore to the north of this is shown occupied by a number of buildings. In the west, part of the 'Fore & Aft Dry Dock' extends into the site. Extending eastwards along the waterfront within the site is East Lane Wharf, Glendenning's Wharf, three buildings labelled Granaries, Sunderland wharf, and a further Granary, as well as four unnamed buildings. The area to the south of Bermondsey Wall has been extensively redeveloped. A number of large buildings now occupy the centre south of the site, labelled as granaries. A large linear building labelled as the Patent Rope Manufactory is shown running through the assessment area, its northern end located in the southwestern corner of the site. A number of new roads provide access to the buildings. These are Mansell Row to the west, and an Alley (later Loftie Street) to the east. Cloyne Row runs along the southern boundary of the site. By this time the immediate vicinity of the site had been heavily built upon, with little open land remaining.

E.4.34 The OS 2nd edition 25" map of 1896–98 of (Vol 20 Plate E.14) and OS 3rd edition 25" map of 1909–20 (Vol 20 Plate E.15) show no significant changes within the site. The whole southern part of the site is built over, intersected by smaller access roads. The northern part of the site is located half on the foreshore, and half within the Thames.

E.4.35 The OS 1:2500 scale map of 1947–72 (Vol 20 Plate E.16) shows some changes within the site. The former granary buildings in the centre south of the site are now labelled Chambers Wharf. In the northern part of the site, on the foreshore, a jetty has been added to the north of the wharf buildings.

E.4.36 The OS 1:2500 scale map of 1952–72 (Vol 20 Plate E.17) shows that major changes had been made to the buildings and road layout in and around the site. A complex of new buildings forming Chamber's Wharf had been built, including the deck, which currently extends out from the river wall and stands on piles located on the foreshore. Further buildings had been constructed around open yards and alleys to the south of the site. A new road, Chambers Street, had been driven through earlier

terraced houses, which had been replaced by new buildings. This layout has mostly survived to the present day, although buildings at the western and eastern ends of the river frontage have since been demolished.

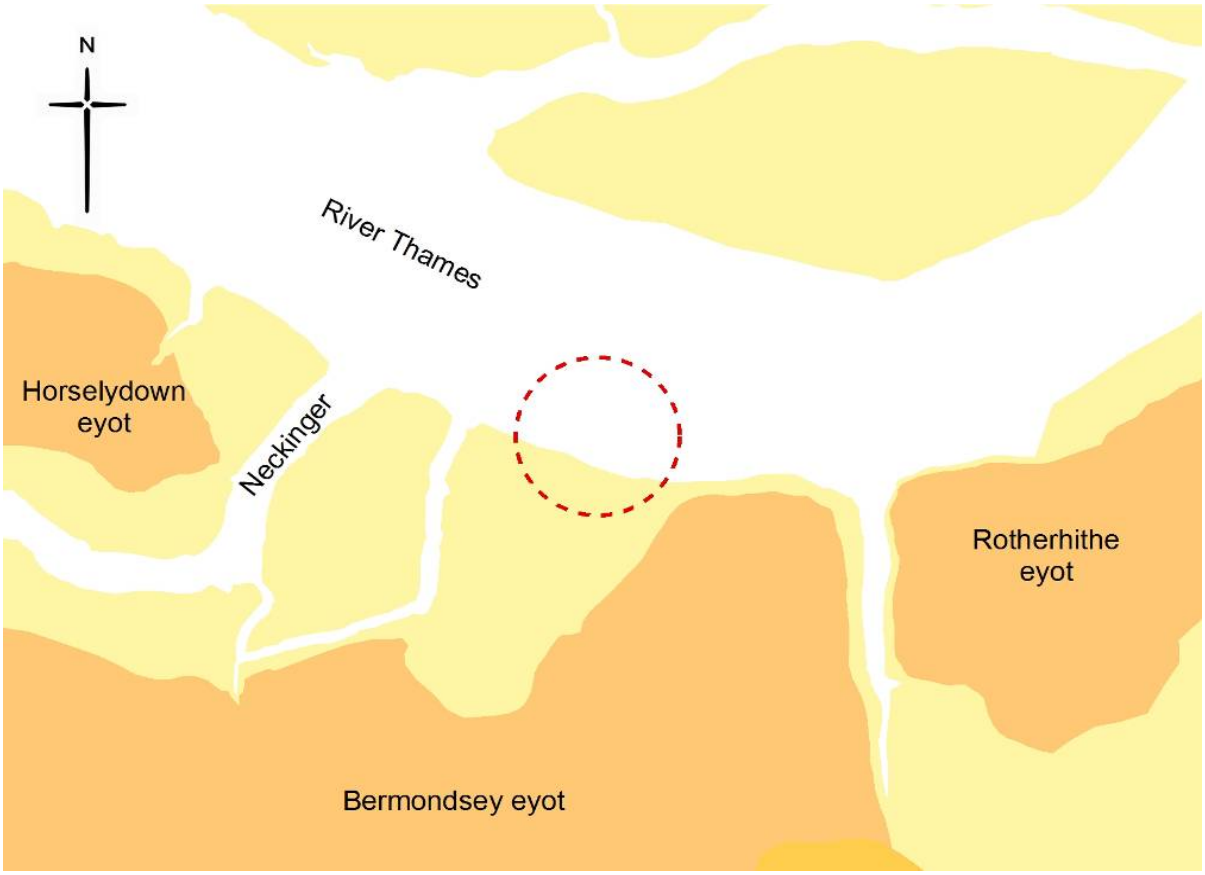
E.4.37 There are a large number of archaeological finds from the site and its immediate vicinity which relate to 17th–19th century wharves, stairs, bollards, barges, and other features. These mostly relate to shipbuilding and maritime industrial activity on the foreshore. Several of the post-medieval remains described in para. E.4.24 above were observed during the site visit, along with animal bone (**HEA 2N**) (Vol 20 Plate E.18) and the remains of a cart or ship's wheel (**HEA 1K**) (Vol 20 Plate E.19). The PAS database also records finds of a number of post-medieval coins and tokens (metal, coin-like objects used as exchange for goods), a pin a knife and a key (**HEA 40, 42, 43, 44, 45, 46** and **47**) from the foreshore and channel, within c. 50m of the site boundary.

The current site

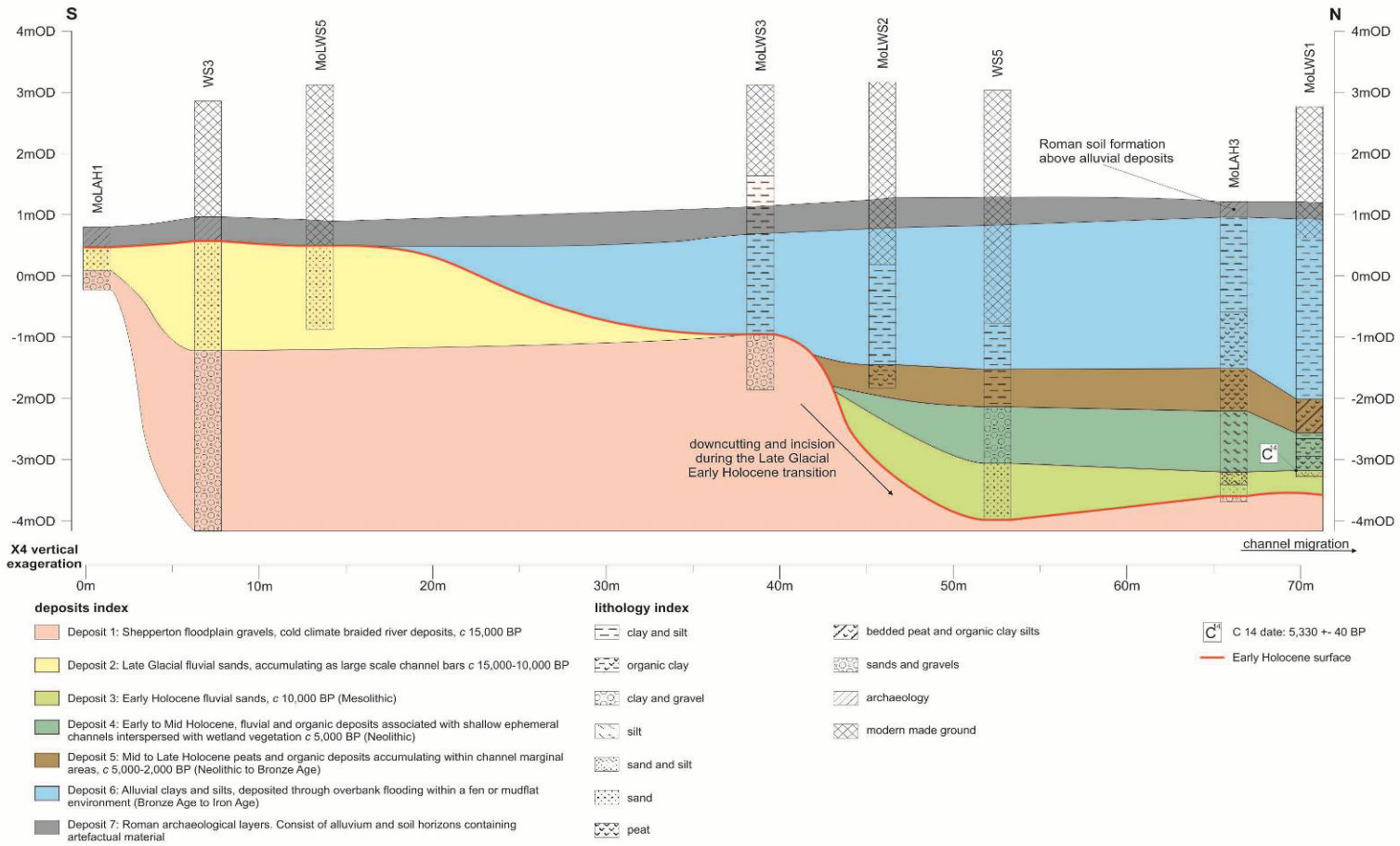
E.4.38 The landward part of the site comprises a fenced construction area with concrete surfacing, and contains work cabins, two large spoil mounds and a partly demolished 20th century warehouse building in the southeastern part of the site (Vol 20 Plate E.20). Approximately half of the site comprises undeveloped land which lies on the foreshore and within the Thames channel. The river wall within the site is a modern brick construction with a large piled mid-20th century deck (HEA2O) which projects over the foreshore, adjacent to it to the north (Vol 20 Plate E.21).

E.5 Plates

Vol 20 Plate E.1 Historic environment – map showing the prehistoric topography of Southwark and the eyots surrounding the site



Vol 20 Plate E.2 Historic environment – east-facing section immediately south of the site*



** A recent geotechnical borehole at the southern edge of the site suggests the site sequence is likely to resemble that shown in the three southern boreholes located on the edge of the Bermondsey Eyot (MOLAH1, W33, MOLW55). The palaeochannel to the north probably separates the Bermondsey Eyot from an island/eyot to the north, on which the site is situated (Halsey 2010).*

Vol 20 Plate E.3 Historic environment – (A321) Prehistoric tree roots (Thames Discovery Programme 2011)

Vol 20 Plate E.4 Historic environment – (A139) Prehistoric tree roots (Thames Discovery Programme 2011)

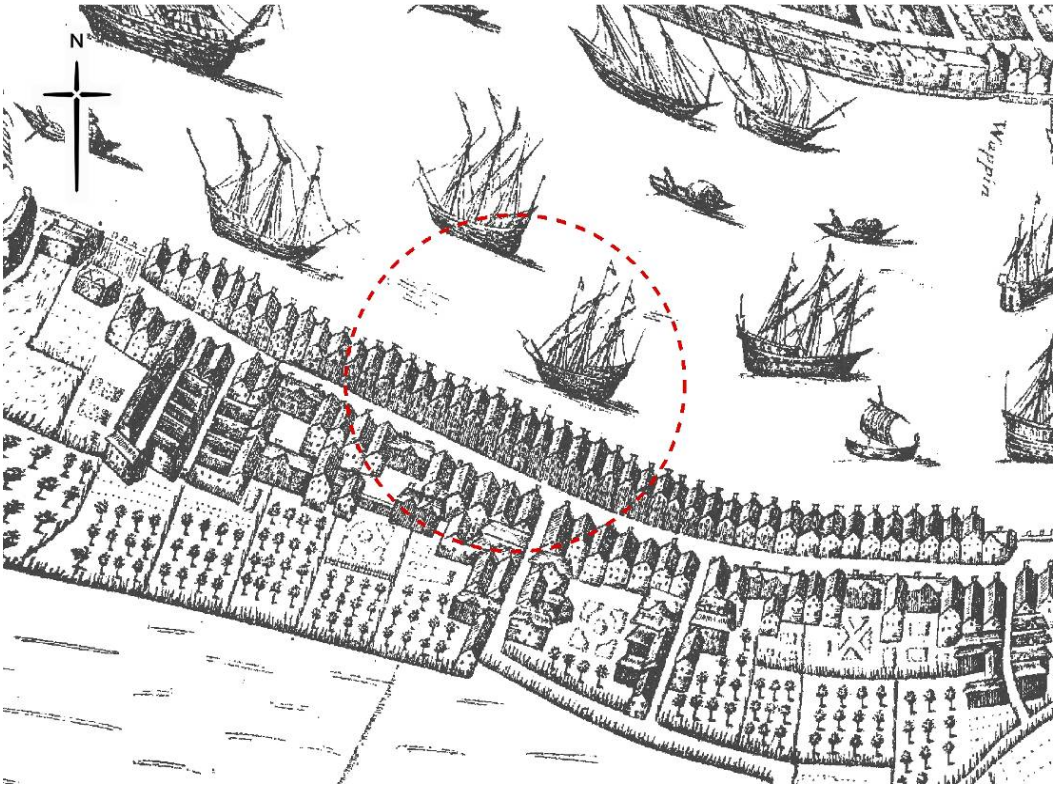
Vol 20 Plate E.5 Historic environment – (A135) Prehistoric laminated silts and peat horizons (Thames Discovery Programme 2011)

Vol 20 Plate E.6 Historic environment – (A325) Prehistoric Peat horizon (Thames Discovery Programme 2011)

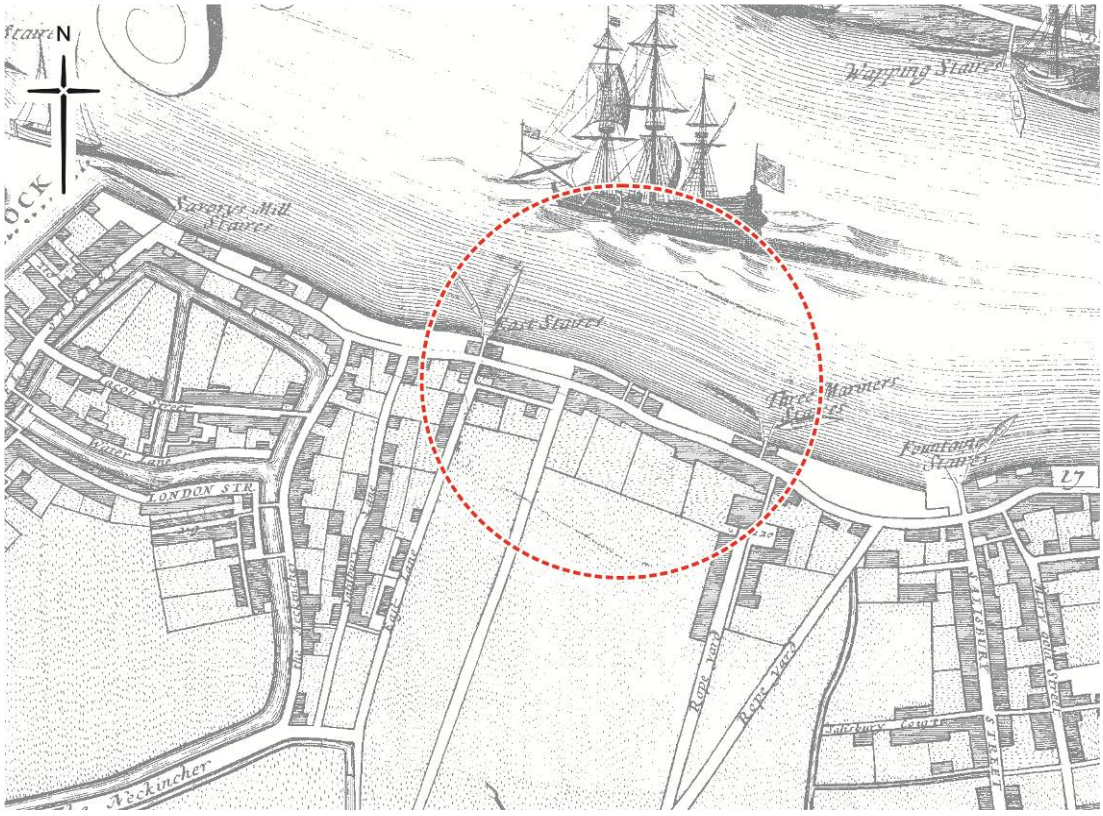
Vol 20 Plate E.7 Historic environment – (A176) Re-used nautical timber (windlass) (Thames Discovery Programme 2011)

Vol 20 Plate E.8 Historic environment – (A163) Re-used nautical timbers (rudder and probable rising deadwood) (Thames Discovery Programme 2011)

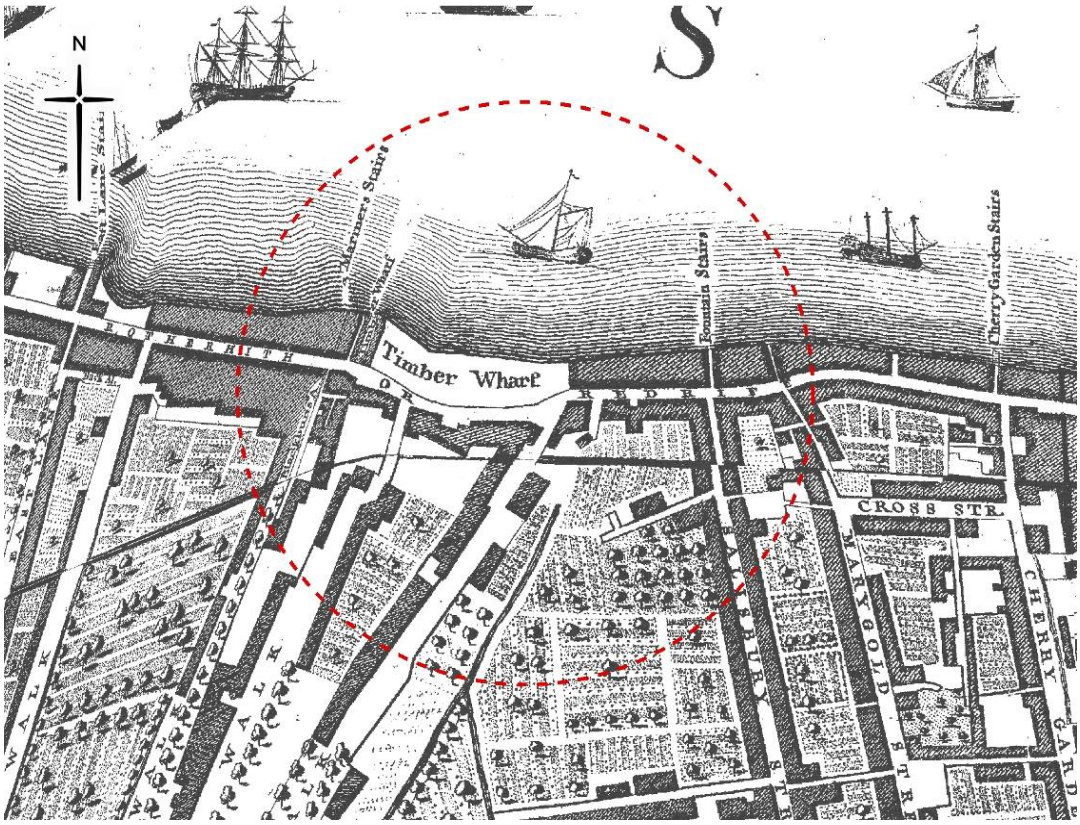
Vol 20 Plate E.9 Historic environment – Faithhorne and Newcourt's map of 1658



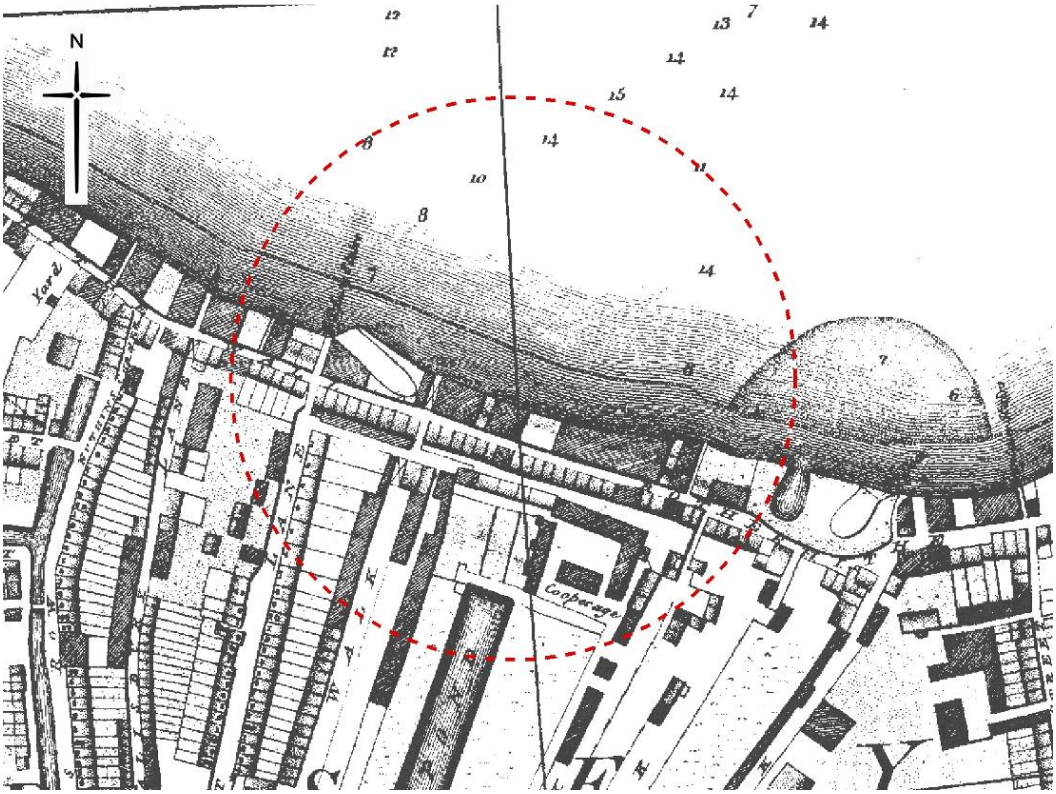
Vol 20 Plate E.10 Historic environment – Morgan's map of approximately 1682



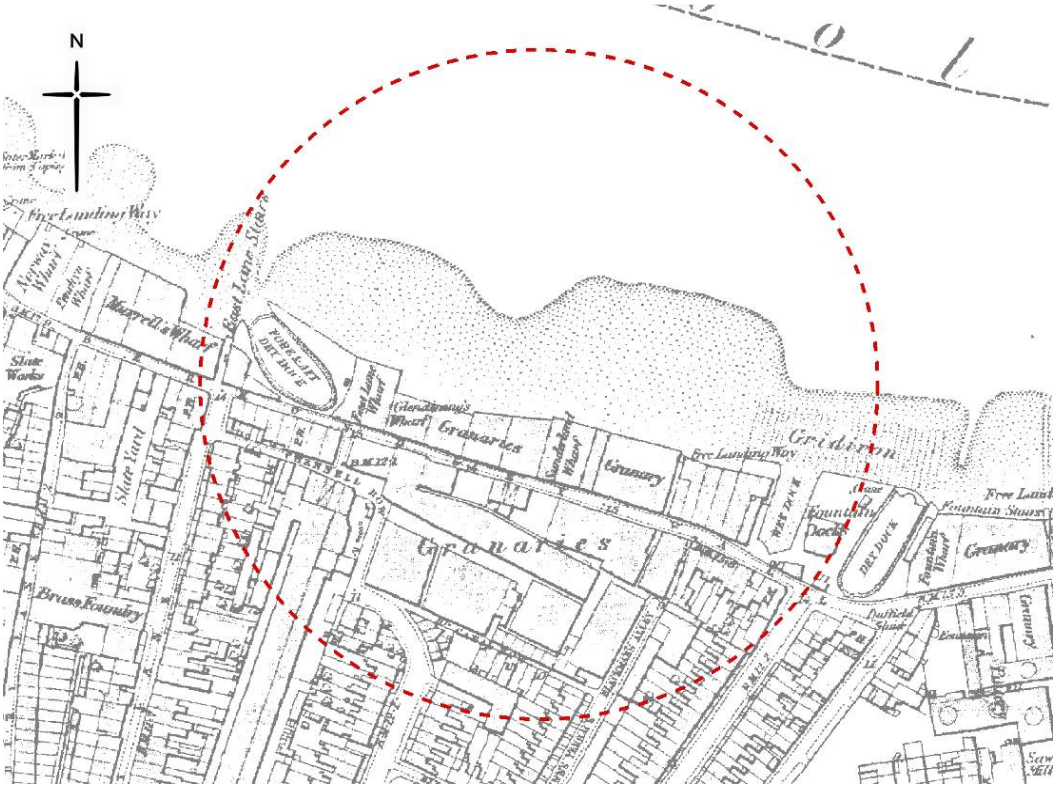
Vol 20 Plate E.11 Historic environment – Rocque's map of 1746



Vol 20 Plate E.12 Historic environment – Horwood's map of 1799

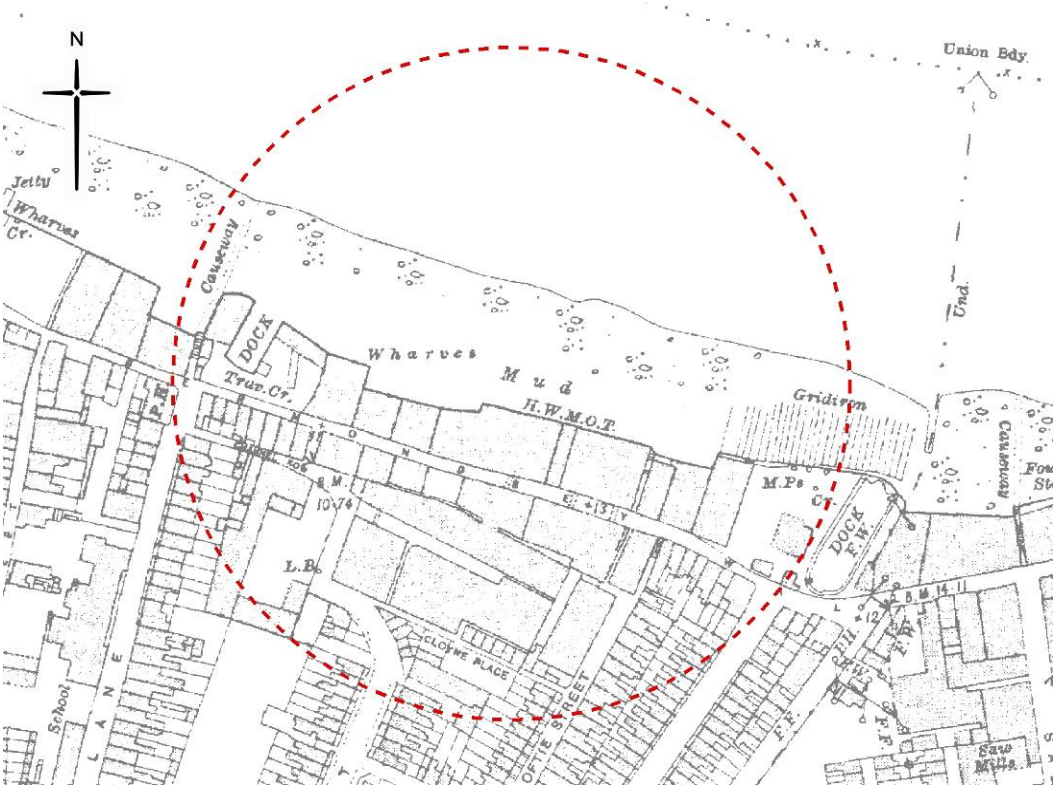


Vol 20 Plate E.13 Historic environment – Ordnance Survey 1st edition 25” scale map of 1862–95 (not to scale)

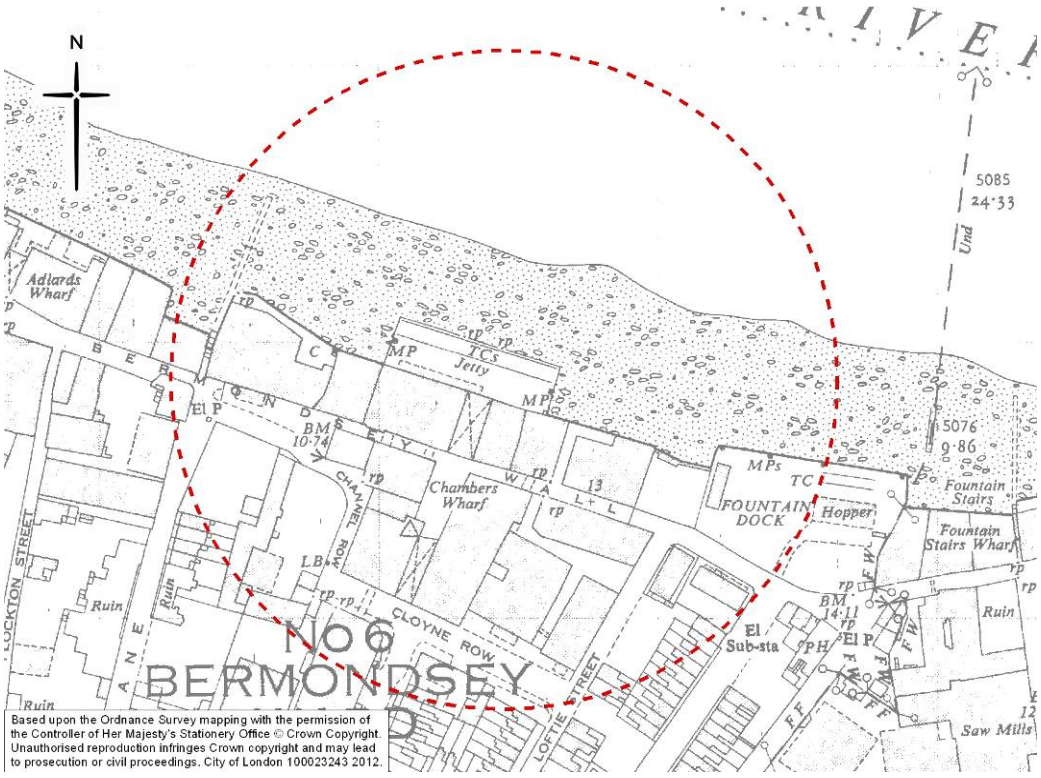


Vol 20 Plate E.14 Historic environment – Ordnance Survey 2nd edition 25” scale map of 1896–98 (not to scale)

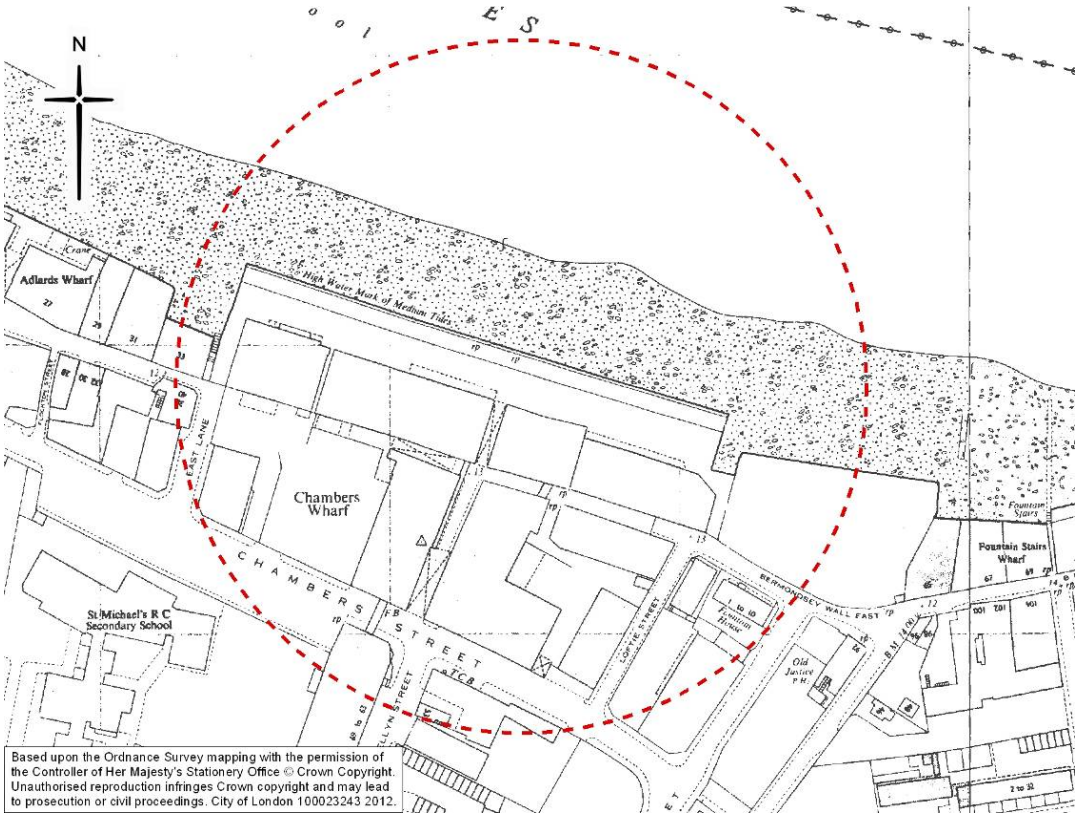
Vol 20 Plate E.15 Historic environment – Ordnance Survey 3rd edition 25" scale map of 1909–20 (not to scale)



Vol 20 Plate E.16 Historic environment – Ordnance Survey 1:2500 mile map of 1947–72 (not to scale)



Vol 20 Plate E.17 Historic environment – Ordnance Survey 1:2500 mile map of 1952-72 (not to scale)



Vol 20 Plate E.18 Historic environment – Animal bones, of unknown date, observed on the foreshore within the site during the site visit (MOLA 2011)

Vol 20 Plate E.19 Historic environment – A post-medieval ship's or cart wheel observed at the edge of the foreshore

Vol 20 Plate E.20 Historic environment – The site landward of the river wall, looking north-east; MOLA 2011

Vol 20 Plate E.21 Historic environment – Piled deck extending out from the river wall within the site and over the foreshore, looking north-west; MOLA 2011

Vol 20 Plate E.22 Historic environment – view south beneath piled jetty over the foreshore towards the existing 20th century river wall; MOLA 2011

References

[1] British Geological Survey. *Drift Geology sheet 256*.

[2] Sidell, EJ., Wilkinson, K., Scaife, R. and Cameron, N. *The Holocene Evolution of the London Thames*, MoLAS Monograph 5 (2000).

[3] Ridgeway, V. *Prehistoric finds at Hopton Street in Southwark.* In: London Archaeologist 9, no. 3. (1999), 72–76; Rogers, W. *Mesolithic and Neolithic flint tool-manufacturing areas buried beneath Roman Watling Street in Southwark*. In: London Archaeologist *6*, no. 9 (1990), 227–31.

[4] Sidell, EJ., Wilkinson, K., Scaife, R. and Cameron, N. See citation above.

[5] Hill, R. *Archaeological Potential of a Riverine Intertidal Zone: a case study from the Thames at Bermondsey and related observations*. University of London. Institute of Archaeology (1996) (unpublished dissertation).

[6] Ridgeway, V. See citation above.

[7] Cotton, J. and Green, A. *Further Prehistoric finds from Greater London*. London and Middlesex Archaeological Society, vol. no. 55 (2004), 134.

[8] Cotton, J. and Green, A. See citation above.

[9] Cotton, J. and Green, A. See citation above.

[10] Rippon S. *The Transformation of Coastal Wetlands: Exploitation and Management of Marshland Landscapes in North West Europe during the Roman and Medieval Periods.* London: British Academy (2000).

[11] Hill, R. See citation above.

[12] Heard, K. *The hinterland of Roman Southwark* in London Archaeologist 8, no. 3 (1996).

[13] Museum of London site code PHW88.

[14] Museum of London site code WOY94.

[15] SCH03; J Corcoran pers comm.

[16] Cowan, C., Seeley, F., Wardle, A., Westman, A., Wheeler, L. *Roman Southwark settlement and economy*. MOLA Monograph 42 (2009), 12–13.

[17] Margary, ID. *Roman Roads in Britain* (1967), 45.

[18] Mackinder, A. *A Romano-British cemetery on Watling Street: excavations at 156 Great Dover Street, Southwark.* London, MoLAS Archaeol Stud Ser 4 (2000), 5–7.

[19] Heard, K. The hinterland of Roman Southwark. In London Archaeologist 8 no. 3 (1996).

[20] Blair, J. *Early Medieval Surrey* (1991).

[21] Malden, HE (editor). *Victoria County History A History of the County of Surrey.* Volume 4: Southwark (1912), 125–135.

[22] Steele, A., Sloane, B. *The monastery of St Saviours Bermondsey*. English Heritage/MOLA (1997).

[23] Knight, H. *Aspects of medieval and later Southwark: Archaeological excavations (1991–8) for the London Underground Limited Jubilee Line Extension Project* MoLAS Monograph 13 (2002).

[24] Malden, HE (editor). See citation above, 14–24.

[25] Rankin, S. *Shipbuilding in Rotherhithe- an historical introduction.* Rotherhithe local history paper no. 1 (1998) 2.

[26] Cohen, N. *River Thames Foreshore, Chambers Wharf, London SE16. A report on the foreshore survey.* MOLAS unpublished report (2008) 11-12. Heard, K. with Goodburn, D. *Investigating the maritime history of Rotherhithe. Excavations at Pacific Wharf, 165 Rotherhithe Street, Southwark.*

MOLAS Archaeology Studies Series 11 (2003) 4. Rankin, S. *Shipbuilding in Rotherhithe- an historical introduction.* Rotherhithe local history paper no. 1 (1998) 2-3.

[27] Malden, HE (editor). See citation above, 14–24.

Thames Tideway Tunnel
Thames Water Utilities Limited

Application for Development Consent

Application Reference Number: WWO10001

Environmental Statement

Doc Ref: **6.2.20**

Volume 20: Chambers Wharf appendices

Appendix F: Land quality

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

Hard copy available in

Box **34** Folder **B**
January 2013

Thames Tideway Tunnel

Creating a cleaner, healthier River Thames

This page is intentionally blank

Thames Tideway Tunnel

Environmental Statement

Volume 20 appendices: Chambers Wharf site assessment

Appendix F: Land quality

List of contents

Page number

List of tables

Page number

This page is intentionally blank

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, including historic maps and environmental records

c. stakeholder consultation

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

F.1.2 The baseline report relates only to the main Chambers Wharf site. The Highway site is referred to explicitly where relevant.

Site walkover

F.1.3 A site walkover survey of Chambers Wharf was undertaken on 25th May 2011.

F.1.4 The aim of the walkover survey was to inspect the condition of the site and surrounding areas in order to identify evidence of historical or ongoing contamination sources, as well as any nearby sensitive receptors.

F.1.5 Chambers Wharf is currently a vacant area of recently cleared land, with the northern section of the site comprising of the River Thames Foreshore.

F.1.6 No access to Chambers Wharf was available during the walkover survey and all observations were made from publicly accessible areas along the sites eastern boundary (Thames Path) and also from Chambers Street to the south.

F.1.7 Detailed site walkover notes are provided in Vol 20 Table F.2 below.

Vol 20 Table F.2 Land quality – site walkover report

Item (Site Ref: PSK3X, Chambers Wharf)		Details
Date of walkover	25th May 2011	
Site location and access	The Chambers Wharf main construction site is located on Chambers Street. Access to the site is restricted as such the site was observed from the eastern boundary of the site (Thames Path) and also from Chambers Street to the south. In addition, the Chambers Wharf highway works site is located on Bevington Street, situated to the southeast of the main construction site was not included in this site walkover.	
Size and topography of site and surroundings	Record elevation in relation to surroundings, any hummocks, breaks of slope	Site is flat and level with surrounding land.

Item (Site Ref: PSK3X, Chambers Wharf)		Details
	etc.	
Neighbouring site use (in particular note any potentially contaminative activities or sensitive receptors)	North	The River Thames forms the northern boundary of the site.
	South	Vacant area of recently cleared land. Earmarked for redevelopment. A school (St Michael's Catholic School) located on Chambers Street, directly to the southwest. The site is located on Chambers Street and can be accessed via Bermondsey Wall East Road. This is accessible from the main road, A200 Jamaica Road, by Bevington Street, south of the site.
	East	Residential properties are situated on Loftie Street and Bermondsey Wall West.
	West	High rise residential/commercial properties such as Luna House and Axis House
Site buildings	Record extent, size, type and usage. Any boiler rooms, electrical switchgear?	Buildings onsite recently demolished. One partially demolished building remained at time observed, with electrical hazard warning signs being displayed.
Surfacing	Record type and condition	Much of the surface of the site consists of crushed concrete; the site extends over the River Thames onto a wooded decked area with a concrete surfacing.
Vegetation	Any evidence of distress, unusual growth or invasive species such as Japanese Knotweed?	None from distance 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

Item (Site Ref: PSK3X, Chambers Wharf)		Details
	Containment systems (eg, 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?	Demolition waste stored on-site at time of observation. Site fenced off so adequately secured.
Surface water	Record on-site or nearby standing water	The River Thames forms the northern boundary of the site.
Site drainage	Is the site drained, if so to where? Evidence of flooding?	None observed
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 from distance observed, however site partially covered with stockpiled materials Subsequent site investigations undertaken in 2011 revealed six small pieces of asbestos within these heaps. Overall the material has been classified as non hazardous and is intended to be removed before construction. The infill to the existing basements is likely to contain similar material.
Summary of potential contamination sources		Demolition wastes, mostly comprising crushed concrete and hard surfacing.

Item (Site Ref: PSK3X, Chambers Wharf)		Details
Any other comments	Eg access restrictions/ limitations	Site access restricted, site observation restricted due to hoarding, site observed from the Thames Path. Site vacant, evidence of recent demolition and stockpiled demolition waste. Other evidence of clearance at adjacent site to the south.

Review of historical contamination sources

F.1.8 Historical mapping (dated between 1878 and 1986) has been reviewed in order to identify potentially contaminating land-uses at the site and within the 250m assessment area.

F.1.9 Vol 20 Table F.2 tabulates the potentially contaminating land-uses, inferred dates of operation and typical contaminants associated with the land-uses in question. 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.1.10 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.1.11 Items listed in the table below are also shown on Vol 20 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 20 Appendix E.

Vol 20 Table F.3 Land quality – potentially contaminating land- uses

Ref	Item	Inferred date of operation	Potentially contaminative substances associated with item1,2
On-site			
1	(a) Granaries	c1878	Heavy metals, arsenic, asbestos, phenols, oil/fuels, hydrocarbons, polyaromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), sulphide, sulphate, chlorinated aromatic
	(b) Wharf (including electrical substation)	c1896-recent	

Ref	Item	Inferred date of operation	Potentially contaminative substances associated with item1,2
			hydrocarbons, chlorinated aliphatic hydrocarbons
Off-site*			
2	Timber yard (90m west)	c1878	Heavy metals, arsenic, boron, sulphate, phenol, acetone, aromatic hydrocarbons, PAHs, cresols
3	Brass foundry (40m southwest)	c1878	Heavy metals, PAHs
4	Dock (10m east)	c1950	Heavy metals, arsenic, asbestos, phenols, oil/fuels, hydrocarbons, PCBs, PAHs, sulphide, sulphate, chlorinated aromatic hydrocarbons, chlorinated aliphatic hydrocarbons
5	Medicinal manufactory (30m south)	c1950	Benzene, glycols, chlorinated hydrocarbons, ammonia, hydrogen chloride
6	Wharves (closest adjacent west)	c1978-recent	Heavy metals, arsenic, asbestos, phenols, oil/fuels, hydrocarbons, PAHs, PCBs, sulphide, sulphate, chlorinated aromatic hydrocarbons, chlorinated aliphatic hydrocarbons
7	Electrical substation (115m east)	c1971-c1986	Oils, PCBs
8	Depot (85m east)	c1986	Oil/fuel hydrocarbons,

Ref	Item	Inferred date of operation	Potentially contaminative substances associated with item1,2
			aromatic hydrocarbons, PAHs, chlorinated aliphatic hydrocarbons, organolead compounds, heavy metals and asbestos
9	Electrical substation (115m southeast)	c1971-c1986	Oils, PCBs
10	Saw mills (135m east)	c1950-c1969	Heavy metals, arsenic, boron, sulphate, phenol, acetone, aromatic hydrocarbons, PAHs, cresols
11	Warehouse (105m west)	c1971-c1986	Use unknown
12	Jam factory (105m west)	c1950	Heavy metals, nitrates, sulphates, sulphides, asbestos, hydrocarbons
13	Electrical substation (25m east)	c1950-c1969	Oils, PCBs
14	Flour mill (105m west)	c1971-c1986	Hydrocarbons (oils and greases) associated with machinery
15	Warehouse (230m east)	c1968	Use unknown
16	Factory (170m west)	c1950-c1969	Heavy metals, arsenic, nitrates, sulphates, sulphides, asbestos, solvents, petroleum hydrocarbons (TPH), PAH
17	Electrical substation (215m southwest)	c1971-c1986	Oils, PCBs
18	(a) Iron Foundry (220m southwest)	c1878	Heavy metals, PAHs
	(b) Engineering works	c1950-c1969	Heavy metals, sulphate, sulphur,

Ref	Item	Inferred date of operation	Potentially contaminative substances associated with item1,2
	(220m southwest)		asbestos, phenol, aromatic hydrocarbons, PAHs, chlorinated aliphatic hydrocarbons, petroleum hydrocarbons, solvents
19	Warehouse (200m east)	c1968	Use unknown
20	Works (145m southwest)	c1878	Heavy metals, arsenic, boron, free cyanide, nitrates, sulphates, sulphides, asbestos, aromatic hydrocarbons, PAHs, PCBs, chlorinated aliphatic hydrocarbons
21	Works (50m west)	c1878	
22	Timber yard (115m southeast)	c1878	Heavy metals, arsenic, boron, sulphate, phenol, acetone, aromatic hydrocarbons, PAHs, cresols
23	(a) Timber yard (230m southeast)	c1878	
	(b) Saw mills (230m southeast)	c1916	
24	(a) Paint works (200m southeast)	c1951	Heavy metals, boron, asbestos, nitrate, sulphate, phenol, acetone, oil/fuel hydrocarbon, aromatic hydrocarbons, chlorinated aliphatic hydrocarbons, dieldrin, PCBs
	(b) Works (200m southeast)	c1963-c1969	Heavy metals, arsenic, boron, free cyanide, nitrates, sulphates, sulphides, asbestos, aromatic hydrocarbons, PAHs, PCBs, chlorinated
25	Works (240m south)	c1963	

Ref	Item	Inferred date of operation	Potentially contaminative substances associated with item1,2
			aliphatic hydrocarbons
26	Various wharves (225m north)	c1878-c1975	Heavy metals, arsenic, asbestos, phenols, oil/fuels, hydrocarbons, PAHs, PCBs, sulphide, sulphate, chlorinated aromatic hydrocarbons, chlorinated aliphatic hydrocarbons
27	Wharf (225m north)	c1920-c1987	
28	Wapping Entrance (230m north)	c1878	Heavy metals, arsenic, asbestos, phenols, oil/fuels, hydrocarbons, PCBs, PAHs, sulphide, sulphate, chlorinated aromatic hydrocarbons, chlorinated aliphatic hydrocarbons

** refers to the main site.*

On-site

F.1.12 The historical mapping has identified one previous site use that could be regarded as potentially contaminating; this is identified as a channel with wharves, situated along the south bank of the River Thames. Chambers Wharf and the immediate wharves to the east consisted of granaries until 1978. Following use as a grain store, it is understood the site was used for cold storage and then as a data centre.

Off-site

F.1.13 Within the 250m assessment area, the historical mapping shows that there were areas of previous industrial land-use in close proximity to the site and other surrounding areas. This includes a dock immediately east of the site boundary, a medicine factory to the south and flour mill to the west. A former vehicle repair garage is also understood to have recently operated on the southern side of Chambers Street.

Geology

F.1.14 Data from the Thames Tideway Tunnel project ground investigation indicates the anticipated geological succession, as summarised in Vol 20 Table F.3 below.

Vol 20 Table F.4 Land quality – anticipated site geology

Geological unit/ strata	Description	Approximate depth below ground level (m)
Made Ground	Variable	0.0-2.00
Alluvium/peat	Very soft silt to silty clay	2.00-5.00
River Terrace Deposits	Generally very sandy gravel with sandy clay pockets, becoming more clayey with depth	5.00-9.50
London Clay Formation	Very firm to stiff silty clay	9.50-11.50
Harwich Formation	Slightly sandy clay	11.50-13.00
Lambeth Group (Upper Mottled Beds)	Very stiff fissured silty clay with bivalve shells and dense glauconitic sands with rounded black pebbles The Lower and Upper Mottled Beds comprise mottled or multicoloured, stiff or very stiff fissured clay, compact silt, and dense or very dense sand. The Upnor Formation is a fine grained glauconitic sand.	13.00-17.9
Lambeth Group (Laminated Bed Sand Channel)		17.9-18.5
Lambeth Group (Laminated Bed)		18.5-20.5
Lambeth Group (Lower Shelly Beds)		20.5-22.8
Lambeth Group (Lower Mottled Beds)		22.8-27.4
Lambeth Group (Upnor Formation)		27.4-29.0
Thanet Sand Formation	Generally dense glauconitic silty fine sand with occasional rounded flint gravel	29.0-42.9
Chalk Group	Weak fine grained limestone with nodular and tabular flint	42.9-unproven

Unexploded ordnance

F.1.15 During both World War I and II, the London area was subject to bombing and in some cases bombs failed to detonate on impact. During construction works unexploded ordnance (UXO) are sometimes encountered and require safe disposal.

F.1.16 A desk based assessment for UXO threat was undertaken by 6 Alpha Associates Ltd at the Chambers Wharf site(see Appendix F.2). The assessment covered three areas within the Chambers Wharf site (Area A – land aspect of the main work area, Area B - foreshore of main work area and Area C – secondary work area).

F.1.17 The report reviews information sources such as the Ministry of Defence (MoD), Public Records Office and the Port of London Authority (PLA).

F.1.18 Taking into account the findings of this study and the known extent of the proposed works at the Chambers Wharf site, it was considered that within Area A there is an overall medium/high threat from UXO, within Area B there is a high threat and within Area C there is a low/medium threat from UXO.

Thames Tideway Tunnel ground investigation data

F.1.19 This section summarises the ground investigation undertaken by the Thames Tideway Tunnel project.

F.1.20 Boreholes were drilled in the immediate vicinity of the Chambers Wharf site (borehole reference SR2034) as part of the project-wide ground investigation; Vol 20 Figure F.1.2 (see separate volume of figures) identifies the location of the boreholes in relation to the site.

F.1.21 Vol 20 Figure F.1.2 (see separate volume of figures) also identifies a number of other 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 shaft location or because certain boreholes were excavated purely for geotechnical purposes.

Soil contamination data

F.1.22 Borehole SR2034 was located in the River Thames; limited soil contamination data was collected.

F.1.23 No boreholes were located within the land side section of the Chambers Wharf site.

Soil gas testing

F.1.24 No soil gas testing was undertaken at Chambers Wharf site.

Sediment quality testing

F.1.25 An investigation into the sediment quality at the Chambers Wharf foreshore was undertaken by the Port of London Authority (PLA) hydrographic department in December 2011[3]. A report on the findings is presented in Mott MacDonald Limited *Thames tunnel foreshore sediment quality interpretative report*[4].

F.1.26 Three samples of sediment were taken from the foreshore of the River Thames at the site and sent for laboratory analysis. The testing showed relatively low levels of PAHs and metals within the foreshore sediments which are typical of the sediments along the tidal River Thames.

F.1.27 These contaminants reflect the former industrial nature of the river (and surrounding area) and are present as they tend to bind with soils.

F.1.28 The results are not elevated in terms of risk to human health but slightly elevated over PLA approved sediment quality guideline. Refer to Volume 2 Environmental assessment methodology for full guidance on the benchmarks used.

Third party ground investigation data

F.1.29 A phased investigation of the Chambers Wharf site was undertaken by Clarke Bond in December 2008[5]. The report presents the findings of an intrusive ground investigation covering the site and includes a desk study phase from which an initial site conceptual model has been generated.

Desk study

F.1.30 The desk study highlights that the site has been used for granaries and latterly warehousing and a vehicle repair centre. It is understood that a buried fuel tank was present on the south side of Chambers Street (off-site) where it may be associated with vehicle repair garage.

F.1.31 The initial site conceptual model assess the site to have 'substantial' risks from on-site historical activities including possible contamination by fuels, oils, volatile organic compounds (VOCs), PAHs, benzene, toluene, ethylbenzene and xylenes (BTEX), methyl tert-butyl ether (MTBE) as well as from heavy metals in the Made Ground. A lesser 'substantial' risk is attributed to off-site current and historical industrial activities.

Intrusive ground investigation

F.1.32 The intrusive phase of investigation comprised 13 cable percussion boreholes, 10 trial pits and nine window sampler boreholes.

F.1.33 The boreholes recorded Made Ground to extend locally to a maximum depth of 6.2mbgl and thick layer of alluvium/peat deposits to a maximum depth of 8.0mbgl

Soil contamination data

F.1.34 31 soil samples (mostly comprising Made Ground) were tested for a range of common metal and semi-metal contaminants. Some elevated levels of lead and to a lesser extent arsenic were found in comparison with the screening values that were used.

F.1.35 19 and 27 samples of soil were tested for TPH and PAHs respectively. No widespread TPH contamination was found. Moderate PAHs were recorded in the samples that were tested.

F.1.36 Three soil samples were tested for VOCs. No significantly elevated concentrations of these compounds were recorded.

F.1.37 On the basis of the reviewed report, the soils tested at the site may be regarded as fairly typical of those in older urban / industrial environments. No gross soil contamination was observed.

Groundwater contamination data

F.1.38 The report details that seven groundwater samples were analysed for a suite of determinants, although it is unclear which samples were tested.

F.1.39 Elevated TPH recorded up to 1.8mg/l was found by the analysis. Slightly elevated PAH concentrations were also recorded by the analysis.

F.1.40 No VOC or semi volatile organic compounds (SVOC) testing was undertaken.

F.1.41 It is assumed that the testing represents only one round of sampling and analysis. Groundwater testing shows levels of metals, TPH and PAHs.

Other environmental records

F.1.42 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 20 Table F.4 below. Pertinent records are discussed in further detail below.

F.1.43 The location of these records is shown on Vol 20 Figure F.1.3 (see separate volume of figures).

Vol 20 Table F.5 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	1
LA pollution prevention and control	0	1
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*	0	5
Registered waste transfer site	0	0
Registered waste treatment or disposal site	0	0

**Does not include regular combined sewer overflow (CSO) discharges*

F.1.44 Inspection of the data has identified one local authority pollution prevention and control area, located 250m southeast of the site. This location is considered to be too far from the site to be of concern.

F.1.45 In addition, there are areas of past potential contaminated industrial use recorded along the southern and northern banks of the river. It could be

inferred from the historical mapping that these areas relate to the previous wharf areas present along the river as shown on Vol 20 Figure F.1.1 (see separate volume of figures). Common contaminants associated with such land-uses are identified in Vol 20 Table F.2.

F.1.46 Within a 250m radius of the site, inspection of the data has identified five pollution incidents to controlled waters. Four of these are located within the river and the fifth is located adjacent to the eastern boundary of the site. One incident is associated with a major impact to the river from oils and fuels. It is unclear what the other entries relate to.

F.1.47 They are not considered to have significant impacts upon the terrestrial Chambers Wharf site; however, there may have been minor localised impacts to sediments located within the foreshore section of the proposed development.

Land quality data from local authority

F.1.48 The London Borough (LB) of Southwark was consulted with respect to land quality information for this area. No data for the site has been received.

Summary of contamination sources

F.1.49 Following the review of the baseline data, the following on-site sources of contamination which may impact on construction of the proposed development have been identified:

a. contamination of underlying soils and groundwater as a result of former industrial use (wharves, electrical substation etc) - contamination with heavy metals and PAHs has been recorded in soils and TPH identified in groundwater. In addition, asbestos has been recorded within demolition materials stockpiled at the site

b. historical minor contamination of foreshore sediments with PAHs and heavy metals/metalloids

c. potentially elevated ground gas within the Alluvium/shallow organic rich sediments

d. potential UXO.

F.1.50 Off-site sources of contamination include historical and existing industries including, wharves, timber yard, foundries and docks, the main potential contaminants of concern are likely to be, but not limited to: hydrocarbons, cresols, phenols, PAHs, hydrocarbons, PCBs and heavy metals.

F.2 Detailed Unexploded Ordnance (UXO) risk assessment

6 Alpha Associates Limited
Quatro House, Frimley Road
Camberley, Surrey
GU16 7ER

T: +44(0) 203 371 3904
F: +44(0) 1276 804 676
W: www.6alpha.com

Detailed Unexploded Ordnance (UXO) Risk Assessment

Study Site: Work Area PSK3X – Chambers Wharf
Document Number: 336-RG-TPI-PSK3X-000001
Client Name: Thames Water
6 Alpha Project Number: P2853_R2_V3.0
Date: 31st May 2012

Originator: Max Chainey (8th May 2012)
Quality Review: Lisa Askham (31st May)
Released by: Lee Gooderham (31st May)

Contents

Figures

EXECUTIVE SUMMARY

Study Site	The Client has specified the Study Site as Work Area PSK3X, located at National Grid Reference "534343, 179778". For the purposes of this report, the Site has been divided into **AREA A** (Land aspect of main Work Area), **AREA B** (Foreshore of main Work Area), and **AREA C** (Secondary Work Area).
Key Findings	In light of the research for this report, 6 Alpha has assessed the threat on this Site based on these pertinent facts: • **AREA A and AREA C** are situated on what was predominantly developed land during World War Two (WWII). The development within the Site consisted of *Chambers Wharf*, as well as reports of the military using the Site for the "Cold Stores". **AREA B** overlaps the foreshore of the *River Thames*. • The "docks and warehousing" 220m to the north of the Site were a primary bombing target. • *Bermondsey Metropolitan Borough*, where the Site is located, experienced a bombing density of 458 High Explosive (HE) bombs per 1,000 acres. This is a relatively high bombing density for *London*. • One V1 bomb strike and one HE bomb strike occurred within **AREA A**, as well as five strikes within the buffered Site boundary and twelve HE bomb strikes within 100m of the buffered Site boundary. Additionally, a land mine reportedly exploded adjacent to **AREA A** on *New Church Street*. • Within **AREA B,** historical records indicate that an unexploded bomb (UXB) landed on the foreshore. Whilst UXO information from the 33 Engineer Regiment (Explosive Ordnance Disposal) does not contain a record of the removal of an UXB within the Site boundary (where it is known that records are incomplete due to some being destroyed by enemy bombing during WWII), it is highly likely that the UXB was dealt with during WWII given that it has been recorded and does not appear in the Official Abandoned Bomb Register. In light of this, the recommended risk mitigation measures for **AREA B** will be sufficient to reduce the risk of UXO within this area to ALARP. • Bomb damage varied significantly at the Site location and within **AREA A**, ranging from "general blast damage; minor in nature" to "total destruction" of structures. • The Site has not been developed since WWII, however there have been some significant structural changes within **AREA A**. This predominantly involved the demolition of previous structures on the Site, and thus is unlikely to have removed buried UXO items. 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** **MEDIUM/HIGH** | **AREA B** **HIGH** | **AREA C** **LOW/MEDIUM**
Recommended Risk Mitigation	**The following actions are recommended before undertaking any activity on the Study Site:** **ALL 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. **AREA A** **3. On-Site Banksman;** all open excavation works should be accompanied by an UXO Specialist to monitor works down to the maximum bomb penetration depth. **AREA B** **4. Non-intrusive Magnetometer Survey**; Prior to any dredging or sheet piling of the foreshore, 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 PSK3X. The Site is located at National Grid Reference 534343, 179778. 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, B, and C** 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 to the southeast of the *City of London* within the *Bermondsey Metropolitan Borough*. Current aerial photography has identified the following within each area:

AREA A: "Waste ground" and unidentified structural developments.

AREA B: *River Thames* and foreshore.

AREA C: *Bevington Street*.

Proposed Engineering Works

Thames Water have specified a summary of the proposed engineering works, including working draft plans with drawing no. 100-DA-CNS-PSK3X-235105_AF; 100-DA-CNS-PSK3X-235106_AG; 100-DA-CNS-PSK3X-235107_AG; 100-DA-CNS-PSK3X-235108_AG; and 100-DA-CVL-PSK3X-335021_AH. These works have been divided between **AREAS A, B, and C**, however where not explicitly stated, 6 Alpha has made an assumption of which area the work will be carried out.

Areas A & C

- A 25m internal diameter shaft 60m deep. The shaft is anticipated to be constructed by diaphragm wall methods with an in-situ concrete secondary lining. Ground treatment or dewatering will be required.
- Construction of the main 7.2m internal diameter tunnel to the Abbey Mills Pumping Station site. This would be driven from the bottom of the shaft **(**within **AREA B** also).
- Reception of a 5.0m internal diameter tunnel from Greenwich. This would enter the shaft 2.2m above the bottom of the shaft **(**within **AREA B** also).
- A ventilation building, including a 15m chimney.
- Hardstanding with access from the road, to provide access for cranes and other maintenance vehicles.

Within the construction compound there will be offices/welfare facilities, a storage area for shaft and tunnel segments, a storage and handling area for excavated material, a workshop for Tunnel Boring Machine (TBM) maintenance and possibly slurry processing equipment for handling the excavated chalk.

Area B

The area extending into the River Thames is likely to be constructed as a cofferdam, with sheet piles around the perimeter and filled to the level of the existing land adjacent to the river. It is likely that the existing decking and piles within the foreshore will be removed. Barges will be used to transport imported fill for the cofferdam and export excavated material from the site. It is proposed that barges will be moored up against the edge of the cofferdam. Some dredging may be required.

Ground Conditions

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

Site Geology	Depth Below Ground Level (m)	Thickness (m)
Made Ground	0.00	1.50
Alluvium	1.50	5.50
River Terrace Deposits	7.00	3.40
London Clay	10.40	4.10
Lambeth Group	14.50	Proven 15.50

It is important to establish the ground conditions within this report to determine both the maximum *German* 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 predominantly developed land consisting of unidentified structures. **AREA B** contains a "jetty". **AREA C** is located on developed land consisting of an unlabelled road. **1949 OS mapping** – There are no significant or noticeable changes to the areas. A road labelled *Bermondsey Wall* transects **AREA A**.
1945 Aerial Photography ***(Figure 4)***	**AREAS A and C:** The 1945 aerial photography confirms structural development on Site, and despite the lack of clarity in the aerial photography, we can infer that much of the Site is intact, given the buildings present on the photograph are concomitant with mapping from 1938.
WWII Luftwaffe Bombing Targets ***(Figure 5)***	**ALL AREAS**: Primary targets have been identified as the "docks and warehouses" located approximately 220m to the north of the buffered Site boundary, and "gas works" located 1.75km to the southeast. "Opportunistic" targets include railway stations and railway infrastructure, "depots", "goods sheds", "docks" and "warehouses" all located within 2km of the Site.
WWII HE Bomb Strikes ***(Figure 6)***	Air Raid Precaution (ARP) reports indicate the following: **AREA A:** One HE bomb strike and one V1 strike within the east of the area. Research also indicates the presence of a landmine that exploded adjacent to **AREA A** on *New Church Street*. **AREA B:** An unexploded HE bomb was recorded within this area during WWII. **AREA C:** No bomb strikes. Five bomb strikes occurred within the buffered Site boundary, and twelve strikes within 100m of the buffered Site boundary.
WWII Bomb Damage ***(Figure 7)***	*London County Council* (LCC) bomb damage maps indicate the following: **AREA A**: "Damage beyond repair" to structures within the east of the area, as well as a range of damage amounting to "total destruction" and "damage beyond repair" to structures within the west of the area. **AREA B:** No bomb damage. **AREA C:** "General blast damage; minor in nature" to the housing to the east and west of the area. Within much of the buffered Site boundary, a range of bomb damage occurred to structures from "general blast damage; minor in nature" to "total destruction".
WWII HE Bomb Density ***(Figure 8)***	The Study Site is located within the *Bermondsey Metropolitan Borough,* which recorded 458 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 recorded one 1000kg HE bomb located 600m to the southwest and one 250kg HE bomb located 1.2km to the south east of the buffered Site boundary. There is no reference to an abandoned bomb still present within this Site boundary.

STAGE THREE – DATA ANALYSIS	
Was the ground undeveloped during WWII?	**AREA A:** No; the ground was predominantly developed. **AREA B:** Mostly; this area overlaps the *River Thames* and was undeveloped, except for a "jetty" that extended into the river. **AREA C:** No; the ground was developed as a public highway.
Is there a reason to suspect that the immediate area was a bombing target during WWII?	**ALL AREAS:** Yes; the "docks and warehouses" contained within an industrial compound on the opposite side of the *River Thames* were only 220m to the north of the Site, and as a primary target, suffered numerous bomb strikes during WWII.
Is there firm evidence that ordnance landed on Site?	**AREA A:** Yes; there was one bomb strike and one V1 strike within the area boundary. **AREA B:** Yes; an unexploded HE bomb was recorded in this area, however the plotted position may be inaccurate. **AREA C:** No.
Is there evidence of damage sustained on Site?	**AREA A:** Yes; bomb damage recorded to varying degrees including "damage beyond repair" and "total destruction". **AREA B:** No; but unlikely to have been recorded given the environment. **AREA C:** Yes; "General blast damage; minor in nature". Additionally, there was a large range of damage from "general blast damage" to "total destruction" of structures within the buffered Site boundary.
Is there any reason to suspect that military training may have occurred at this location?	**ALL AREAS:** No; whilst there are reports of the military using this Site briefly during WWII, the nature of their occupancy and purpose relates to the use of the Cold Store facilities for preserving food.
Would an UXB entry hole have been observed and reported during WWII?	**AREA A:** Yes; the land was mostly developed and a UXB entry hole would be witnessed. **AREA B:** Unlikely; although one UXB has been identified in the foreshore. Generally however, 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 the high tide. **AREA C:** Yes; the land was fully developed and a UXB entry hole would be witnessed.
What is the expected UXO contamination?	**ALL AREAS:** The most likely source of UXO contamination is from *German* aerial delivered ordnance, which ranges from small incendiary bombs 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; changes within the central aspect of this area consist mostly of demolition activity, and no significant new structural developments have occurred within this area. Demolition alone is unlikely to have removed the potential for UXO to be present. **AREA B:** No; no significant earthworks have occurred. **AREA C:** No; no significant earthworks have occurred.

STAGE FOUR – RISK ASSESSMENT		
Threat Items	The threat is predominately posed by WWII *German* HE bombs and Incendiary Bombs. Additionally, *British* Anti Aircraft Artillery (AAA) projectiles (the latter were used to defend against German bombing raids) 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 bgl.	
Maximum Penetration	Considering the general ground conditions (highlighted in Stage 1) including the potential depth of made ground and the hard surface geology within **AREA A and C**, the most likely Bomb Penetration Depth (BPD) for a 250kg bomb is assessed to be a maximum of 6m bgl, dependant on the depth of rock. As the boundary of **AREA B** overlaps 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. Whilst the *Luftwaffe* used larger bombs, their deployment was so few and only used against notable targets, 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	2x1=2	3x2=6	2x6=12
Tunnelling	1x2=2	1x2=2	2x2=4
Shaft Installation	2x2=4	1x2=2	4x2=8
Open Excavations	2x2=4	2x2=4	4x4=16

Activity	AREA B		
	Probability (SHxEM=P)	**Consequence** (DxPSR=C)	**Risk Rating** (PxC=RR)
Tunnelling	3x2=6	1x1=1	6x1=6
Cofferdam (Sheet Piles)	3x3=9	2x2=4	9x4=36
Dredging	3x3=9	3x2=6	9x6=54

Activity	AREA C		
	Probability (SHxEM=P)	**Consequence** (DxPSR=C)	**Risk Rating** (PxC=RR)
Enabling Works	1x1=1	3x2=6	1x6=6
Open Excavations	1x2=2	2x2=4	2x4=8

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 (1.5m for this Site) 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 may be more 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, however deep excavation of made ground is required prior to the use of this methodology. 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**
ALL 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.	ALARP
AREA A	**3. On-Site Banksman;** all open excavation works should be accompanied by an UXO Specialist to monitor works down to the maximum bomb penetration depth.	
AREA B	**4. Non-intrusive Magnetometer Survey**; Prior to any dredging or sheet piling 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.	
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

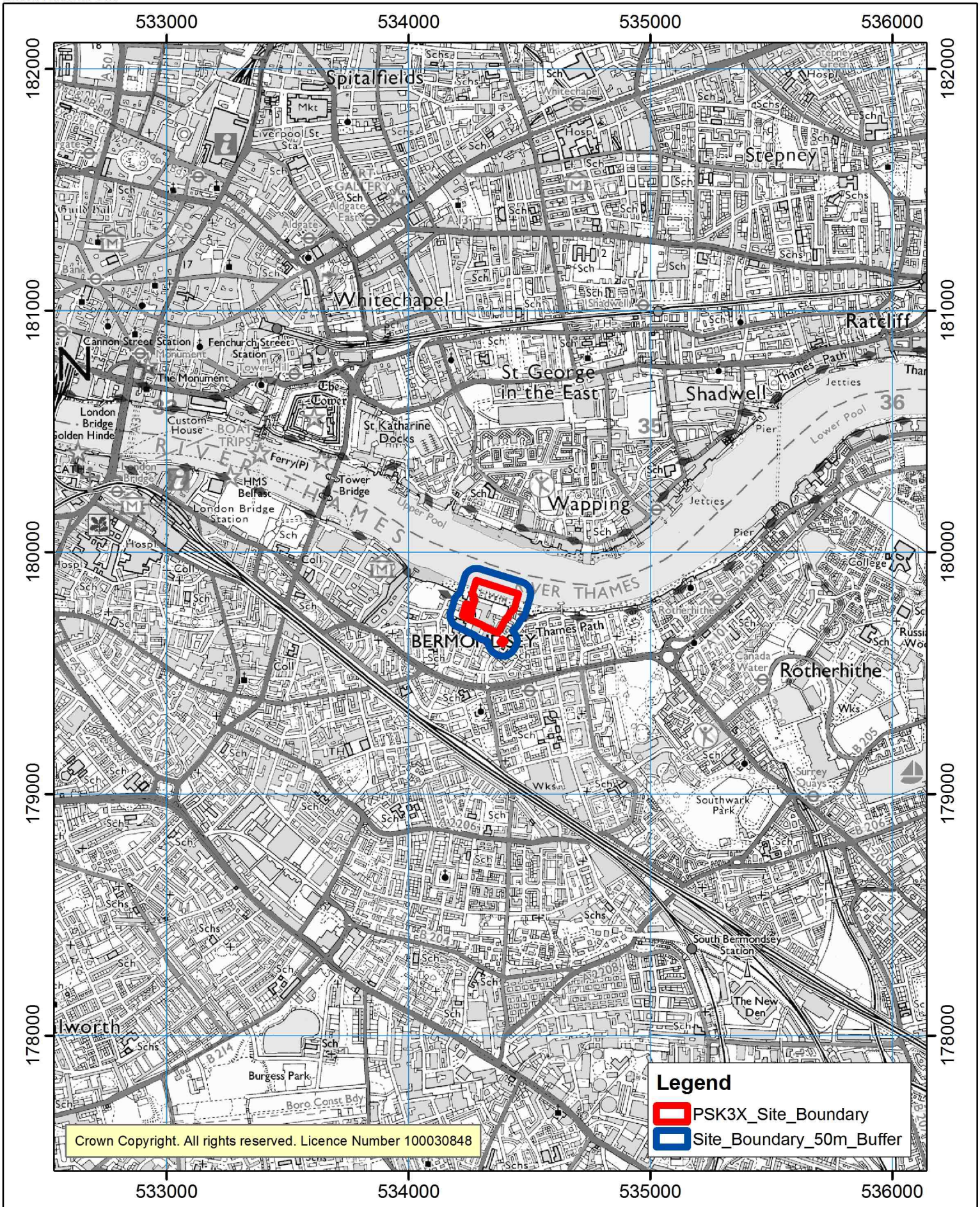
Figure One

Site Location

Thames Tideway Tunnel - Work Area PSK3X
Site Location

Figure 1

British National Grid



BOMB SEARCH

6 Alpha Associates Ltd.
Quatro House
Frimley Road
Camberley
Surrey GU16 7ER
United Kingdom
www.6alpha.com
0203 371 3900

0 100 200 400 600 800 1,000 Meters

N

Project Number: P2853_PSK3X

Drawn By: Dominique René

Checked by: Lee Gooderham

Date: 2nd May 2012

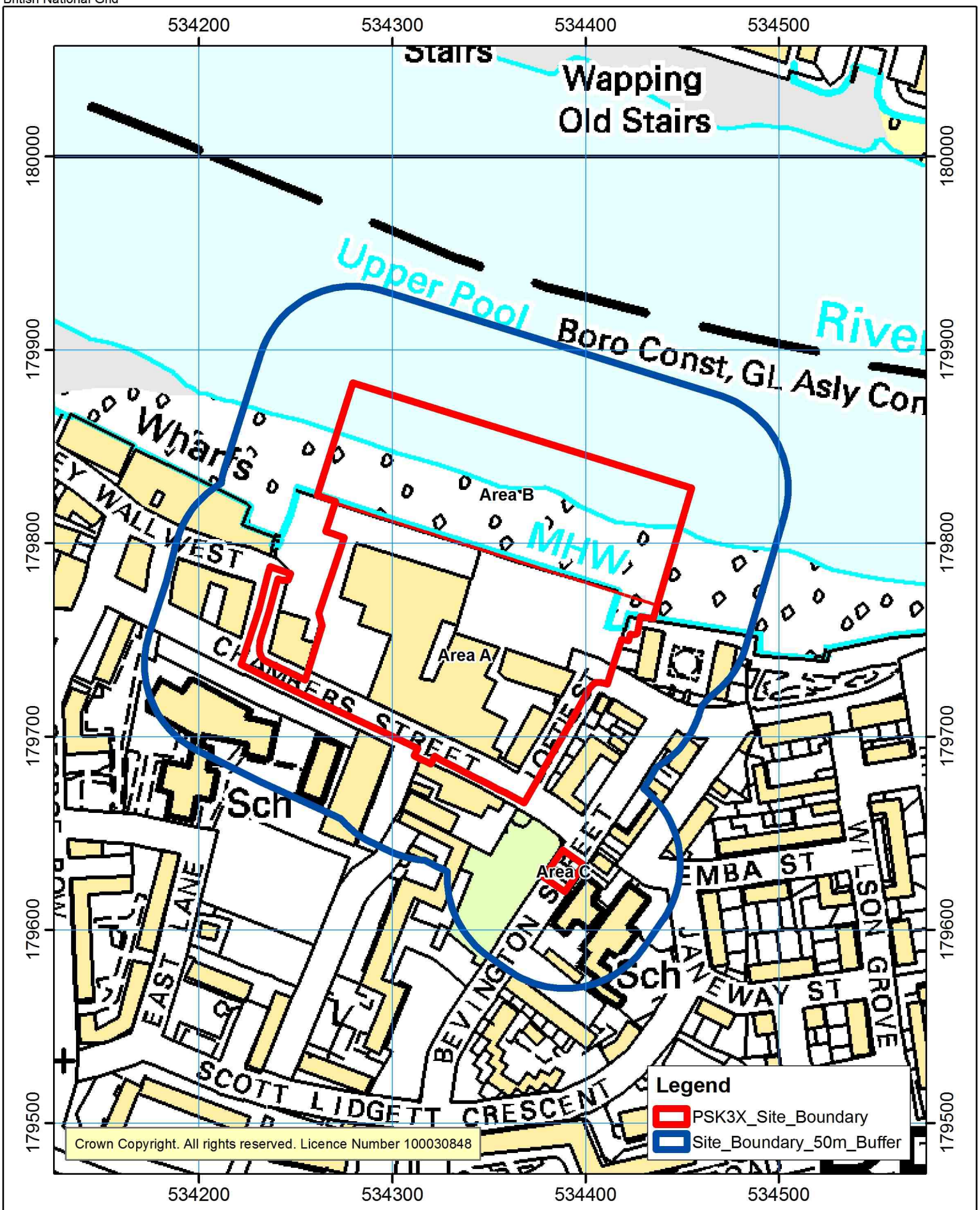
Figure Two

Site Plan

Thames Tideway Tunnel - Work Area PSK3X
Site Boundary

Figure 2

British National Grid



BOMB SEARCH

6 Alpha Associates Ltd.
Quatro House
Frimley Road
Camberley
Surrey GU16 7ER
United Kingdom
www.6alpha.com
0203 371 3900

0 10 20 40 60 80 100 Meters

N

Project Number: P2853_PSK3X

Drawn By: Dominique René

Checked by: Lee Gooderham

Date: 2nd May 2012

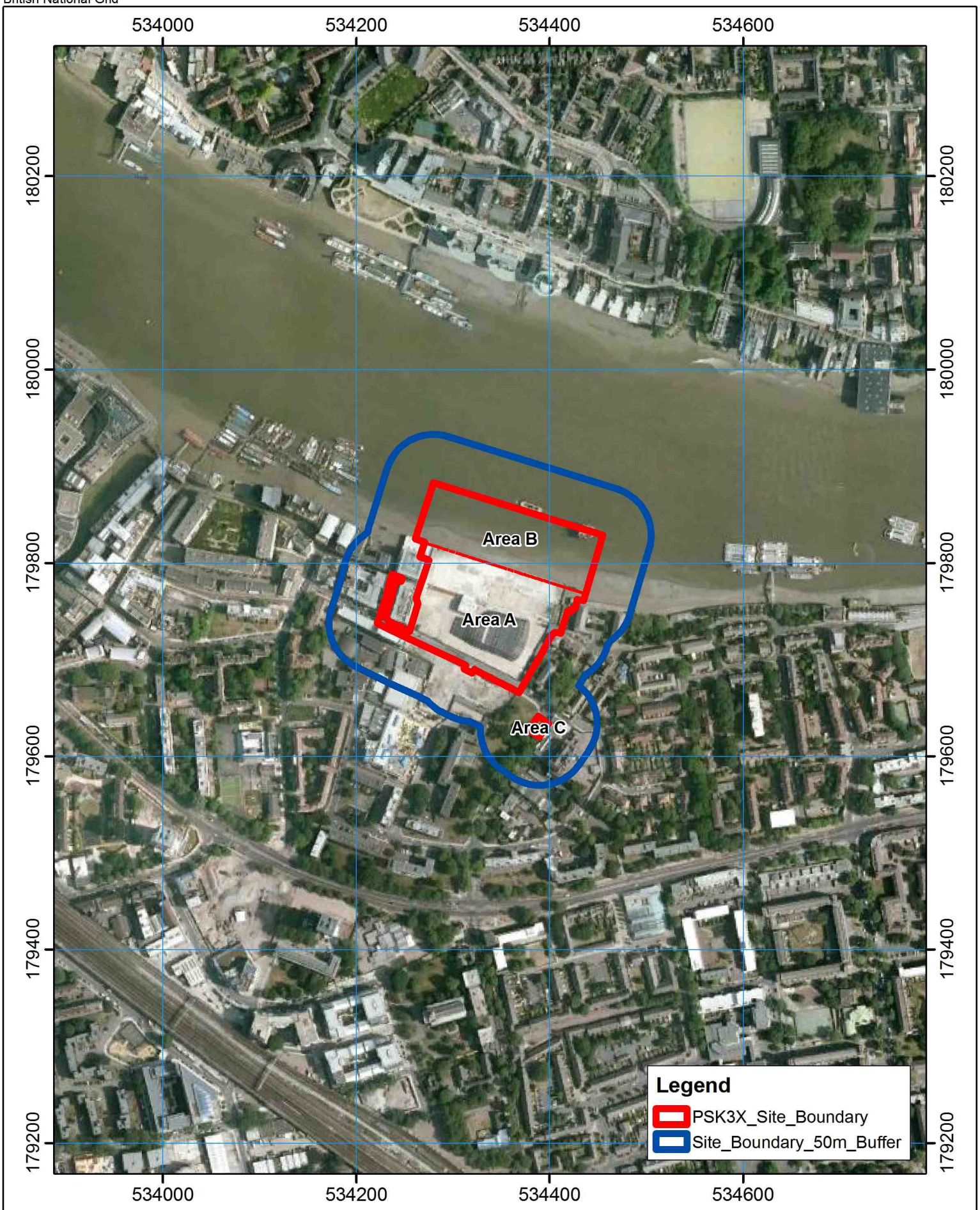
Figure Three

Current Aerial Photography

Thames Tideway Tunnel - Work Area PSK3X
Current Aerial Photography

Figure 3

British National Grid



BOMB SEARCH

6 Alpha Associates Ltd.
Quatro House
Frimley Road
Camberley
Surrey GU16 7ER
United Kingdom
www.6alpha.com
0203 371 3900

0 25 50 100 150 200 250 Meters

N

Project Number: P2853_PSK3X

Drawn By: Dominique René

Checked by: Lee Gooderham

Date: 2nd May 2012

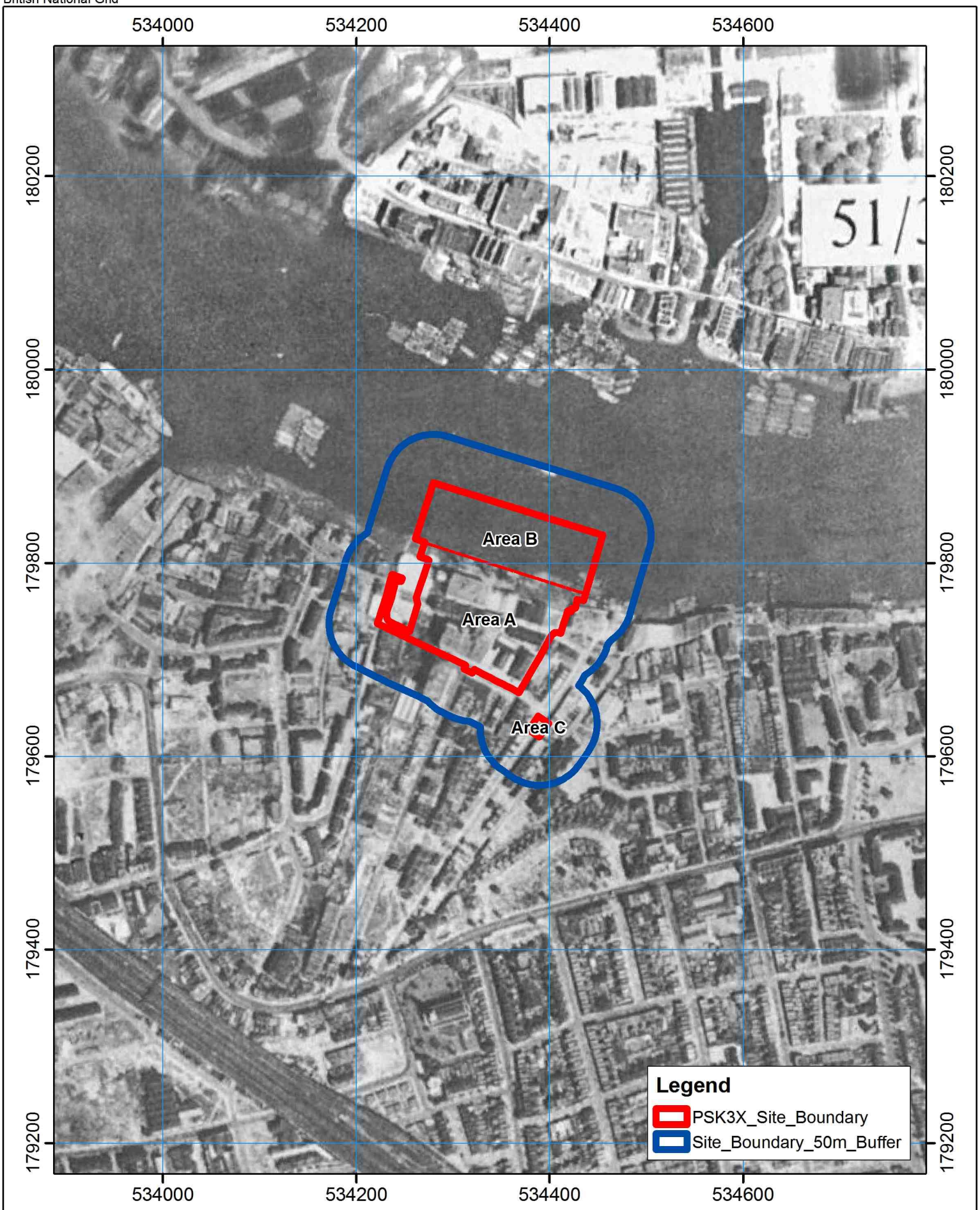
Figure Four

1945 Aerial Photography

Thames Tideway Tunnel - Work Area PSK3X
1945 Aerial Photography

Figure 4

British National Grid



6 Alpha Associates Ltd.
Quatro House
Frimley Road
Camberley
Surrey GU16 7ER
United Kingdom
www.6alpha.com
0203 371 3900

0 25 50 100 150 200 250 Meters

N

Project Number: P2853_PSK3X

Drawn By: Dominique René

Checked by: Lee Gooderham

Date: 2nd May 2012

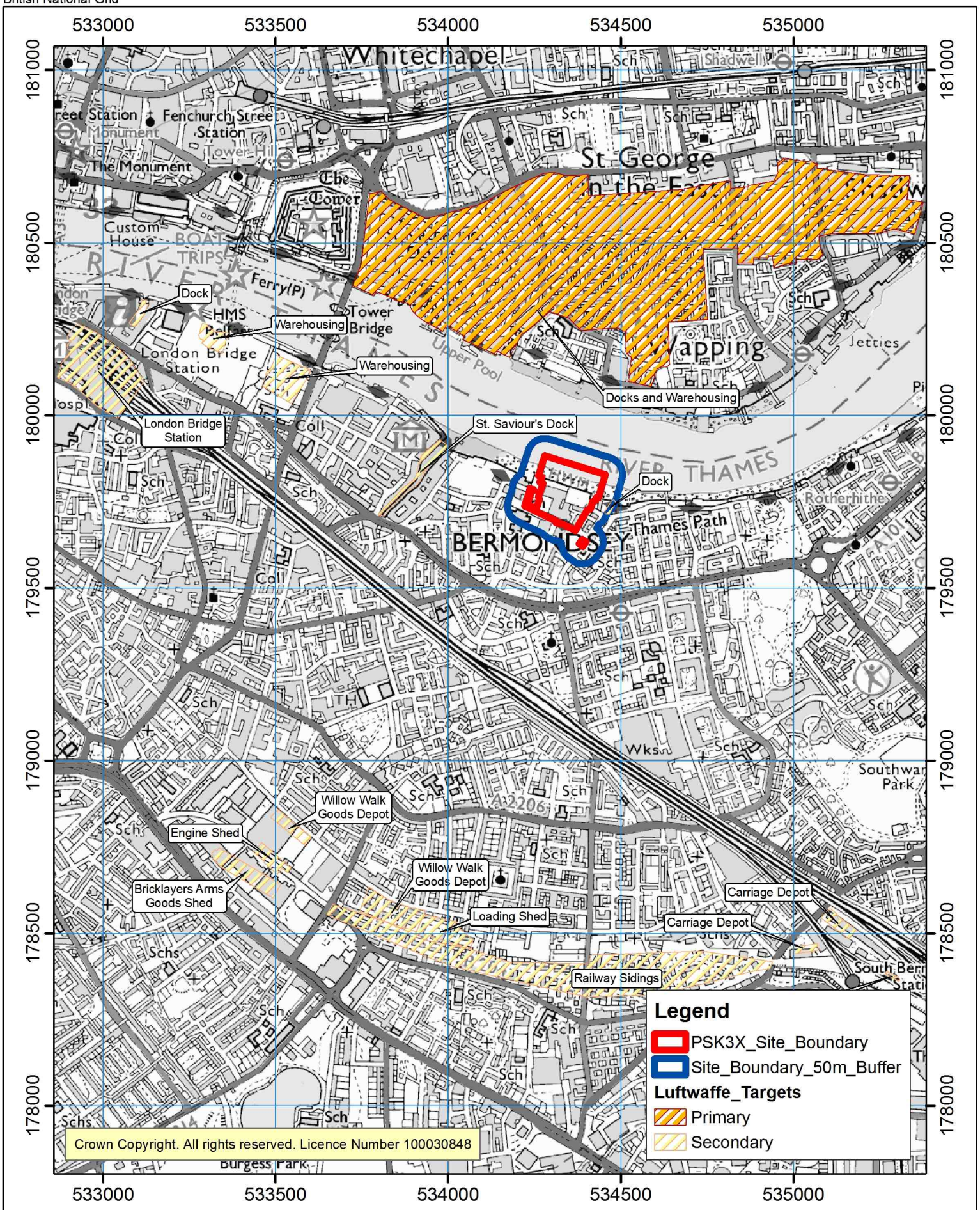
Figure Five

WWII *Luftwaffe* Bombing Targets

Thames Tideway Tunnel - Work Area PSK3X
WWII Luftwaffe Bombing Targets

Figure 5

British National Grid



BOMB SEARCH

6 Alpha Associates Ltd.
Quatro House
Frimley Road
Camberley
Surrey GU16 7ER
United Kingdom
www.6alpha.com
0203 371 3900

0 50 100 200 300 400 500 Meters

N

Project Number: P2853_PSK3X
Drawn By: Dominique René
Checked by: Lee Gooderham
Date: 2nd May 2012

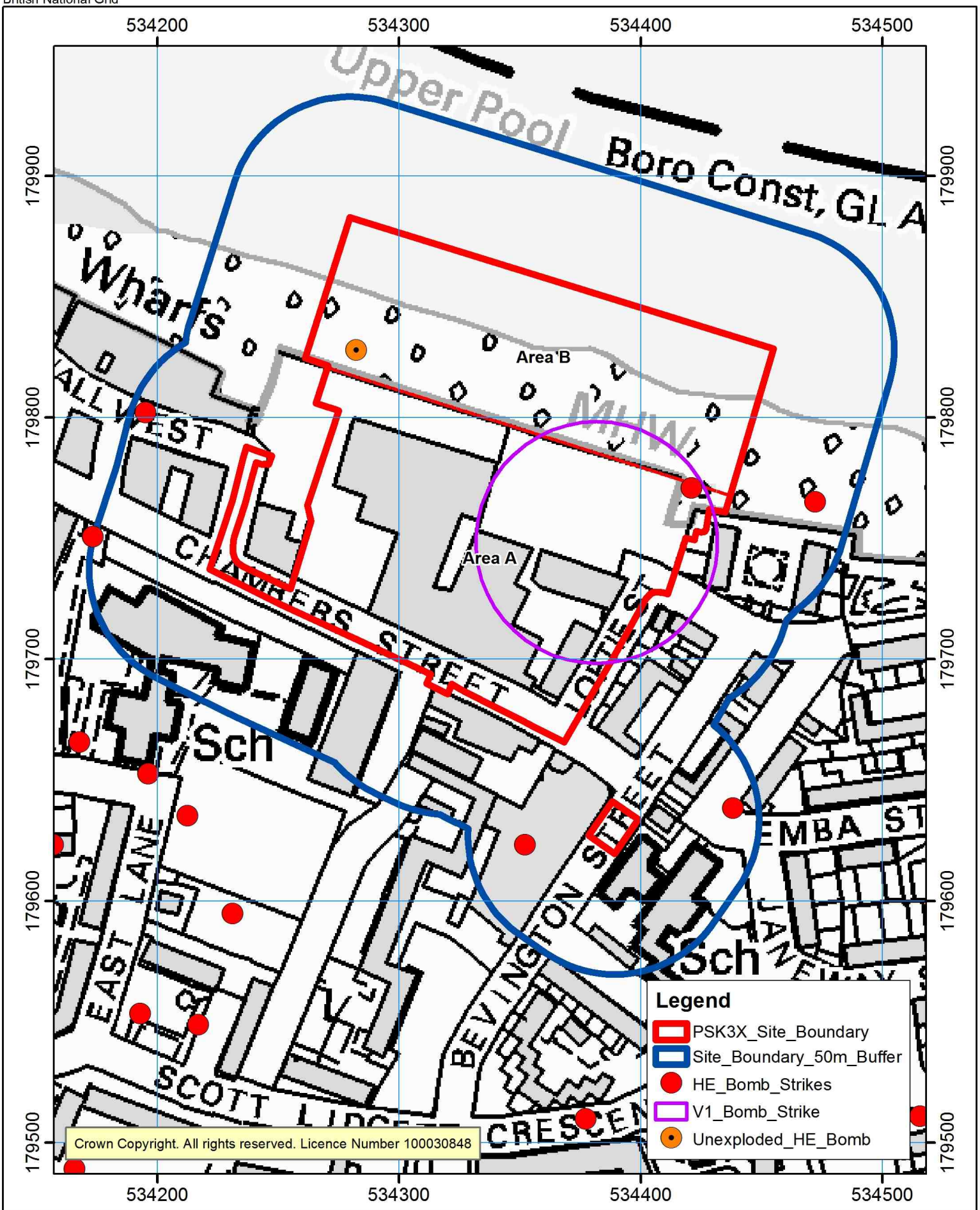
Figure Six

WWII High Explosive Bomb Strikes

Thames Tideway Tunnel - Work Area PSK3X
WWII High Explosive Bomb Strikes

Figure 6

British National Grid



6 Alpha Associates Ltd.
Quatro House
Frimley Road
Camberley
Surrey GU16 7ER
United Kingdom
www.6alpha.com
0203 371 3900

0 10 20 40 60 80 100 Meters

N

Project Number: P2853_PSK3X

Drawn By: Dominique René

Checked by: Lee Gooderham

Date: 3rd May 2012

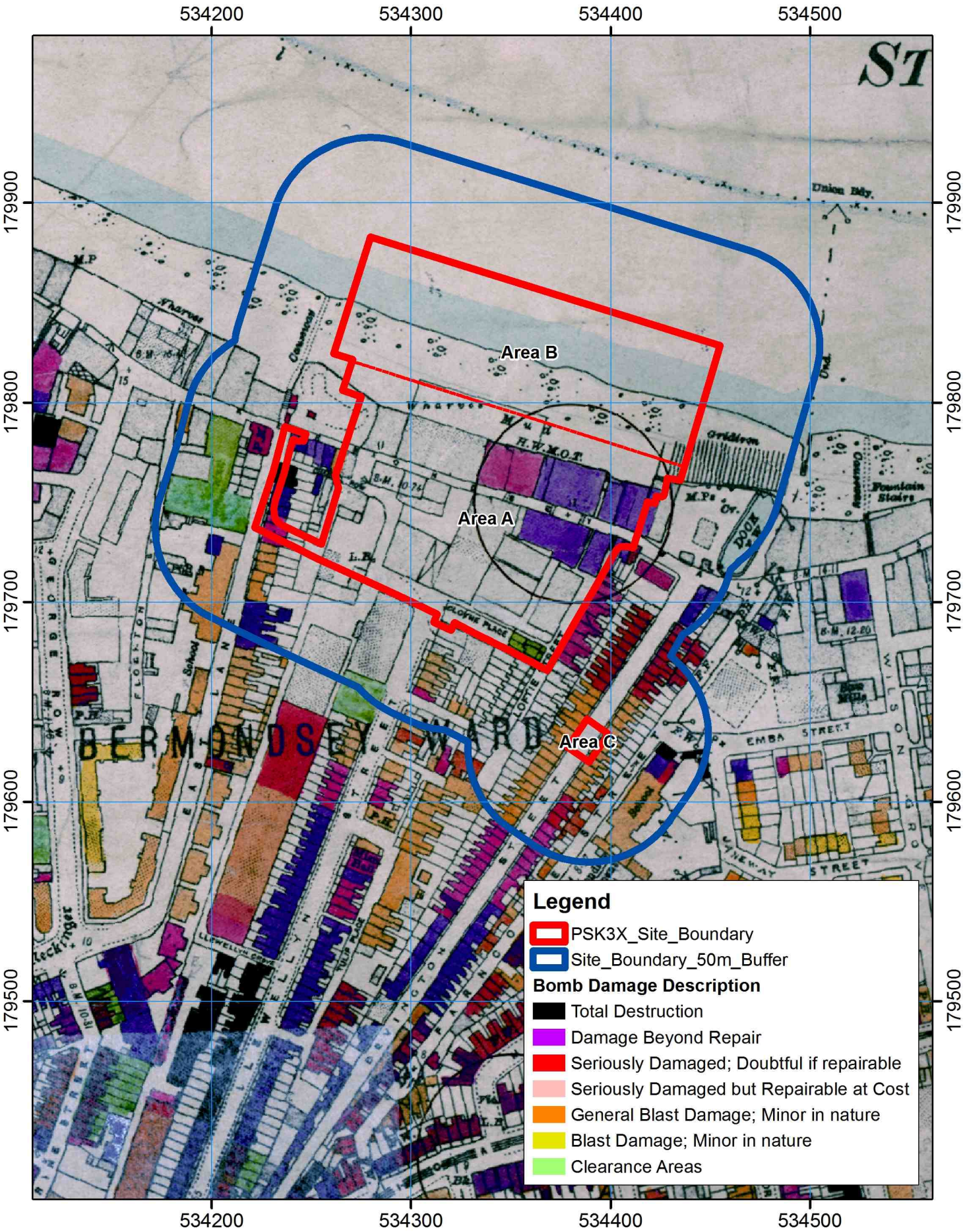
Figure Seven

London County Council Bomb Damage Mapping

Thames Tideway Tunnel - Work Area PSK3X
London County Council Bomb Damage Map

Figure 7

British National Grid



6 Alpha Associates Ltd.
Quatro House
Frimley Road
Camberley
Surrey GU16 7ER
United Kingdom
www.6alpha.com
0203 371 3900

0 10 20 40 60 80 100 Meters

N

Project Number: P2853_PSK3X

Drawn By: Dominique René

Checked by: Lee Gooderham

Date: 2nd May 2012

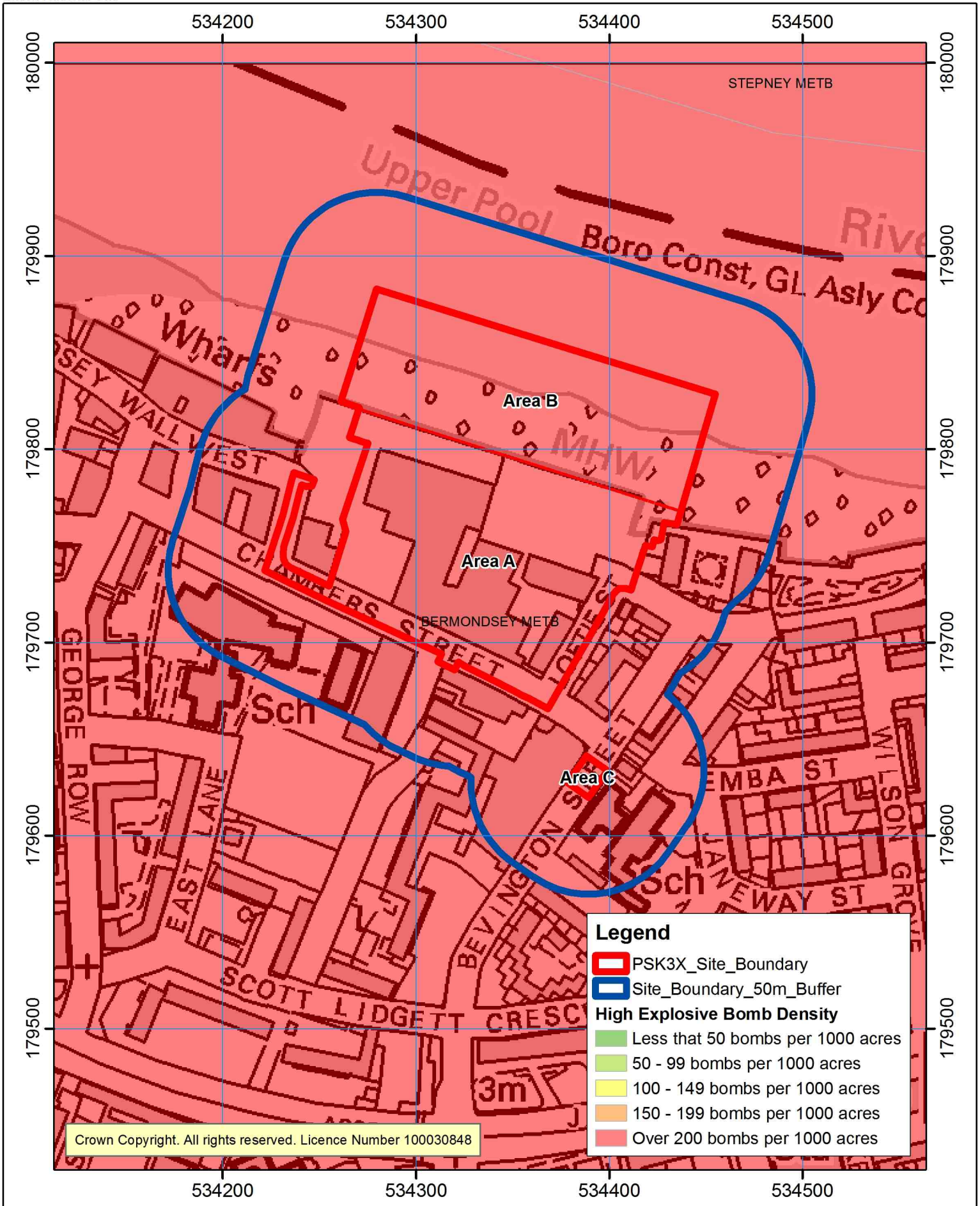
Figure Eight

WWII High Explosive Bomb Density

Thames Tideway Tunnel - Work Area PSK3X
WWII High Explosive Bomb Density

Figure 8

British National Grid



BOMB SEARCH

6 Alpha Associates Ltd.
Quatro House
Frimley Road
Camberley
Surrey GU16 7ER
United Kingdom
www.6alpha.com
0203 371 3900

0 10 20 40 60 80 100 Meters

N

Project Number: P2853_PSK3X
Drawn By: Dominique René
Checked by: Lee Gooderham
Date: 3rd May 2012

This page is intentionally blank

References

[1] Department for the Environment, Food and Rural Affairs and The Environment Agency, *CLR8: Potential Contaminants for the assessment of land,* Environment Agency (2002).

[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] Port of London Authority. *Thames Tunnel Foreshore Contamination Sampling Report*. PLA Ref Q55/11 (Dec 2011).

[4] Mott MacDonald Limited. *Thames Tunnel Foreshore Sediment Quality Interpretative Report* (May 2012).

[5] Clarke Bond Engineering and Management Consultants (South East Ltd) Chambers Wharf Geotechnical Interpretation (2008)

This page is intentionally blank

Thames Tideway Tunnel
Thames Water Utilities Limited

Application for Development Consent

Application Reference Number: WWO10001

Environmental Statement

Doc Ref: **6.2.20**

Volume 20: Chambers Wharf appendices

Appendix G: Noise and vibration

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

Hard copy available in

Box **34** Folder **B**
January 2013

Thames Tideway Tunnel

Creating a cleaner, healthier River Thames

This page is intentionally blank

Thames Tideway Tunnel

Environmental Statement

Volume 20 Chambers Wharf appendices

Appendix G: Noise and vibration

List of contents

Page number

List of plates

Page number

List of tables

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 noise sensitive receptors to Chambers Wharf are the residential dwellings to the east and west of the site and St Michael's RC School to the south of the site.

Survey methodology

G.1.3 The London Borough of Southwark 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 10th-11th July 2011 and additional data was collected on 11th October 2011. These surveys comprised short term attended measurements taken during the daytime, evening and night time. Continuous unattended monitoring was also completed over an eight day period (10th-17th October 2011).

G.1.5 During the initial baseline survey, short term attended noise monitoring was completed at five locations. Measurements were undertaken during the interpeak periods of 10:00-12:00, 14:00-16:00 and 20:00-22:00 and on a typical weekday, and 14:00-18:00 and 00:00-04:00 on a typical weekend day so that the baseline data is representative of the quieter periods where any disturbance from construction would be most noticeable.

G.1.6 During the additional baseline survey further short term attended noise monitoring was completed at all five locations. Measurements were undertaken during the interpeak periods of 00:00-04:00 on a typical weekday and continuous unattended monitoring was completed at one location.

G.1.7 Vol 20 Table G.1 describes the survey equipment that was used to collect the baseline data at the site.

Vol 20 Table G.1 Noise – survey equipment

Item	Type	Manufacturer	Serial Number(s)	Laboratory Calibration Date
Initial baseline survey: 10th-11th July 2011				
Hand-held analyzers	2250	Brüel & Kjær	2506362 2626233	25/05/2011* 15/02/2010**
½ " microphones	4189	Brüel & Kjær	2519772 2621212	12/05/2011* 15/02/2010**
B&K sound calibrator	4231	Brüel & Kjær	2445811 2619374	14/10/2010* 21/02/2011**
Additional baseline survey: 11th October 2011				
Hand-held analyzers	2250	Brüel & Kjær	2626230	19/01/2010**
½ " microphones	4189	Brüel & Kjær	2621208	19/01/2010**
B&K sound calibrator	4231	Brüel & Kjær	2619372	13/01/2011**
Continuous unattended monitoring: 10th-17th October 2011				
Hand-held analyzers	2250	Brüel & Kjær	2626210	20/12/2010**
½ " microphones	4189	Brüel & Kjær	2621186	20/12/2010**
B&K sound calibrator	4231	Brüel & Kjær	2123002	13/01/2011**

**Hand-held analyzer, ½ " microphone and calibrator valid for one year from the date listed.*
***Hand-held analyser(s) and ½ " 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 surveys, 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 For the attended measurements, 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.1.11 For the unattended measurement, the environmental case used for the continuous data logging was locked to avoid any potential tampering. The microphone was tripod-mounted approximately 1.3m above ground level. A windshield with bird spikes was fitted over the microphone at all times during the survey period to minimise the effects of any wind induced noise, and also to prevent birds from perching on the equipment.

G.1.12 The prevailing weather conditions observed for both attended baseline surveys are described in Vol 20 Table G.2.

G.1.13 Contemporary weather data recorded at Heathrow Airport has been summarised in Vol 20 Table G.3. This is deemed to be representative of the prevailing weather conditions for the continuous unattended monitoring kit.

Vol 20 Table G.2 Noise – weather conditions during baseline noise surveys

Wind Speed (ms^{-1})	Wind Direction	Temperature (°C)	Precipitation	Description
Initial baseline survey – 10th July, 2011 (daytime, 14:00-18:00)				
Maximum: 1.1-3.8 Average: 0.4-1.7	SW, W	21-23	No	Scattered cloud with a light breeze
Initial baseline survey – 11th July, 2011 (night-time, 00:00-04:00)				
Maximum: 0.4-2.3 Average: 0.0-0.8	NW, W	15-17	No	Calm and clear with scattered cloud
Initial baseline survey – 11th July, 2011 (daytime, 10:00-12:00)				
Maximum: 1.3-2.6 Average: 0.3-1.0	NNE, N	22-25	No	Sunny, but cloudy and wind picking up later
Initial baseline survey – 11th July, 2011 (daytime, 14:00-16:00)				
Maximum: 1.4-2.4 Average:	N, NNW	23-25	No	Cloudy and breezy

Wind Speed (ms^{-1})	Wind Direction	Temperature (°C)	Precipitation	Description
0.3-0.7				
Initial baseline survey – 11th July, 2011 (evening, 20:00-22:00)				
Maximum: 0.6-4.2 Average: 0.3-1.7	NNE, NE	20-22	No	Cloudy with wind picking up
Additional baseline survey – 11th October, 2011 (night-time, 00:00-04:00)				
Maximum: 2.2-9.5 Average: 0.7-3.5	WSW	17	No	Overcast, with gusty wind

Vol 20 Table G.3 Noise – contemporary weather data for Heathrow Airport

Wind Speed (ms^{-1})	Wind Direction	Temperature (°C)	Precipitation	Description
Monday 10th October, 2011 (07:00 onwards)a				
7-13	W, WSW	16-20	No	Mostly cloudy, dry and breezy
Tuesday 11th October, 2011b				
6-10	W, WSW	15-19	No	Mostly cloudy, dry and breezy
Wednesday 12th October, 2011c				
1.5-7	W, WNW, WSW	14-20	No	Cloudy, dry and breezy
Thursday 13th October, 2011d				
0.5-5.1	Variable	11-17	No	Cloudy and dry, light breeze
Friday 14th October, 2011e				
1-6.2	Variable	8-16	No	Clear and dry, light breeze
Saturday 15th October, 2011f				

Wind Speed (ms^{-1})	Wind Direction	Temperature (°C)	Precipitation	Description
1-4.1	Variable	6-17	No	Clear and dry, light breeze
Sunday 16th October, 2011g				
0.5-5.7	Variable	5-18	No	Cloudy and dry, light breeze

a http://www.wunderground.com/history/airport/EGLL/2011/10/10/DailyHistory.html
b http://www.wunderground.com/history/airport/EGLL/2011/10/11/DailyHistory.html
c http://www.wunderground.com/history/airport/EGLL/2011/10/12/DailyHistory.html
d http://www.wunderground.com/history/airport/EGLL/2011/10/13/DailyHistory.html
e http://www.wunderground.com/history/airport/EGLL/2011/10/14/DailyHistory.html
f http://www.wunderground.com/history/airport/EGLL/2011/10/15/DailyHistory.html
g http://www.wunderground.com/history/airport/EGLL/2011/10/16/DailyHistory.html

Measurement locations

G.1.14 Vol 20 Table G.4 details the measurement locations which are also presented in Vol 20 Figure G.1 Noise – measurement locations (see separate volume of figures), and shown in Plates G.1 to G.6.

Vol 20 Table G.4 Noise – measurement locations

Measurement location number	Description	Co-ordinates	
		X	Y
CHW01	On public footpath adjacent to East Lane, in front of Luna House	534243	179787
CHW02	On public footpath on the corner of Loftie Street and Bermondsey Wall East, in front of residential dwellings	534405	179727
CHW03	On public footpath adjacent to Cinnabar Wharf East, in front of commercial offices	534406	180078
CHW04	On public footpath adjacent to Chambers Street, in front of residential dwellings	534250	179721
CHW05	On public footpath adjacent to Chambers Street, near to intersection with Loftie Street	534337	179678
CHW06	Within southwest corner of Chambers Wharf site, near to Chambers Street	534262	179740

Results

G.1.15 The range of values for each of the parameters collected during the baseline surveys are summarised in Vol 20 Table G.5 – Table G.11.

Vol 20 Table G.5 Noise – sampled noise survey results - CHW01

Location Detail: CHW01, on public footpath adjacent to East Lane, in front of Luna 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)	98	46	53-66	61	64*	65
Evening (20.00-22.00)	76	45	51-52	51	54*	55
Night (00.00-04.00)	79	41	44-53	50	53*	55
Weekend day (14.00-18.00)	75	46	53-56	55	58*	60
Weekend night (00.00-04.00)	57	39	40-41	41	44*	45

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

Vol 20 Table G.6 Noise – sampled noise survey results CHW02

Location Detail: CHW02, on public footpath on the corner of Loftie Street and Bermondsey Wall East, in front of residential dwellings						
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)	78	46	50-58	52*	55	55
Evening (20.00-22.00)	75	42	54-56	52*	55	55
Night (00.00-04.00)	67	42	45-48	43*	46	45
Weekend day (14.00-18.00)	80	44	53-55	51*	54	55
Weekend night (00.00-04.00)	78	36	37-45	39*	42	40

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

Vol 20 Table G.7 Noise – sampled noise survey results - CHW03

Location Detail: CHW03, on public footpath adjacent to Cinnabar Wharf East, next to Capital Wharf						
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)	84	49	52-60	57	60*	60
Evening (20.00-22.00)	83	46	51-56	54	57*	55
Night (00.00-04.00)	71	46	53-54	53	56*	55
Weekend day (14.00-18.00)	85	51	56-60	58	61*	60
Weekend night (00.00-04.00)	64	41	47	47	50*	50

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

Vol 20 Table G.8 Noise – sampled noise survey results - CHW04

Location Detail: CHW04, on public footpath adjacent to Chambers Street, in front of residential dwellings						
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)	82	44	56-57	54*	57	55
Evening (20.00-22.00)	76	41	52-54	50*	53	55
Night (00.00-04.00)	69	38	43-46	42*	45	45
Weekend day (14.00-18.00)	80	43	56	53*	56	55
Weekend night (00.00-04.00)	84	36	44-53	48*	51	50

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

Vol 20 Table G.9 Noise – sampled noise survey results - CHW05

Location Detail: CHW05, on public footpath adjacent to Chambers Street, near to intersection with Loftie Street						
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)	78	44	57-59	55*	58	60
Evening (20.00-22.00)	81	41	51-57	52*	55	55
Night (00.00-04.00)	69	42	49-50	47*	50	50
Weekend day (14.00-18.00)	84	44	54-60	55*	58	60
Weekend night (00.00-04.00)	83	35	53	50*	53	55

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

Vol 20 Table G.10 Noise – continuously logged noise survey results - CHW06

Location Detail: CHW06, within southwest corner of Chambers Wharf site, near to Chambers Street							
Day	**Period**	**Period noise level (dB(A) free-field)**			**Period noise level (dB(A) façade)**		
		L_{AFmax}	**L_{A90}**	**L_{Aeq}**	**L_{AFmax}**	**L_{A90}**	**L_{Aeq}**
Weekday	07.00-08.00	99	51	61	102	54	64
	08.00-18.00	89	51	59	92	54	62
	18.00-19.00	71	50	54	74	53	57
	19.00-22.00	76	48	54	79	51	57
	22.00-07.00	73	43	51	76	46	54
Saturday	07.00-08.00	72	42	50	75	45	53
	08.00-13.00	78	42	54	81	45	57
	13.00-14.00	74	42	55	77	45	58
	14.00-22.00	78	41	53	81	44	56
	22.00-07.00	80	35	44	83	38	47
Sunday	07.00-21.00	82	47	53	85	50	56
	21.00-07.00	71	42	49	74	45	52

Vol 20 Table G.11 Noise measurements near embankment (for river-based traffic assessment

Sensitive receptor locations	Measurement location	Measurement period	Noise level (dBL_{Aeq}, facade)
Chambers Wharf (east of site)	CHW02	Day/evening (07.00-23.00)	55
		Night (23.00-07.00)	45
Chambers Wharf (west of site)	CHW01	Day/evening (07.00-23.00)	62
		Night (23.00-07.00)	47

Baseline survey photographs

G.1.16 The following plates (plates G.1 to G.6) illustrate the noise measurement locations

Vol 20 Plate G.1 Noise measurement location CHW01

Note: On public footpath at end of East Lane, looking north towards Luna House

Vol 20 Plate G.2 Noise measurement location CHW02

Note: On public footpath on the corner of Loftie Street and Bermondsey Wall East, looking southwest at residential dwelling

Vol 20 Plate G.3 Noise measurement location CHW03

Note: On public footpath alongside Cinnabar Wharf East, looking southwest towards Tower Bridge

Vol 20 Plate G.4 Noise measurement location CHW04

Note: On public footpath alongside Chambers Street, looking west-northwest

Vol 20 Plate G.5 Noise measurement location CHW05

Note: On public footpath alongside Chambers Street, looking northwest

Vol 20 Plate G.6 Noise measurement location CHW06

Note: Within southwest corner of Chambers Wharf site, looking south-southwest towards Chambers Street

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 20 Table G.12.

G.2.4 Time histories of the predicted daytime construction noise levels across the programme of construction works are shown in Plates G.7 to G.17.

Vol 20 Table G.12 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, 14 t
	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	93	15	BS5228-1: Table D.5, Item 5	Compressor for hand-held pneumatic breaker,
	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, accommodation and general	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,	Compressor for hand-

Construction activity	Plant	Unit No(s)	Activity LWA (dB)	% on-time	Data Source	Description of equipment used in the assessment
site					Item 5	held pneumatic breaker,
	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
	Dewatering Pump	1	96	100	BS5228-1: Table C.4, Item 88	Water pump,
	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
	Water settling/treatment	1	104	100	Measured	Dirty water plant
	JCB with hydraulic breaker	1	116	20	BS5228-1: Table C.5, Item 1	Backhoe mounted hydraulic breaker
	Scissor lift	1	106	25	BS5228-1: Table C.4, Item 59	Diesel, scissor lift, 6 t

Construction activity	Plant	Unit No(s)	Activity LWA (dB)	% on-time	Data Source	Description of equipment used in the assessment
Demolition (General site equipment also applicable during this phase)	Service Crane 25T mobile Crane	1	98	30	BS5228-1: Table C.4, Item 43	Wheeled mobile crane, 35 t
	22T Excavator c/w hydraulic hammer	1	118	10	BS5228-1: Table C.1, Item 9	Breaker mounted on excavator, 15 t, 1650 kg
	22T Excavator	2	106	15	BS5228-1: Table D.2, Item 3	Tracked excavator, 71 t
	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,
	Concrete crusher	1	110	40	BS5228-1: Table C.1, Item 14	Tracked crusher, 47 t
	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)	150t crawler crane	1	98	60	BS5228-1: Table C.3, Item 29	Tracked mobile crane, 110 t
	Barges	1	101	10	Measured	Barges
	Jack-up barge	1	100	10	Measured	Jack-up barge,
	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

Construction activity	Plant	Unit No(s)	Activity LWA (dB)	% on-time	Data Source	Description of equipment used in the assessment
	400 cfm compressor	1	93	60	BS5228-1: Table C.5, Item 5	Compressor for hand-held pneumatic breaker, 1 t
	Oxyaceteline cutting equipment	1	93	10	BS5228-1: Table C.3, Item 35	Hand-held gas cutter, 230 bar
Note: piling and backfilling will be concurrent however the two operations will be separated by some distance.	Silent piler	1	91	60	BS5228-1: Table C.3, Item 9	Piling, 10 t
	25t excavator	1	105	80	BS5228-1: Table C.2, Item 19	Tracked excavator, 25 t
	Vibratory piling rig	1	116	60	BS5228-1: Table C.3, Item 8	Vibratory piling rig, 52 t
	Dewatering pumps - cofferdam	2	96	100	BS5228-1: Table C.4, Item 88	Water pump (diesel), 100 kg
	Plate compactors	2	101	50	BS5228-1: Table C.2, Item 38	Roller, 18 t
	Vibrating rollers	2	108	10	BS5228-1: Table C.2, Item 41	Vibratory plate (petrol)
Diaphragm walling (General site equipment also applicable during this	Diaphragm wall rig (grab)	1	114	5	BS5228-1: Table D.4, Item 101	Dwall rig,
	Diaphragm wall rig (hydrofraise)	1	110	70	Measured	Hydrofraise D wall rig,
	Diaphragm wall slurry treatment plant	1	100	100	Measured	Slurry treatment plant

Construction activity	Plant	Unit No(s)	Activity LWA (dB)	% on-time	Data Source	Description of equipment used in the assessment
phase)	Compressor 400cfm	1	93	70	BS5228-1: Table C.5, Item 5	Compressor for hand-held pneumatic breaker, 1 t
	Waste water treatment plant	1	104	100	Measured	Dirty water plant
	Concrete deliveries (discharging)	1	95	20	BS5228-1: Table C.4, Item 24	Concrete pump + cement mixer truck (discharging), 8 t / 350 bar
	Dumper	1	104	25	BS5228-1: Table C.4, Item 3	Dumper, 7 t
	Concrete pump	1	106	50	BS5228-1: Table C.3, Item 25	Concrete pump
	150t crawler crane	1	103	50	BS5228-1: Table C.4, Item 52	Tracked mobile crane, 105 t
Shaft excavation (General site equipment also applicable during this phase)	Dewatering pump	4	96	100	BS5228-1: Table C.4, Item 88	Water pump (diesel), 100 kg
	Ventilation fans	1	100	100	Measured	Ventilation fans,
	20t excavator with breaker	2	108	50	BS5228-1: Table C.1, Item 3	Pulverizer mounted on excavator,
	25t excavator	1	105	80	BS5228-1: Table C.2, Item 19	Tracked excavator, 25 t
	Long reach excavator	1	106	30	BS5228-1: Table C.7, Item	Long reach tracked excavator, 39 t

Construction activity	Plant	Unit No(s)	Activity LWA (dB)	% on-time	Data Source	Description of equipment used in the assessment
	Dumper	1	104	50	BS5228-1: Table C.4, Item 3	Dumper, 7 t
	80t crawler crane	1	103	50	BS5228-1: Table C.4, Item 52	Tracked mobile crane, 105 t
	150t crawler crane	1	103	50	BS5228-1: Table C.4, Item 52	Tracked mobile crane, 105 t
Main tunnel drive (TBM assembly and disassembly)	250t mobile (TBM assembly only)	1	106	25	BS5228-1: Table C.4, Item 38	Wheeled mobile crane, 400 t
	500t mobile (TBM assembly only)	1	106	25	BS5228-1: Table C.4, Item 38	Wheeled mobile crane, 400 t
Main tunnel drive (General site equipment also applicable during this phase)	150t 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 7t
	Grout mixer including silos and feeders	1	108	50	BS5228-1: Table D.6, Item 13	Grout and mixer,
	Flatbed trucks for materials haulage	1	105	20	BS5228-1: Table C.4, Item 53	Lorry with lifting boom, 6 t
	Flatbed trucks for segment haulage	1	105	20	BS5228-1: Table C.4, Item 53	Lorry with lifting boom, 6 t
	Tunnel slurry treatment plant	1	100	100	Measured	Slurry treatment plant
	Waste water treatment plant	1	104	100	Measured	Dirty water plant

Construction activity	Plant	Unit No(s)	Activity LWA (dB)	% on-time	Data Source	Description of equipment used in the assessment
	Land conveyor to stockpile	1	90	100	Measured data	Conveyor,
	Barge conveyor	2	90	90	Measured data	Conveyor,
	25T loading shovel	1	114	50	BS5228-1: Table C.9, Item 8	Wheeled loader, 50 t
	Mains substation	1	94	100	BS5228-1: Table C.4, Item 78	Diesel generator,
	Alimak service hoist	1	96	10	BS5228-1: Table C.4, Item 61	Caged material hoist, 500 kg
	Ventilation fans - set	2	100	100	Estimated	Ventilation fans,
	Gantry cranes 30t, 25m span with cantilever one end	2	105	80	Measured data	Gantry crane,
Main tunnel secondary lining (General site equipment NOT applicable during this phase)	Air compressor 600cfm	2	93	100	BS5228-1: Table C.5, Item 5	Compressor for hand-held pneumatic breaker, 1 t
	Concrete batching plant 40m3/hr	1	95	100	Measured data	Batching,
	Concrete pump	1	106	20	BS5228-1: Table C.3, Item 25	Concrete pump
	Sump pumps 150mm	1	96	100	BS5228-1: Table C.4, Item 88	Water pump (diesel), 100 kg
	Waste water treatment plant	1	104	100	Measured	Dirty water plant

Construction activity	Plant	Unit No(s)	Activity LWA (dB)	% on-time	Data Source	Description of equipment used in the assessment
	Gantry cranes 30t, 25m span with cantilever one end	2	105	80	Measured data	Gantry crane,
	25T loading shovel	2	114	30	BS5228-1: Table C.9, Item 8	Wheeled loader, 50 t
	Mains substation	1	94	100	BS5228-1: Table C.4, Item 78	Diesel generator,
Shaft secondary lining	100t crawler crane	1	103	50	BS5228-1: Table C.4, Item 52	Tracked mobile crane, 105 t
	Service Crane 40T mobile Crane	1	98	20	BS5228-1: Table C.4, Item 43	Wheeled mobile crane, 35 t
	Concrete deliveries (discharging)	1	103	20	BS5228-1: Table C.4, Item 18	Cement mixer truck (discharging),
	Concrete pump	2	106	20	BS5228-1: Table C.3, Item 25	Concrete pump
	Fixed and portable concrete vibrators	2	106	20	BS5228-1: Table C.4, Item 33	Poker vibrator,
	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

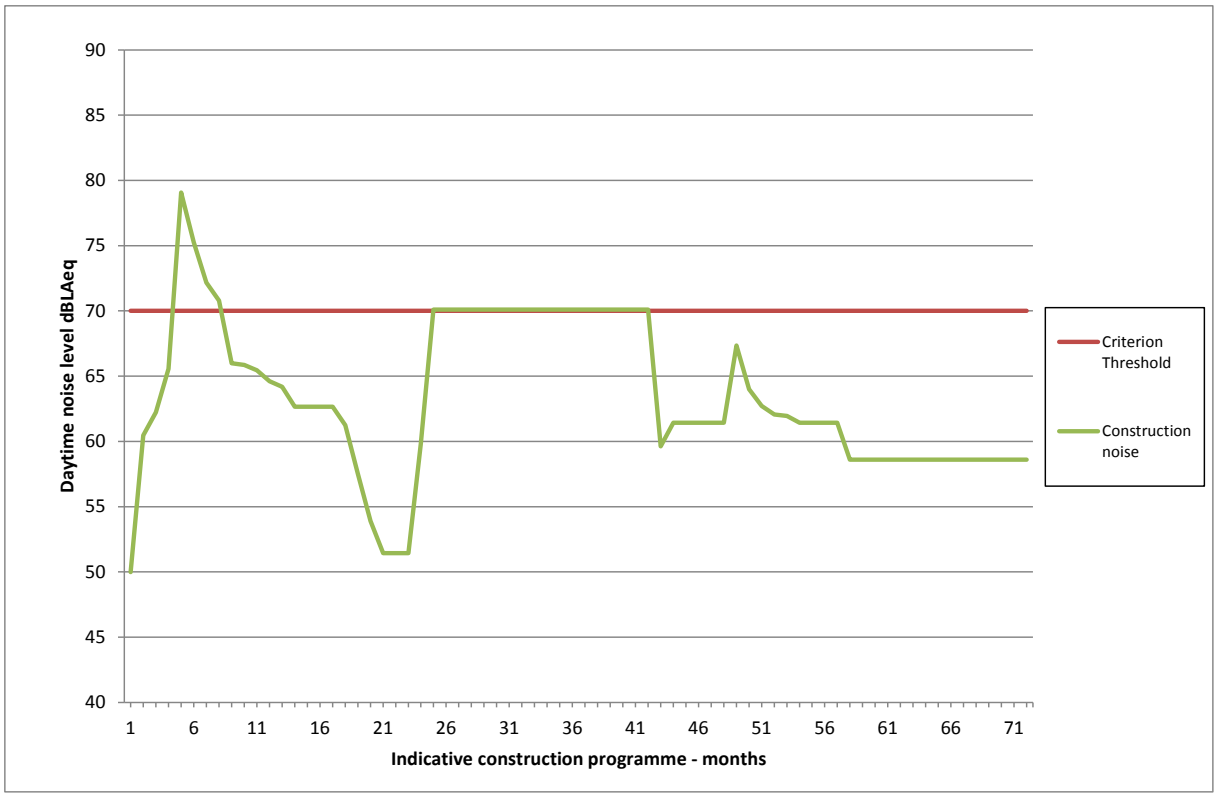
Construction activity	Plant	Unit No(s)	Activity LWA (dB)	% on-time	Data Source	Description of equipment used in the assessment
	Vibratory piling rig	1	116	80	BS5228-1: Table C.3, Item 8	Vibratory piling rig, 52 t
Culvert and chamber works (General site equipment also applicable during this phase)	Service 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	2	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 wrenches)	4	95	80	Estimated	Impact wrench and compressor,
Landscaping (General site equipment NOT applicable during this phase)	25t excavator	1	105	50	BS5228-1: Table C.2, Item 19	Tracked excavator, 25 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

Construction activity	Plant	Unit No(s)	Activity LWA (dB)	% on-time	Data Source	Description of equipment used in the assessment
	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	93	10	BS5228-1: Table C.5, Item 5	Compressor for hand-held pneumatic breaker, 1 t
	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

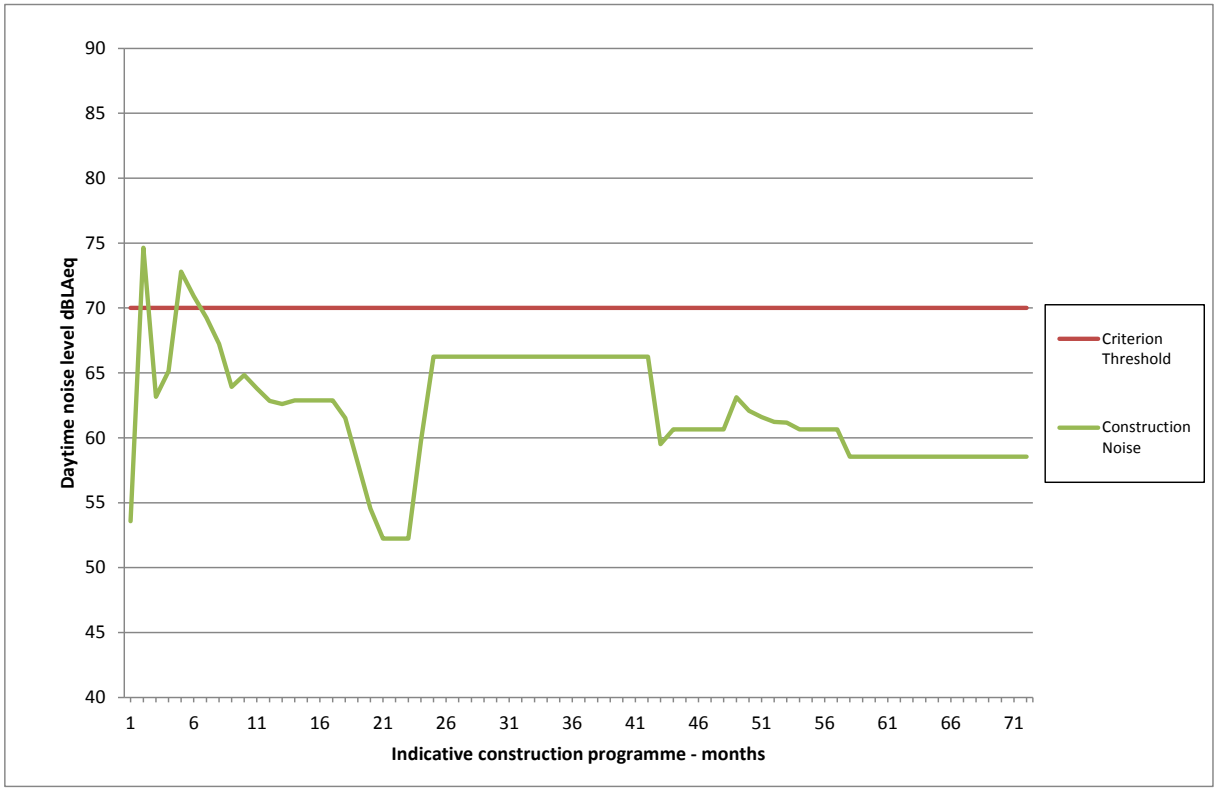
Note: This schedule provides an illustration of typical plant that could be used in the construction of the Thames Tideway Tunnel at this site. The appointed Contractor must comply with section 6 of the CoCP but may vary the method and plant to be used. This schedule therefore represents the most reasonable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

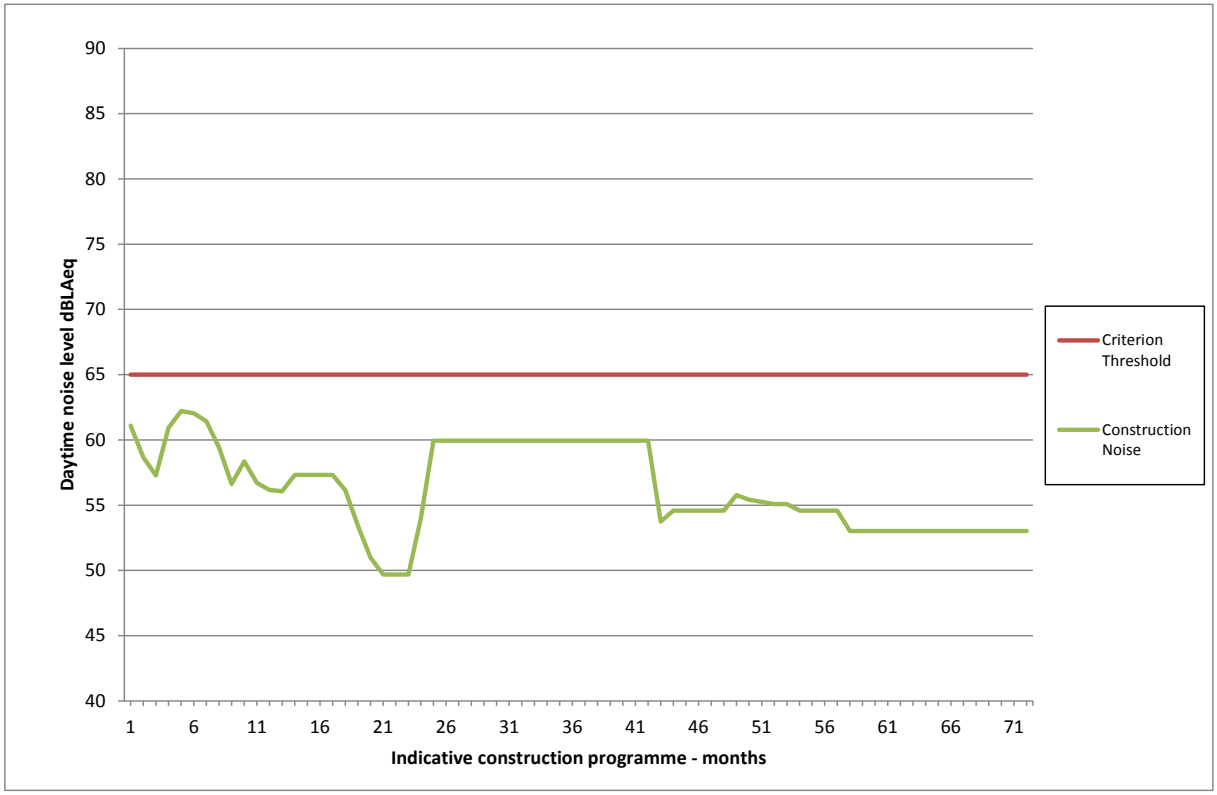
Vol 20 Plate G.7 Average monthly daytime noise level over duration of construction – Luna House (residential) (CW1)



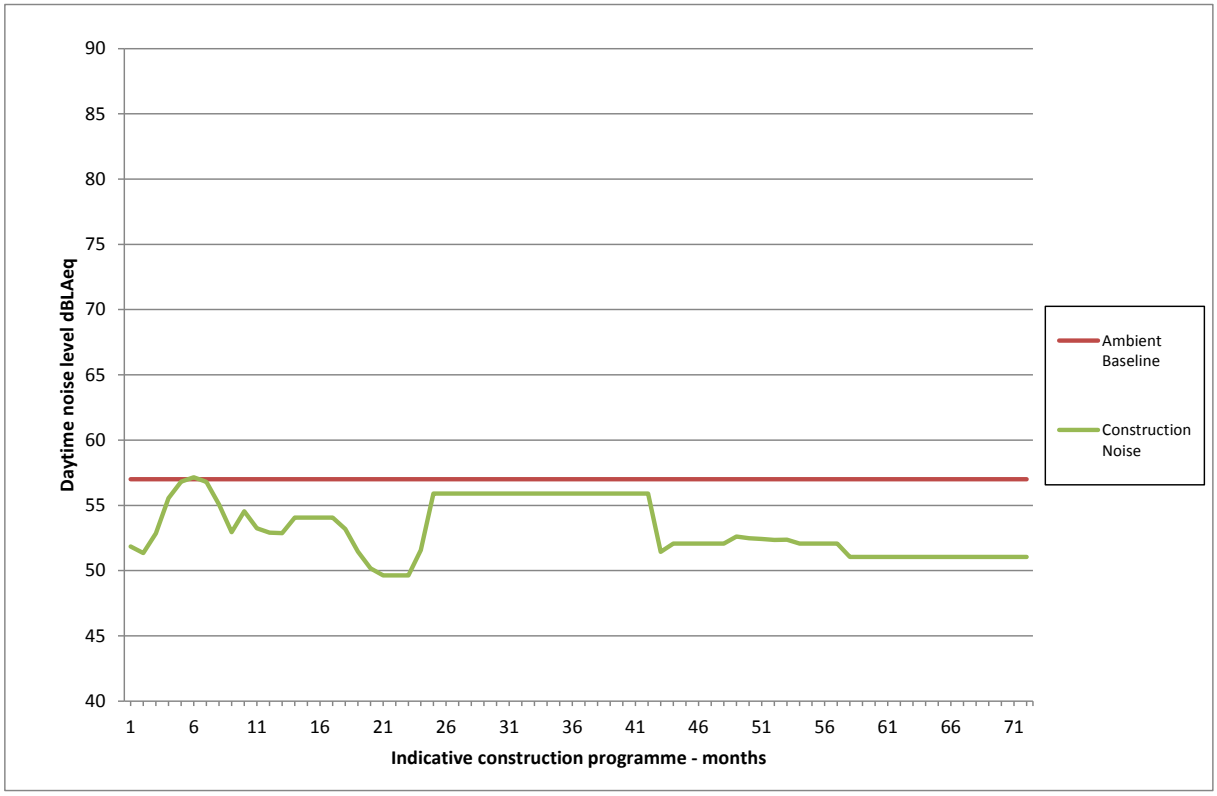
Vol 20 Plate G.8 Average monthly daytime noise level over duration of construction – Axis Court (CW2)



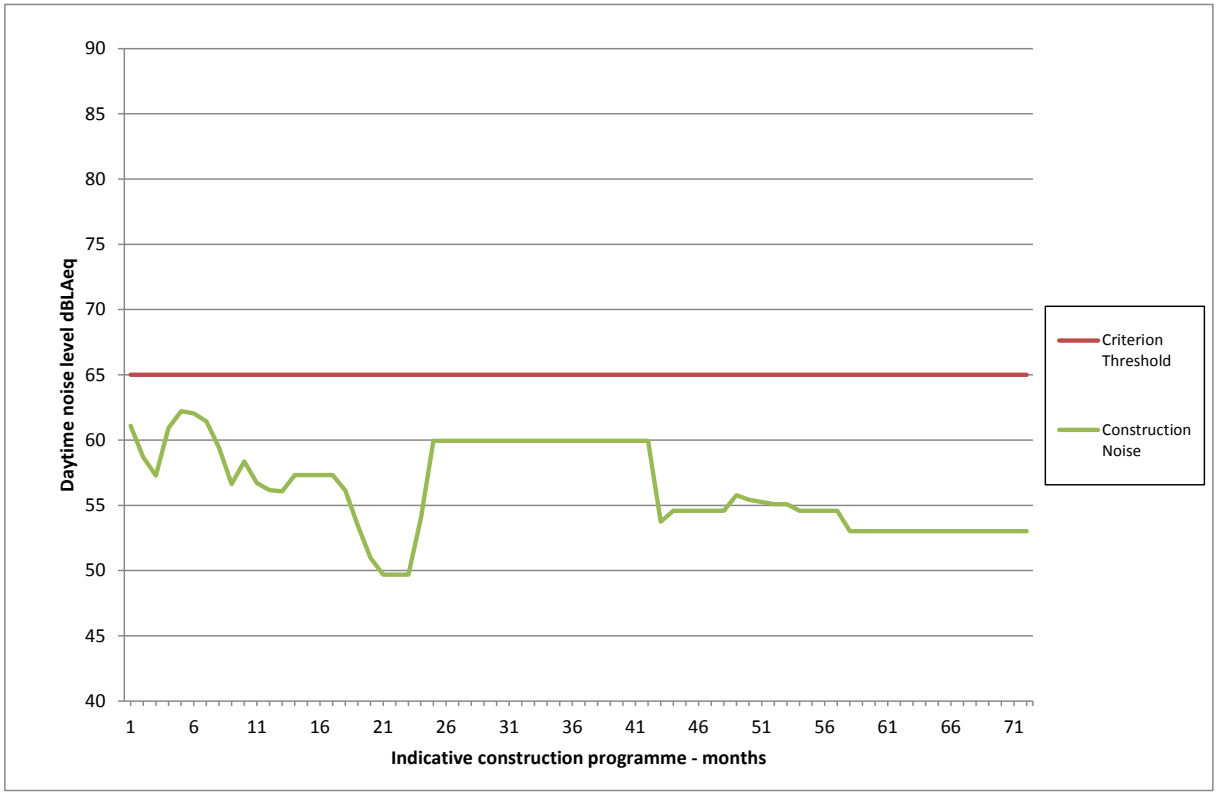
Vol 20 Plate G.9 Average monthly daytime noise level over duration of construction – 10-28 Chambers Street (CW3)



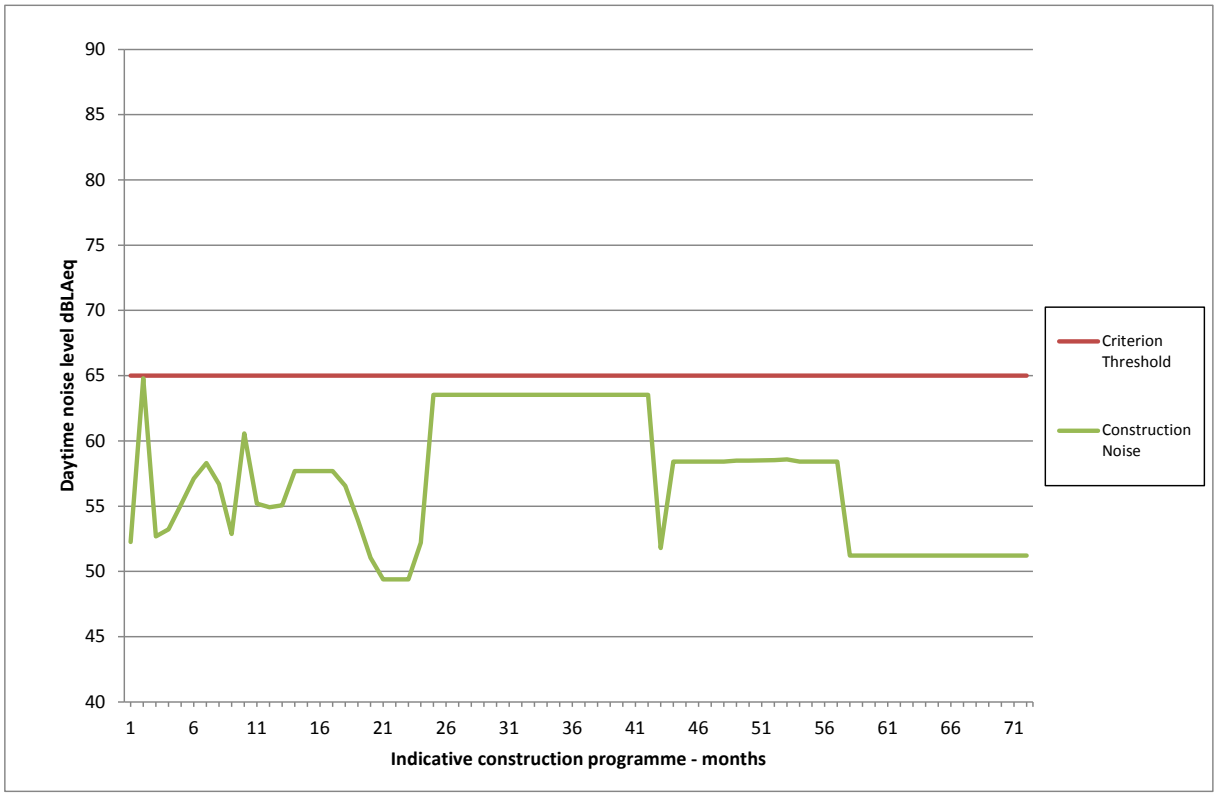
Vol 20 Plate G.10 Average monthly daytime noise level over duration of construction – St Michael's Catholic School (CW4)



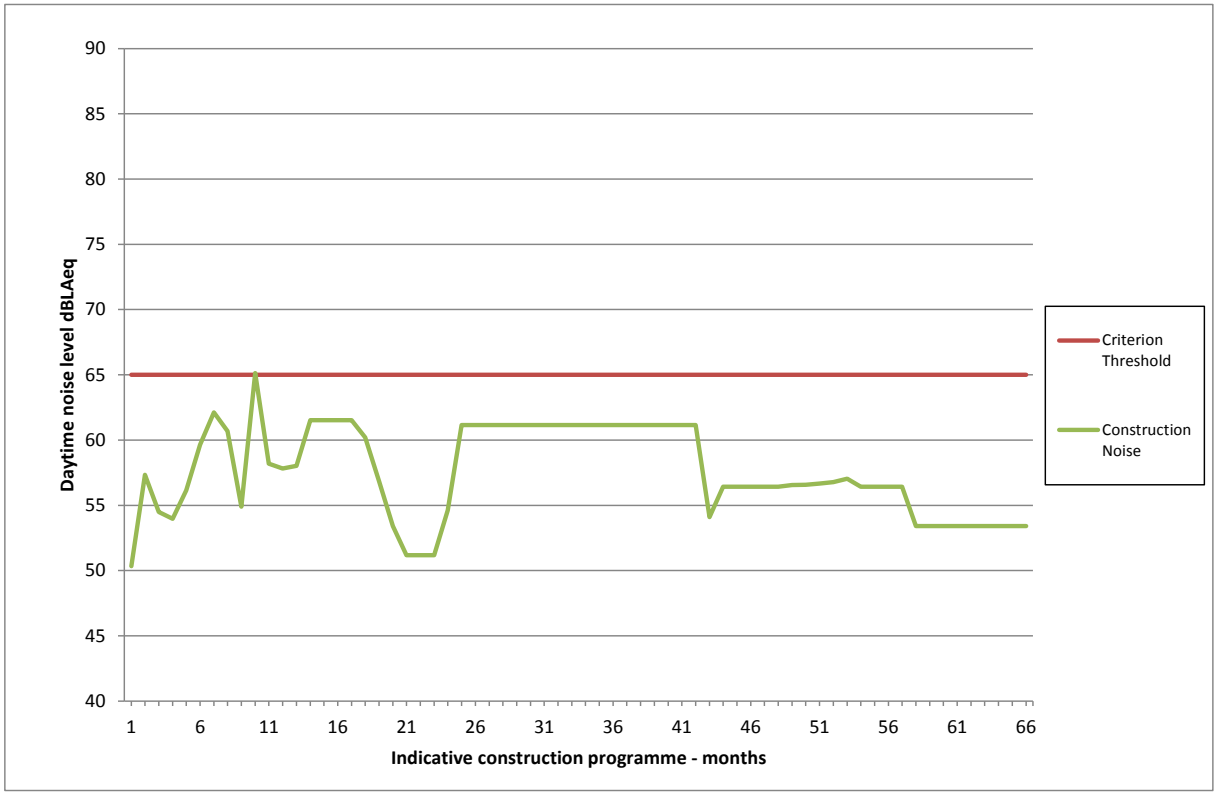
Vol 20 Plate G.11 Average monthly daytime noise level over duration of construction – Chambers Wharf (CW5)



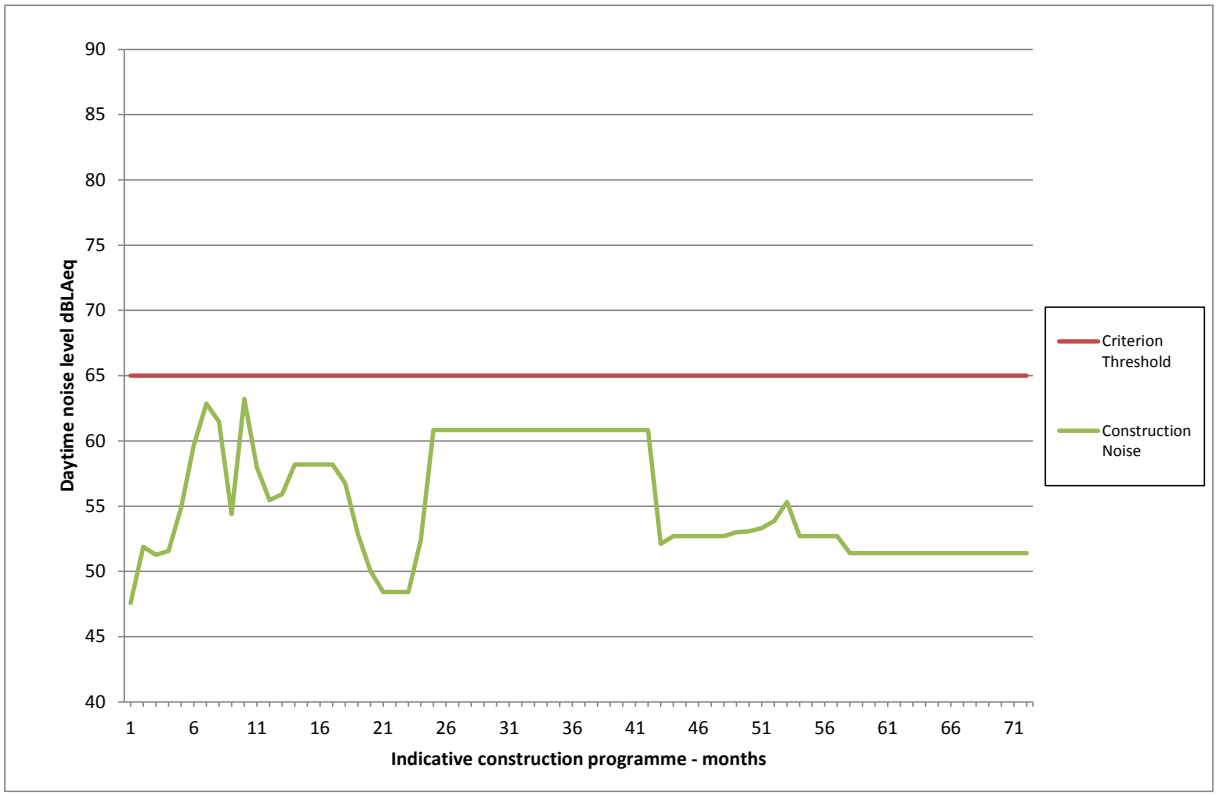
Vol 20 Plate G.12 Average monthly daytime noise level over duration of construction – 1-13 Loftie Street (CW6)



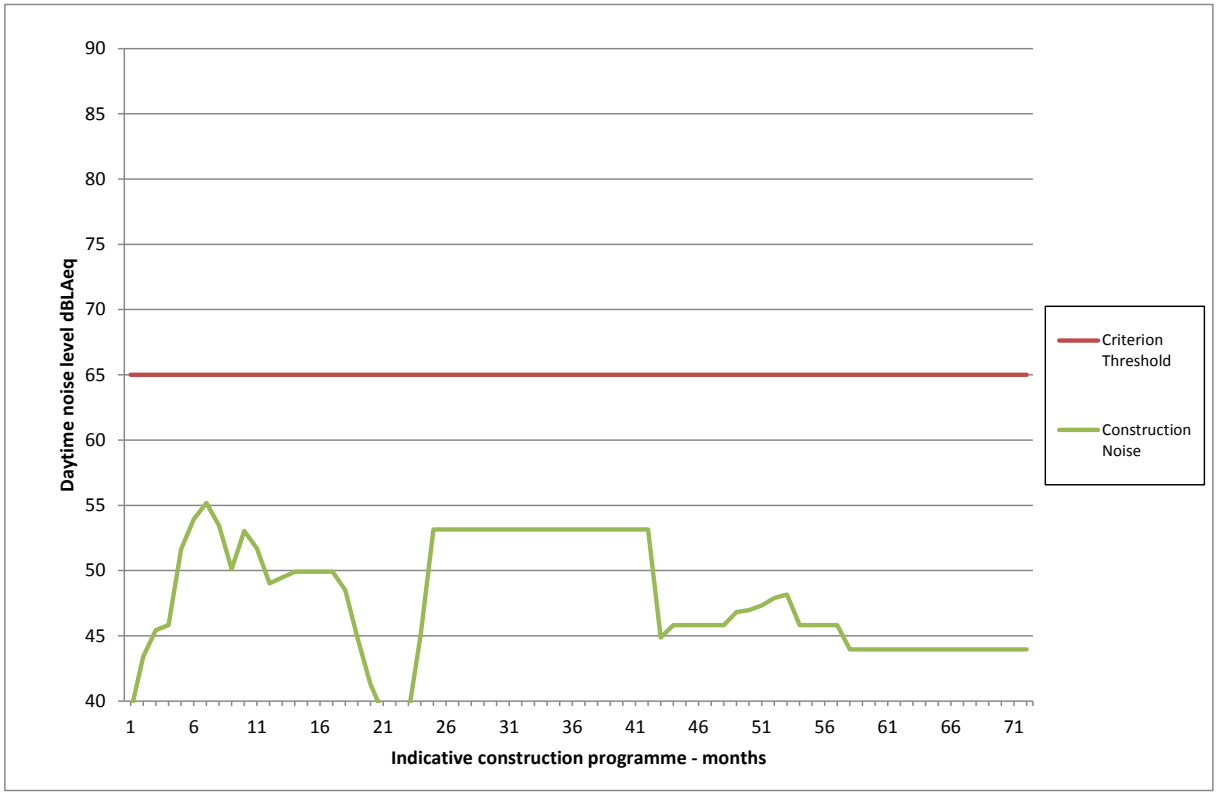
Vol 20 Plate G.13 Average monthly daytime noise level over duration of construction – 210-212 Bevington Street (CW7)



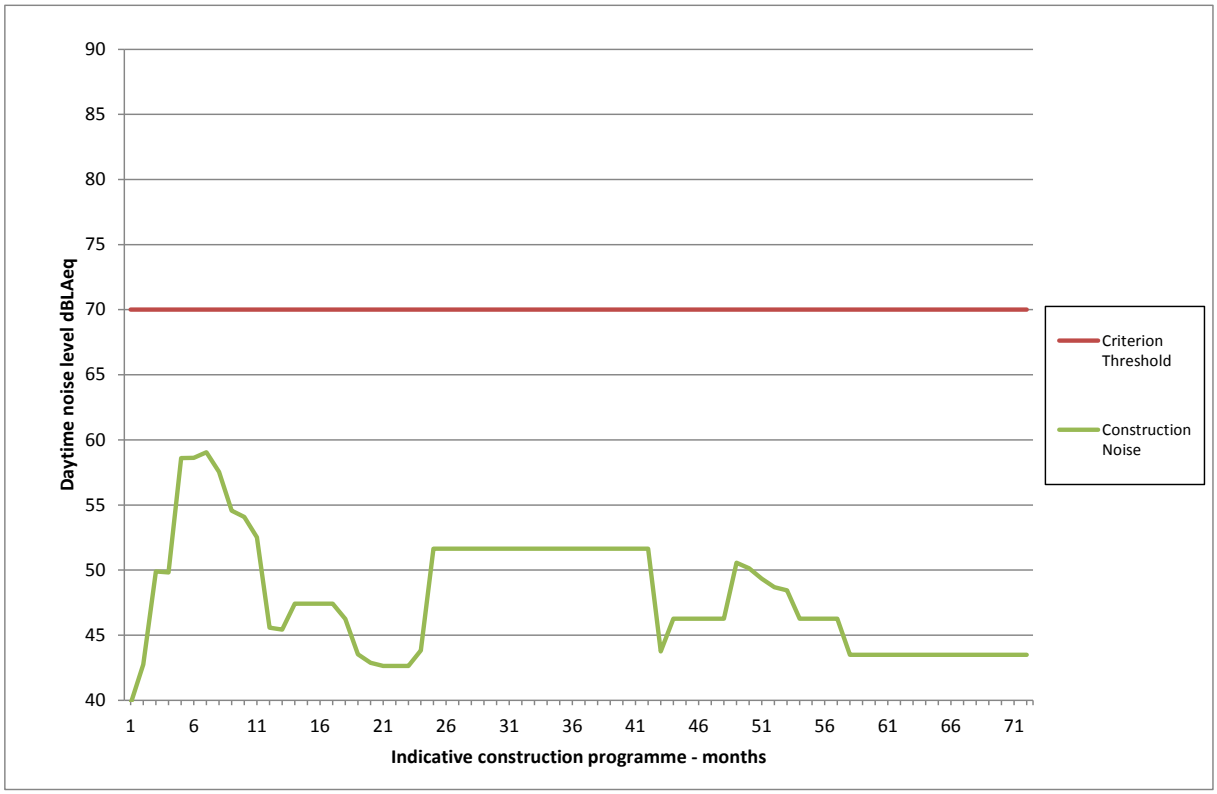
Vol 20 Plate G.14 Average monthly daytime noise level over duration of construction – 8-14 Fountain Green Square (CW8)



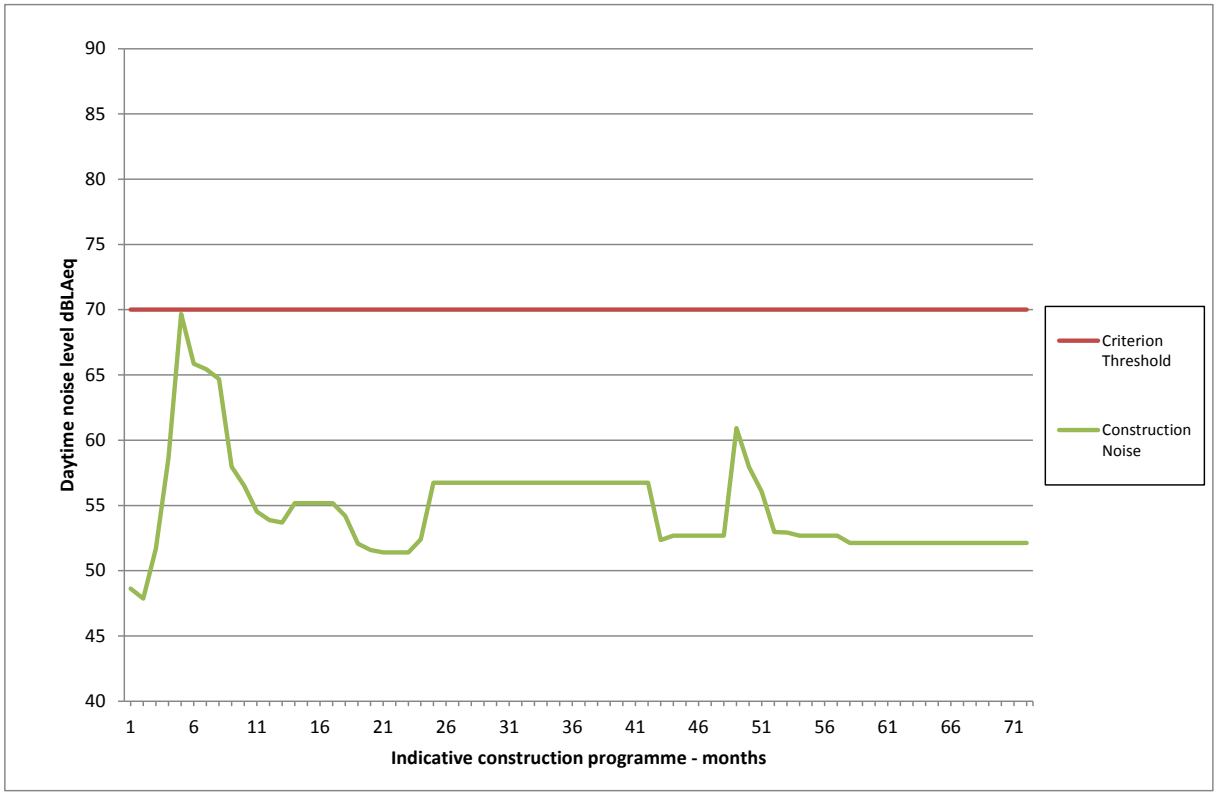
Vol 20 Plate G.15 Average monthly daytime noise level over duration of construction – 35 Wapping High Street (CW9)



Vol 20 Plate G.16 Average monthly daytime noise level over duration of construction – Houseboats (CW10)



Vol 20 Plate G.17 Average monthly daytime noise level over duration of construction – 33 East Street (CW11)



References

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

Thames Tideway Tunnel
Thames Water Utilities Limited

Application for Development Consent

Application Reference Number: WWO10001

Environmental Statement

Doc Ref: **6.2.20**

Volume 20: Chambers Wharf appendices

Appendix H: Socio-economics

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

Hard copy available in

Box **34** Folder **B**
January 2013

Thames Tideway Tunnel

Creating a cleaner, healthier River Thames

This page is intentionally blank

Thames Tideway Tunnel

Volume 20 Appendices: Chambers Wharf site assessment

Appendix H: Socio-economics

List of contents

Page number

List of tables

Page number

This page is intentionally blank

Appendix H: Socio-economics

H.1 Baseline community profile

H.1.1 The community profile is based on both '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.1.2 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 an assessment area of 250m) the 'wider local area' (ie, within an assessment area of 1km) and the overall borough level (which in this case is the London Borough [LB] of Southwark).

H.1.3 The main protected characteristic groups concentrated[iii] within 250m of the proposed construction site are:

a. persons aged over 65 years old

b. persons suffering from a long term or limiting illness.

H.1.4 The main protected characteristic groups concentrated within 1km of the site are:

a. persons of Asian ethnicity

b. persons suffering from income deprivation and overall deprivation.

Resident population

H.1.5 The resident population was approximately 2,500 within 250m of the site and approximately 34,375 within 1km at the time of the last census.

Gender and age

H.1.6 Of the total population within 250m of the site, 51.1% of residents are female, in line with the borough wide proportion of female residents (also 51.1%) and the Greater London average (51.6%). Within 1km however, male residents are slightly more predominant (50.7%).

[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.1.7 Vol 20 Table H.1 outlines age breakdown by assessment area, it illustrates that the proportions of under 16 year olds within 250m (17.8%) and 1km (17.7%) are broadly in line, but somewhat lower than both the LB of Southwark (20.3%) and Greater London (20.2%) averages.

H.1.8 Within 250m the number of over 65 year olds (15.0%) is somewhat higher than the Greater London average (12.4%) and moderately higher than within 1km (10.8%) and the LB of Southwark (10.4%).

Vol 20 Table H.1 Socio-economics - age breakdown by assessment area

Age group	Assessment area			
	Immediate area (250m)	Wider local area (1km)	Borough wide (LB of Southwark)	Greater London
Under 16 years old	17.8%	17.7%	20.3%	20.2%
Over 65 years old	15.0%	10.8%	10.4%	12.4%

Ethnicity

H.1.9 Vol 20 Table H.2 outlines ethnicity by assessment area, showing that within 250m of the site, White residents comprise over four fifths of the population (80.5%), with Black and Minority Ethnic (BME) residents making up the remaining 19.5%.

H.1.10 The proportion of White residents within 250m (80.5%) is moderately higher the LB of Southwark level (63.0%). Within 1km, the proportion of White residents (72.0%) is broadly in line with the Greater London level (71.2%) but somewhat lower than within 250m (80.5%).

H.1.11 Within 250m, the proportion of Black residents (11.0%) is in line with the Greater London average (10.9%) and slightly lower than within 1km (12.5%). Within all the above assessment areas, the proportion of Black residents is considerably lower than the LB of Southwark level (25.9%).

H.1.12 The proportion of Asian residents within 250m (3.5%) is somewhat lower than the LB of Southwark level (4.1%) and considerably lower than the proportion within 1km (9.9%) and at a Greater London level (12.1%).

Vol 20 Table H.2 Socio-economics - ethnicity by assessment area

Ethnicity	Assessment area			
	Immediate area (250m)	Wider local area (1km)	Borough wide (LB of Southwark)	Greater London
White	80.5%	72.0%	63.0%	71.2%
BME	19.5%	28.0%	37.0%	28.8%
Asian	3.5%	9.9%	4.1%	12.1%

Ethnicity	Assessment area			
	Immediate area (250m)	Wider local area (1km)	Borough wide (LB of Southwark)	Greater London
Black	11.0%	12.5%	25.9%	10.9%
Other	2.3%	2.7%	3.3%	2.7%
Mixed	2.8%	2.9%	3.7%	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.1.13 Within 250m and 1km of the site and at a borough wide level, Christians are the predominant religious group at 65.3%, 59.2% and 61.6% respectively. Within 250m, Muslims are the second most predominant religious group (4.7%), somewhat lower than the proportion of Muslims at a borough wide level (6.8%) and considerably lower than within 1km (11.5%).

H.1.14 Within 250m, approximately 27.6% of residents do not follow or state a religion, broadly in line with the borough wide level (28.4%) and 1km level (26.8%), and somewhat higher than the Greater London average (24.3%).

Health indicators

H.1.15 Vol 20 Table H.3 outlines health indicators by assessment area, noting that within 250m of the site, the proportion of residents suffering from a long term or limiting illness (16.5%) is slightly higher than within 1km (15.3%) the LB of Southwark (15.6%) and Greater London (15.5%) proportions. Those residents who claim disability living allowance within 250m and 1km (both 4.9%) are slightly lower than the LB of Southwark average (5.4%) but slightly higher than the Greater London level (4.5%).

Vol 20 Table H.3 Socio-economics - health indicators by assessment area

Health indicator	Assessment area			
	Immediate area (250m)	Wider local are (1km)	Borough wide (LB of Southwark)	Greater London
Long term limiting sick	16.5%	15.3%	15.6%	15.5%
Disability living allowance	4.9%	4.9%	5.4%	4.5%

H.1.16 In the Middle Layer Super Output Area (MSOA)[iv5] within which the construction site falls, adult obesity falls in the second lowest quintile (ie, the lowest being the best) relative to Greater London. In contrast, the incidence of child obesity falls within the highest quintile (ie, the highest being the worst) relative to Greater London.

H.1.17 In terms of the rates of adults undertaking physical activity, as measured borough wide, the LB of Southwark ranks within the second highest quintile (ie, the highest being the best) relative to Greater London. The proportion of children undertaking physical activity falls within the highest quintile, relative to Greater London.

H.1.18 Death rates by circulatory disease, cancer, strokes and heart disease within the MSOA within which the site falls are in the lowest quintile (ie, the lowest being the best) relative to Greater London. Deaths caused by respiratory disease are more prevalent and the local MSOA falls within the second lowest quintile.

H.1.19 In the MSOA that the construction site is located within, both male and female life expectancy fall in the highest quintile (ie, the highest being the best) relative to Greater London. Average life expectancy for both male and female residents is 84.9 to 93.1years old.

Lifestyle and deprivation indicators

H.1.20 Vol 20 Table H.4 outlines lifestyle and income deprivation indicators by assessment area, showing that within 250m and 1km of the site, and at a borough level, approximately half of all households do not own cars (50.4%, 51.8% and 51.9% respectively). The Greater London average (37.5%) is somewhat lower than the above assessment areas.

H.1.21 The incidence of income deprivation[v] within 250m (29.4%) is moderately lower than within 1km (41.3%) and the LB of Southwark (37.4%). Income deprivation within Greater London (21.5%) is somewhat lower than within 250m (29.4%) and considerably lower than within 1km (41.3%) and at a borough level (37.4%).

H.1.22 Overall deprivation within 250m (29.4%) is moderately lower than within 1km (35.8%) and within the LB of Southwark (31.4%). Within Greater London, overall deprivation (18.3%) is moderately lower than within 250m (29.4%) and considerably lower than within 1km (35.8%) and the borough wide level (31.4%).

[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.

[v] Income deprivation and overall deprivation in this instance both refer to the percentage of the population which fall within the top 20% of deprived areas nationally. Percentages therefore refer to the proportion of residents within each assessment area who fall within the highest quintile of deprivation within England.

Vol 20 Table H.4 Socio-economics - lifestyle and income deprivation levels by assessment area

Indicator	Assessment area			
	Immediate area (250m)	Wider local area (1km)	Borough wide (LB of Southwark)	Greater London
No car households	50.4%	51.8%	51.9%	37.5%
Income	29.4%	41.3%	37.4%	21.5%
Overall	29.4%	35.8%	31.4%	18.3%

H.2 Baseline economic profile

H.2.1 This section presents a profile of the economy local to the proposed construction site at Chambers Wharf.

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 London Borough [LB] of Southwark) and for Greater London.

H.2.3 Data are sourced from Experian's National Business Database (2012)[6] which draws primarily on regularly updated records from Companies House[vi].

Employment and businesses

H.2.4 Within approximately 250m of the site there are approximately 1,400 jobs.[vii] Vol 20 Table H.5[viii] illustrates the breakdown of employment by sector based on the UK Standard Industrial Classification (SIC) 2007[7]. It presents data for those sectors which account for more than 5% of total employment within 250m. It can be seen that:

a. Administrative and Support Service Activities account for 20% of employment within 250m, more than double that within both the LB of Southwark (8%) and Greater London (8%).

b. Professional, Scientific and Technical Activities account for 11% to 13% of employment at all three geographical levels.

c. Information and Communication accounts for 12% of employment within 250m of the site, considerably more than within both the LB of Southwark (7%) and Greater London (7%).

d. Education accounts for 7% to 8% of employment at all three geographical levels.

e. Wholesale and Retail Trade / Repair of Motor Vehicles and Motorcycles accounts for 8% of employment within 250m, considerably less than within the LB of Southwark (13%) and half that within Greater London (16%).

f. Other Service Activities account for 4% to 6% of employment at all three geographical levels.

[vi] 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.

[vii] 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.

[viii] Data in tables rounded to nearest whole percentage and do not always sum due to rounding.

Vol 20 Table H.5 Socio-economics - employment by top six sectors (2012)

	Assessment area		
Sector (Standard Industrial Code 2007)	**Immediate area (250m)**	**Borough wide (LB of Southwark)**	**Greater London**
Administrative and Support Service Activities	20%	8%	8%
Professional, Scientific and Technical Service Activities	13%	13%	11%
Information and Communication	12%	7%	7%
Education	8%	7%	7%
Wholesale and Retail Trade / Repair of Motor Vehicles and Motorcycles	8%	13%	16%
Other Service Activities	6%	4%	4%
Other (including Unclassified)	32%	47%	47%

H.2.5 Within approximately 250m of the site there are approximately 260 businesses (defined here as business locations[ix]). The split of businesses by sector within 250m generally reflects the breakdown of employment by sector as set out in Vol 20 Table H.5, with a relatively high number of businesses engaged in Administrative and Support Service Activities (13%), Information and Communication Activities (13%), Professional, Scientific and Technical Service Activities (11%) and Wholesale and Retail Trade, Repair of Motor Vehicles and Motorcycles (9%). However, Education only accounts for 2% of businesses (eg, schools), while generating 8% of employment.

H.2.6 Vol 20 Table H.6 illustrates the size of businesses in terms of the number of employees at each business location / unit. At all geographical levels the, businesses within the smallest size band (1 to 9 employees) account for the greatest proportion. However there is a greater proportion of smaller businesses within approximately 250m of the site than within the wider geographical areas. Within 250m, 91% of business units have one to nine employees, compared with 85% within the LB of Southwark and 88% within Greater London. Businesses with ten to 24 employees account for 7% of business locations, slightly less than within the LB of Southwark (9%) and Greater London as a whole (8%).

H.2.7 For the sectors accounting for the greatest proportion of jobs and businesses within approximately 250m, the size banding of businesses follows a similar pattern. Around 90% of Information and Communication, Administrative and Support Service Activities, Professional, Scientific and

[ix] 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.

Technical Activities and Wholesale and Retail Trade, Repair of Motor Vehicles and Motorcycles businesses have one to nine employees similar to the average across all sectors of 91%.

H.2.8 Within the Administrative and Support Service Activities sector the proportion of businesses employing 100 to 249 employees (3%) is considerably greater than both the average across all sectors (0%), the LB of Southwark (1%) and Greater London (1%).

Vol 20 Table H.6 Socio-economics - businesses by size band (number of employees)

Assessment area / sector	Size band (number of employees)					
	1-9	10-24	25-49	50-99	100-249	250+
Immediate area (250m)	91%	7%	1%	0%	0%	0%
Information and Communication	91%	9%	0%	0%	0%	0%
Administrative and Support Service Activities	91%	6%	0%	0%	3%	0%
Professional, Scientific and Technical Activities	87%	10%	3%	0%	0%	0%
- *Wholesale and Retail Trade; Repair of Motor Vehicles and Motorcycles*	87%	13%	0%	0%	0%	0%
Borough wide (LB of Southwark)	85%	9%	3%	1%	1%	0%
Greater London	88%	8%	2%	1%	1%	0%

References

[1] ONS. *Neighbourhood Statistics* (2001). Available at: http://neighbourhood.statistics.gov.uk/dissemination/

[2] Department for Communities and Local Government. *Index of Multiple Deprivation 2010* (2010). Available at: http://www.communities.gov.uk/communities/research/indicesdeprivation/deprivation10/

[3] London Public Health Observatory. *Fair Society, Healthy Lives: The Marmot Review (2012)*. Available from: http://www.lho.org.uk/LHO_TOPICS/NATIONAL_LEAD_AREAS/MARMOT/MARMOTINDICATORS.ASPX. Accessed 30 August 2012

[4] Network of Public Health Observatories. *Health Profiles: London* (2011-2012) Available at: http://www.apho.org.uk/resource/view.aspx?QN=HP_REGION_H. Accessed February 2012.

[5] Office of National Statistics. *Super Output Areas: Introduction* (2012). Available from: http://www.neighbourhood.statistics.gov.uk/dissemination/Info.do;jessionid=vtvdPZRWZ3yhT9ShjB6TTcw00WNTZcPQgyVpGLvZjTzh7nYnBhqL!1624269762!1327075798387?m=0&s=1327075798387&een=1&page=aboutneighbourhood/geography/superoutputareas/soa-intro.htm&nsjs=true&nsck=true&nssvg=false&nswid=1225. Accessed on: 29 May 2012

[6] Experian. *National Business Database* (Database of employment and enterprise statistics). Accessed: September 2012.

[7] Office of National Statistics. *UK Standard Industrial Classification of Economic Activities 2007 (SIC 2007)*, 2009. Available at: http://www.ons.gov.uk/ons/guide-method/classifications/current-standard-classifications/index.html. Accessed 5/9/12.

This page is intentionally blank

Thames Tideway Tunnel
Thames Water Utilities Limited

Application for Development Consent

Application Reference Number: WWO10001

Environmental Statement

Doc Ref: **6.2.20**

Volume 20: Chambers Wharf appendices

Appendix I: Townscape and visual

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

Hard copy available in

Box **34** Folder **B**
January 2013

Thames Tideway Tunnel

Creating a cleaner, healthier River Thames

This page is intentionally blank

Thames Tideway Tunnel

Environmental Statement

Volume 20 Chambers Wharf appendices

Appendix I: Townscape and visual

List of contents

Page number

This page is intentionally blank

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.

This page is intentionally blank

Thames Tideway Tunnel
Thames Water Utilities Limited

Application for Development Consent

Application Reference Number: WWO10001

Environmental Statement

Doc Ref: **6.2.20**

Volume 20: Chambers Wharf appendices

Appendix J: Transport

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

Hard copy available in

Box **34** Folder **B**
January 2013

Thames Tideway Tunnel

Creating a cleaner, healthier River Thames

This page is intentionally blank

Thames Tideway Tunnel

Environmental Statement

Volume 20 Chambers Wharf appendices

Appendix J: Transport

List of contents

Page number

.

This page is intentionally blank

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.

This page is intentionally blank

Thames Tideway Tunnel
Thames Water Utilities Limited

Application for Development Consent

Application Reference Number: WWO10001

Environmental Statement

Doc Ref: **6.2.20**

Volume 20: Chambers Wharf appendices

Appendix K: Water resources - groundwater

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

Hard copy available in

Box **34** Folder **B**
January 2013

Thames Tideway Tunnel

Creating a cleaner, healthier River Thames

This page is intentionally blank

Thames Tideway Tunnel

Environmental Statement

Volume 20 Appendices: Chambers Wharf site assessment

Appendix K: Water resources − groundwater

List of contents

Page number

List of plates

Page number

List of tables

Page number

Appendix K: Water resources – groundwater

K.1 Geology

K.1.1 A summary of the anticipated geological succession at the Chambers Wharf site is shown in Vol 20 Table K.1.

Vol 20 Table K.1 Groundwater – anticipated geological succession

Period	Series	Group	Formation
Quaternary	Holocene	Superficial deposits	Made ground
			Alluvium
			Langley Silt
	Pleistocene		River Terrace Deposits
Palaeogene	Eocene	Thames	London Clay
			Harwich
	Palaeocene	Lambeth	Upper Shelly Beds
			Upper Mottled Beds (UMB)
			Laminated Beds (LtB)
			Lower Shelly Beds (LSB)
			*Mid-Lambeth Hiatus**
			Lower Mottled Beds (LMB)
			Upnor
		No group	Thanet Sand
Cretaceous	Upper Cretaceous	White Chalk Subgroup	Seaford Chalk**
			Lewes Nodular Chalk
			New Pit Chalk
			Holywell Nodular Chalk

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

K.1.2 The superficial and solid geology in the vicinity of the site, as published by the British Geological Survey (BGS), 2009))[1], is shown in Vol 20

Figure13.4.1 and Vol 20 Figure13.4.2 respectively (see separate volume of figures).

K.1.3 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 two overwater boreholes located immediately adjacent to the Chambers Wharf site: these are boreholes SR2034 and SR5018. The locations of boreholes around the site are shown in Vol 20 Figure13.4.1 (see separate volume of figures). The depths and thicknesses of geological layers encountered are summarised in Vol 20 Table K.2.

Vol 20 Table K.2 Groundwater – anticipated ground conditions

Formation	Top elevation* (mATD)**	Depth below ground level (m)	Thickness (m)
Made Ground	104.00	0.00	2.00
Alluvium	102.00	2.00	3.00
River Terrace Deposits	99.00	5.00	4.50
London Clay Formation, unit A2	94.50	9.50	2.00
Harwich Formation	92.50	11.50	1.50
Lambeth Group			
UMB	91.00	13.00	4.90
LtB (Sa)	86.10	17.90	0.60
LtB	85.50	18.50	2.00
LSB	83.50	20.50	2.30
LMB	81.20	22.80	4.60
UPN	76.60	27.40	1.61
Thanet Sand Formation	74.99	29.01	13.90
Chalk	61.09	42.91	Not proven

** Based on an assumed ground level of 104.00mATD*

*** 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)*

UMB–Upper Mottled Beds; LtB (Sa) – Laminated Beds, sand horizon; LMB –Laminated Beds; LSB-Lower Shelly Beds; LMB-Lower Mottled Beds; UPN-Upnor Formation

K.1.4 The main tunnel shaft at Chambers Wharf would extend down to approximately 47.25mATD and would pass through the Made Ground, Alluvium, River Terrace Deposits (RTD), London Clay Formation (unit 2), Harwich Formation, Lambeth Group, Thanet Sand Formation and into the Chalk. The base slab would extend to approximately 41.25mATD and be founded in the Chalk.

K.1.5 The Made Ground, containing sandy gravely silt with occasional brick and concrete fragments, is expected to be 2m thick at the Chambers Wharf site.

K.1.6 The Alluvium, comprising slightly gravely clay, with occasional scattered pebbles and granules, is expected to be 3m at the Chambers Wharf site.

K.1.7 The RTD are formed by extensive alluvial sand and gravel deposits laid down in river terraces by a braided river system of approximately 5km width. The RTD has been set down since the Anglian glaciation. The RTD are expected to be 4.5m thick at the Chambers Wharf site.

K.1.8 The London Clay is described by the BGS as "fine, sandy, silty clay/silty clay, glauconitic at base" (British Geological Survey, May 2012)[2] and is comprised of firm to stiff sandy, silty clay at the Chambers Wharf site. Across the range of the London Clay stratum 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 very thin (approximately 2m thick) at the Chambers Wharf site and to comprise of unit A2 only. In the eastern part of London this formation is absent, and at the site it is very near the feather edge of this stratum.

K.1.9 The Harwich Formation comprises fine-grained glauconitic sand and rounded black flinty pebble beds, commonly deposited in a series of superimposed channels and is expected to be 1.5m thick at the Chambers Wharf site.

K.1.10 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 4.9m thick at the Chambers Wharf site.

K.1.11 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 2.6m thick at the Chambers Wharf site. The top 0.6m is comprised of a sand channel at this location.

K.1.12 The Lower Shelly Beds (LSB) of the Lambeth Group comprises dark grey to black clay with abundant shells and are expected to be 2.3m thick at the Chambers Wharf site.

K.1.13 The Lower Mottled Beds (LMB) of the Lambeth Group comprises of silty clay and clay, generally un-bedded, fissured and blocky, with up to 50% silt and sand and are expected to be 4.6m thick at the Chambers Wharf site.

K.1.14 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. The UPN is expected to be 1.61m thick at the Chambers Wharf site.

K.1.15 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 (British Geological Survey . 2000)[3]. The Thanet Sand is expected to be 13.9m thick at the Chambers Wharf site.

K.1.16 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 has not been proven through the available ground investigation.

K.1.17 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, K.R., 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 Embankment Foreshore and tunnel construction at Chelsea Embankment Foreshore. The Chambers Wharf 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.2.1 A summary of the anticipated hydrogeological conditions at the Chambers Wharf site is shown in Vol 20 Table K.3.

Vol 20 Table K.3 Groundwater – anticipated hydrogeological units

Group	Formation	Hydrogeology
Superficial deposits	(MG) Alluvium	Hydraulic continuity with upper aquifer
	RTD	Upper aquifer
Thames	London Clay	Aquiclude*
	Harwich	Aquitard**
Lambeth	Upper Shelly Beds UMB LtB LSB -----Mid Lambeth Hiatus***---- LMB Upnor	Aquitards/ aquifers
		Lower aquifer

Group	Formation		Hydrogeology
No group	Thanet Sand		
White Chalk Subgroup	White Chalk	Undivided mainly Seaford Chalk	

** 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 , August 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 (Environment Agency , April 2012)[6].*
**** Not a Formation but an important depositional feature.*

K.2.2 The Alluvium overlies the RTD or upper aquifer and is likely to be in hydraulic continuity with the upper aquifer.

K.2.3 The upper aquifer (RTD) 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" (EA, 2012)[6].

K.2.4 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)[6].

K.2.5 The main tunnel shaft would pass through the upper aquifer and then the London Clay Formation (A2 sub division). The London Clay Formation is generally acknowledged as an aquiclude between the upper and lower aquifers. Any groundwater present in the London Clay Formation is likely to consist of localised seepages and/or minor flows.

K.2.6 The 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.2.7 The main tunnel shaft would also pass through the Lambeth Group, in which several confined groundwater bodies are anticipated to be encountered. Groundwater inflows are expected during excavation within the Upper Shelly Beds with potentially small inflows and more significantly at sub-artesian pressures within the LtB (formerly part of the Woolwich Formation).

K.2.8 The main tunnel shaft would pass through the UPN, the Thanet Sands and into the underlying Chalk. These units have been considered to be in hydraulic continuity with each other and with the underlying Seaford Chalk.

K.2.9 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 Chambers Wharf 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 $1x10^{-4}$ (EA, 2011) (EA and ESI , June 2010)[7].

K.3 Groundwater level monitoring

K.3.1 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.3.2 Information on groundwater levels for this assessment was collected from two off site ground investigation boreholes located within 450m, one to the west (SR1054A) and one to the east (SR1057) of the Chambers Wharf site (SR1054A and SR1057). These boreholes have response zones[i] and monitor groundwater levels in the Seaford Chalk. There are no boreholes which monitor groundwater levels in the RTD at any nearby locations. The response zone depths, the monitored strata and the frequency of monitoring are detailed in Vol 20 Table K.4. The manual dip and logger data collected from these monitoring boreholes is shown in Vol 20 Table K.5.

Vol 20 Table K.4 Groundwater – monitoring boreholes

Borehole	Response zone depths mATD	Strata	Monitoring
SR1054A	36.40 – 43.50	Seaford Chalk	Fortnightly dip and logger
SR1057	36.02 – 51.02	Seaford Chalk	Fortnightly dip

Vol 20 Table K.5 Groundwater – summary level data

Borehole	Period of record	Maximum		Minimum		Average	
		mbgl	mATD	mbgl	mATD	mbgl	mATD
SR1054A	19/11/2009 – 09/03/2012	14.77 (Dec. 2011)	88.73 (Dec. 2011)	16.94 (Jan. 2010)	86.57 (Jan. 2010)	15.87	87.64

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

Borehole	Period of record	Maximum		Minimum		Average	
		mbgl	mATD	mbgl	mATD	mbgl	mATD
SR1057	01/07/2009 – 24/07/2012	26.90 (April 2011)	77.12 (April 2011)	28.90 (July 2010)	75.12 (July 2010)	27.80	76.22

K.3.3 The recorded water levels (piezometric head[ii]) in the Chalk at SR1054A and at SR1057 range from 75.12mATD to 88. 73mATD. These water levels consistently remain above the top of the Chalk at 61.09mATD, indicating that this formation is fully saturated and confined by the overlying London Clay Formation and Lambeth Group.

K.3.4 The nearest EA groundwater level monitoring borehole is TQ37_276, located at 0.8km to the east of the site. This borehole records groundwater levels in the Chalk aquifer. The recorded water levels in TQ37_276 range from around 81mATD to 90mATD, which is within the range recorded at SR1054A.

K.3.5 A plot of groundwater levels within the Chalk in the vicinity of the site is shown in Vol 20 Figure 13.4.3 (see separate volume of figures). The EA have produced regional groundwater contour plots which display the groundwater flowing in to the northwest across site (EA , June 2011)[8].

K.3.6 In the absence of monitoring boreholes within the upper aquifer, it is difficult to determine the direction of groundwater flow within this waterbody. However it is likely that the direction of groundwater movement is from west to east, towards the River Thames, in these shallow deposits.

K.4 Groundwater abstractions and protected rights

Groundwater licensing policy

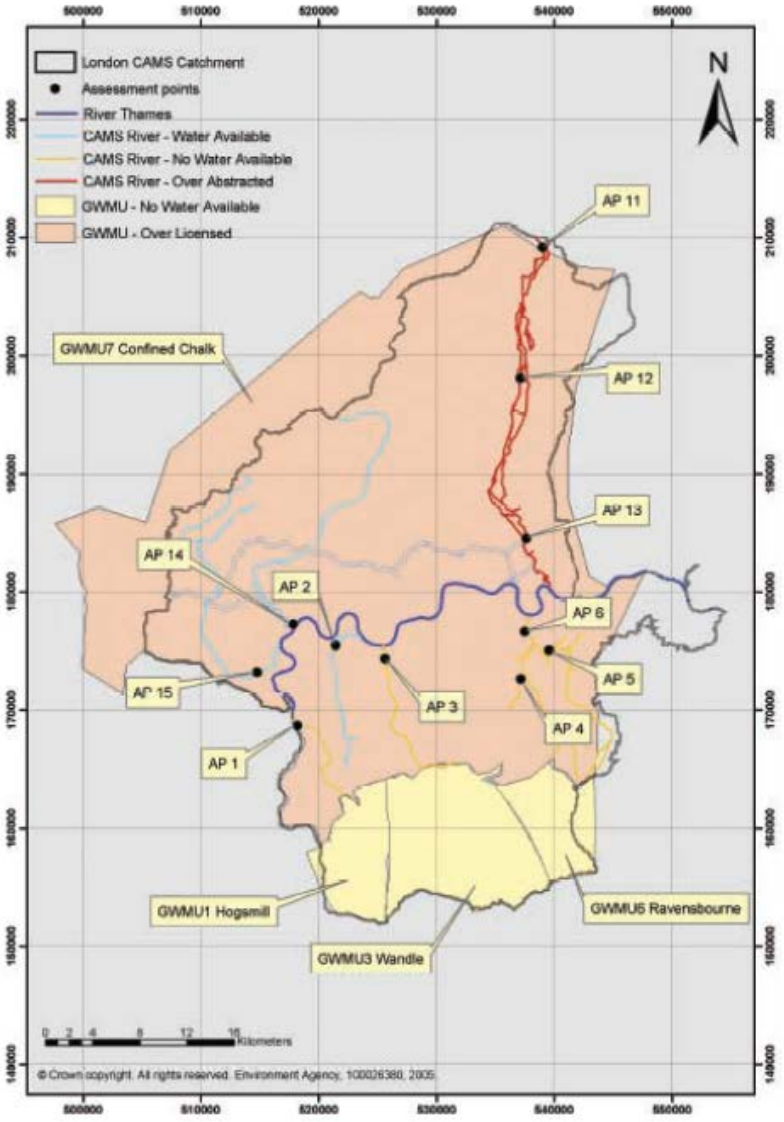
K.4.1 The London Catchment Abstraction Management Strategy (CAMS), (EA , 2006)[9] does not identify a condition status for the upper aquifer.

K.4.2 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 limit (EA , 2006)[10]. The Chambers Wharf site is located within the confined Chalk groundwater management unit GWM7, which is classified as being over-licensed (see Vol 20 Plate K.1) (EA, 2006)[9]. 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)[9]. In addition, large abstractions may

[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.

also have a time limit shorter than the London CAMS common end date of 2013 (EA, 2006)[9].

Vol 20 Plate K.1 Groundwater – confined chalk licensing



K.4.3 The CAMS policy 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)[9]. A preliminary hydrogeological assessment, following guidance provided in the CAMS policy, has been completed for the proposed development in Vol 20 Table K.6.

Vol 20 Table K.6 Groundwater – licensing assessment

No.	Question	Preliminary response
1.	Has there been any long-term (several years) downward trend in the groundwater level in the vicinity of the application?	The hydrograph in Vol 20 Figure13.4.4 for EA observation boreholes in the vicinity of the site show the groundwater level to have been broadly stable

No.	Question	Preliminary response
		with no downward trend since 2000.
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 water level in the lower aquifer is expected to be at about 77mATD and around 4m above the top of the Thanet Sand Formation. The dewatering activity associated with the main tunnel shaft construction could locally lower the water level below the top of the Thanet Sand.
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. Chambers Wharf is not located within the catchment areas of any licensed groundwater abstractions from the Chalk (lower aquifer). The nearest licensed Chalk abstractions are at a distance of 1.0km away to the west and east. There are no unlicensed groundwater abstractions within a 1km radius of the site.
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 operator.	No known ARS in the vicinity.

K.4.4 The estimated dewatering volume required at Chambers Wharf from the lower aquifer of less than 200m^3/d and this is within the most restrictive abstraction licensing limit set by the EA of 0.2Ml/d (200m^3/d) for Central

and South London (EA, 2006)[9]. Therefore a detailed local assessment is unlikely to be required by the EA.

Licensed abstractions

K.4.5 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 20 Figure 13.4.5. The locations of public water supply sources are not presented due to restriction on the display of this information.

K.4.6 There are no licensed groundwater abstractions from the RTD or upper aquifer located within 1km of the Chambers Wharf site; however these are two licensed groundwater abstractions from the Chalk located within 1km of the site.

K.4.7 The nearest licensed groundwater abstraction (28/39/42/0062) is held by London Bridge Development Limited, is located approximately 1km to the west and is used for non-evaporative cooling purposes (Ground Source Heap Pump [GSHP] scheme).

K.4.8 The next nearest licensed groundwater abstraction (28/39/42/0048) is held by the London Borough of Southwark, is located approximately 1.1km to the east and is used for amenity purposes.

K.4.9 The details of these licensed abstractions within approximately 1km radius are summarised in Vol 20 Table K.7.

Vol 20 Table K.7 Groundwater – licensed abstractions

Licence number	Licence holder	Purpose	Aquifer
28/39/42/0062	London Bridge Development Ltd	Non-evaporative cooling	Chalk
28/39/42/0048	LB of Southwark	Amenity	Chalk

K.4.10 There are no known unlicensed groundwater abstractions within 1km of the Chambers Wharf site.

K.5 Groundwater source protection zones

K.5.1 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.5.2 The Chambers Wharf site is not located within a modelled SPZ. The nearest modelled SPZ for a Chalk source lies at approximately 3.4km to the southeast.

K.6 Environmental designations

K.6.1 There are no designations relevant to groundwater such as SSSI, SAC or SNCIs within 1km of the Chambers Wharf site.

K.7 Groundwater quality and land quality assessment

K.7.1 Historical land use mapping at the Chambers Wharf site, reviewed as part of the land quality assessment, has identified one potentially contaminative land use on site (Vol 20 Section 8). The site was previously operated as the Chambers Wharf (around 1878). In addition, areas of previous industrial activities have been identified in close proximity to the site, including a dock immediately east of the site boundary, a medicinal factory to the north and a flour mill to the west. 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.7.2 The groundwater quality data presented in Vol 20 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 between 360m and 1050m of the Chambers Wharf site (SR1055, SA1056, SR1054A, SR1053, SR1052 and SR1051) (for locations see Vol 20 Figure13.4.1) and within the RTD and Chalk. Any exceedances of the UK drinking water standards (The Water Supply (Water Quality) Regulations, 2000)[11] or relevant Environmental Quality Standards (EQS)) (Water Framework Directive, 2010)[12] are shaded in blue in this table.

K.7.3 The data shows no exceedances of the relevant standards within the RTD but several exceedances within the Chalk for ammonia, sodium, heavy metals and pesticides at SR1055 (located 360m from the site), for chloride and heavy metals at SR1054A (located 540m from the site) and for sulphate and magnesium only at SR1053 and SR1052 (located 720m and 870m from the site respectively). The exceedances of chloride, magnesium and sodium indicate brackish conditions, which are expected due to the location close to the tidal River Thames.

K.7.4 The EA monitors groundwater quality at a number of points across London. The nearest EA monitoring location in the Chalk is the Victoria Deepwater Terminal (PGWU1888), at a distance of approximately 3km to the east. The distance of this location from Chambers Wharf makes it unreliable as predictor of water quality conditions around the site.

Vol 20 Table K.8 Groundwater – groundwater quality results

Source of data*				SI	TT	TT	TT	TT	TT	TT	SI	SI	SI	SI
Name				SR1055	SR1055	SR1055	SR1055	SR1055	SR1055	SR1055	SR1054A	SR1053	SR1052	SR1051
Hydrogeological unit**				SCK	CK	CK	CK	CK	CK	CK	SCK	SCK	SCK	SCK
Distance from site	EQS Criteria			362m	362m	362m	362m	362m	362m	362m	543m	719m	867m	1050m
Chemical	Value	Units	Source	2009	15/8/2011	28/9/2011	4/11/2011	30/1/2012	18/4/2012	16/5/2012	1/1/2010	1/1/2010	1/1/2010	1/1/2010
1,1 - Dichloroethane	10	ug/l	WFD 2010	-	-	<0.09	-	-	-	-	<1	-	-	-
1,1 - Dichloroethene	30	ug/l	WHO 2004	-	-	<0.12	-	-	-	-	<1	-	-	-
1,1,1 - Trichloroethane	100	ug/l	SW Regs 98	-	<0.08	<0.1	<0.08	<0.08	-	< 0.08	<1	-	-	-
1,1,2 - Trichloroethane	400	ug/l	SW Regs 98	-	<0.2	<0.2	<0.2	<0.2	-	< 0.2	<1	-	-	-
1,2 - Dibromo - 3 - Chloropropane	0.1	ug/l	DWS 2010	-	-	-	-	-	-	-	<1	-	-	-
1,2 - Dibromoethane	0.1	ug/l	DWS 2010	-	-	-	-	-	-	-	<1	-	-	-
1,2 - Dichlorobenzene	1000	ug/l	WHO 2004	-	-	-	-	-	-	-	<1	-	-	-
1,2 - Dichloroethane {Ethylene Dichloride}	3	ug/l	WS Regs 20	-	<0.12	<0.12	<0.12	<0.12	-	< 0.12	<1	-	-	-
1,2 - Dichloroethene (Trans)	30	ug/l	WHO 2004	-	-	<0.12	-	-	-	-	<1	-	-	-
1,2 - Dichloropropane	0.1	ug/l	DWS 2010	-	-	-	-	-	-	-	<1	-	-	-
1,2,3 - Trichlorobenzene	-	ug/l	None	-	-	-	-	-	-	-	<1	-	-	-
1,2,3 - Trichloropropane	-	ug/l	None	-	-	-	-	-	-	-	<1	-	-	-
1,2,4 - Trichlorobenzene	-	ug/l	None	-	-	-	-	-	-	-	<1	-	-	-
1,2,4 - Trimethylbenzene	-	ug/l	None	-	-	-	-	-	-	-	<1	-	-	-
1,3 - Dichlorobenzene	-	ug/l	None	-	-	-	-	-	-	-	<1	-	-	-
1,3 - Dichloropropane	-	ug/l	None	-	-	-	-	-	-	-	<1	-	-	-
1,3 - Dichloropropene (Trans)	-	ug/l	None	-	-	-	-	-	-	-	<1	-	-	-
1,3,5 - Trimethylbenzene	-	ug/l	None	-	-	-	-	-	-	-	<1	-	-	-
2 - Chloronaphthalene	-	ug/l	None	-	-	-	-	-	-	-	<1	-	-	-
2 - Chlorophenol	50	ug/l	WFD 2010	-	-	<0.02	-	-	-	-	<1	-	-	-
2 - Chlorotoluene	-	ug/l	None	-	-	-	-	-	-	-	<1	-	-	-
2 - Methylnaphthalene	-	ug/l	None	-	-	-	-	-	-	-	<1	-	-	-
2 - Methylphenol {O-Cresol}	-	ug/l	None	-	-	<0.021	-	-	-	-	<1	-	-	-
2 - Nitroaniline	-	ug/l	None	-	-	-	-	-	-	-	<1	-	-	-
2 - Nitrophenol	-	ug/l	None	-	-	-	-	-	-	-	<1	-	-	-
2,2 - Dichloropropane	-	ug/l	None	-	-	-	-	-	-	-	<1	-	-	-
2,3 - Dimethylphenol {2,3-Xylenol}	-	ug/l	None	-	-	<0.05	-	-	<0.0500	-	-	-	-	-
2,3,4,6 - Tetrachlorophenol	-	ug/l	None	-	-	-	-	-	-	-	<0.1	-	-	-
2,3,5,6 - Tetrachloroaminobenzene {2,...Aniline}	-	ug/l	None	-	-	<0.00500	-	-	0.00260	-	-	-	-	-
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	<0.1	-	-	-	-	-	-	<0.1	<0.1	<0.1	<0.1
2,4 - Dimethylphenol {2,4-Xylenol}	-	ug/l	None	<0.1	-	<0.024	-	-	-	-	<0.1	<0.1	<0.1	<0.1
2,4 - Dinitrotoluene	-	ug/l	None	-	-	-	-	-	-	-	<1	-	-	-
2,4,5 - Trichlorophenol	-	ug/l	None	-	-	<0.05	-	-	-	-	<1	-	-	-
2,4,6 - Trichlorophenol	-	ug/l	None	<0.1	-	<0.028	-	-	-	-	<0.1	<0.1	<0.1	<0.1
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	<0.1	-	<0.05	-	-	-	-	<0.1	<0.1	<0.1	<0.1
2,6 - Dimethylphenol {2,6 Xylenol}	-	ug/l	None	-	-	<0.05	-	-	<0.0500	-	-	-	-	-
2,6 - Dinitrotoluene	-	ug/l	None	-	-	-	-	-	-	-	<1	-	-	-
3 - Chlorophenol	-	ug/l	None	-	-	<0.05	-	-	-	-	-	-	-	-
3 - Methylphenol {M-Cresol}	-	ug/l	None	-	-	<0.05	-	-	-	-	-	-	-	-
3 - Nitroaniline	-	ug/l	None	-	-	-	-	-	-	-	<1	-	-	-
3,4 - Dimethylphenol {3,4 Xylenol}	-	ug/l	None	-	-	<0.05	-	-	<0.0500	-	-	-	-	-
3,5 - Dimethylphenol {3,5-Xylenol}	-	ug/l	None	-	-	<0.02	-	-	-	-	-	-	-	-
4 - Bromophenylphenyl ether	-	ug/l	None	-	-	-	-	-	-	-	<1	-	-	-

Source of data*				SI	TT	TT	TT	TT	TT	TT	SI	SI	SI	SI
Name				SR1055	SR1055	SR1055	SR1055	SR1055	SR1055	SR1055	SR1054A	SR1053	SR1052	SR1051
Hydrogeological unit**				SCK	CK	CK	CK	CK	CK	CK	SCK	SCK	SCK	SCK
Distance from site	EQS Criteria			362m	362m	362m	362m	362m	362m	362m	543m	719m	867m	1050m
Chemical	Value	Units	Source	2009	15/8/2011	28/9/2011	4/11/2011	30/1/2012	18/4/2012	16/5/2012	1/1/2010	1/1/2010	1/1/2010	1/1/2010
4 - Chloro - 3- Methylphenol {P-Chloro-M-Cresol}	40	ug/l	WFD 2010	<0.1	-	<0.05	-	-	-	-	<0.1	<0.1	<0.1	<0.1
4 - Chlorophenol	-	ug/l	None	-	-	<0.02	-	-	-	-	-	-	-	-
4 - Chlorophenyl phenyl ether	-	ug/l	None	-	-	-	-	-	-	-	<1	-	-	-
4 - Chlorotoluene	-	ug/l	None	-	-	-	-	-	-	-	<1	-	-	-
4 - Nitroaniline	-	ug/l	None	-	-	-	-	-	-	-	<1	-	-	-
4 - Nitrophenol	-	ug/l	None	-	-	-	-	-	-	-	<1	-	-	-
4-Methylphenol {para-Cresol}	-	ug/l	None	-	-	<0.025	-	-	<0.0500	-	-	-	-	-
Acenaphthene	-	ug/l	None	<0.01	-	-	-	-	-	-	<0.01	<0.01	<0.01	<0.01
Acenaphthylene	-	ug/l	None	<0.01	-	-	-	-	-	-	<0.01	<0.01	<0.01	<0.01
Acenapthene	-	ug/l	None	-	-	<0.01	-	-	<0.01	-	-	-	-	-
Acenapthylene	-	ug/l	None	-	-	<0.01	-	-	<0.01	-	-	-	-	-
Aldicarb	0.1	ug/l	DWS 2010	-	-	<0.02	-	-	-	-	-	-	-	-
Aldicarb Sulphone	-	ug/l	None	-	-	<0.01000	-	-	-	-	-	-	-	-
Aldrin	0.03	ug/l	DWS 2010	-	-	<0.00300	-	-	-	-	-	-	-	-
Aliphatics >C10-C12	-	ug/l	None	<1	-	-	-	-	-	-	100	4	3	2
Aliphatics >C12-C16 (Aqueous)	-	ug/l	None	<1	-	-	-	-	-	-	1300	7	6	4
Aliphatics >C16-C21 (Aqueous)	-	ug/l	None	<1	-	-	-	-	-	-	9	15	11	5
Aliphatics >C21-C35 (Aqueous)	-	ug/l	None	<1	-	-	-	-	-	-	5	79	20	9
Aliphatics >C6-C8	-	ug/l	None	<0.1	-	-	-	-	-	-	<0.1	<0.1	<0.1	<0.1
Aliphatics >C8-C10	-	ug/l	None	<0.1	-	-	-	-	-	-	<0.1	<0.1	<0.1	<0.1
Aliphatics C5-C6	-	ug/l	None	<0.1	-	-	-	-	-	-	<0.1	<0.1	<0.1	<0.1
Alkalinity (Carbonate)	-	mg/l as CaCO3	None	-	-	<4	<4	-	-	-	-	-	-	-
Alkalinity Ph 4.5 - As CaCO3	-	mg/l as CaCO3	None	300	488	422	378	377	-	356	240	370	360	260
Aluminium Dissolved	200	ug/l as Al	DWS 2010	-	-	<50	-	-	0.015	-	-	-	-	-
Aluminium Total	200	ug/l as Al	DWS 2010	-	39	30	34	0.049	-	0.012	-	-	-	-
Ammonia - As N	0.39	mg/l as N	WS Regs 20	-	0.57	0.57	0.68	0.71	-	0.92	-	-	-	-
Ammoniacal nitrogen	-	mg/l	None	0.43	-	-	-	-	-	-	5.3	1.7	1.6	0.87
Ammonium as NH4	0.5	mg/l as NH4	WS Regs 20	-	-	-	-	-	-	-	<0.001	-	-	-
Anions	-	meq/l	None	-	-	17.241	-	-	-	-	-	-	-	-
Anthracene	0.1	ug/l	SW WFD	<0.01	-	<0.01	-	-	<0.01	-	<0.01	<0.01	<0.01	<0.01
Antimony Total	5	ug/l	DWS 2010	-	-	0.3	-	-	0.4	-	7	-	-	-
Aromatics >C7-C8	50	ug/l	WFD 2010	<0.1	-	-	-	-	-	-	<0.1	<0.1	<0.1	<0.1
Aromatics >EC10-EC12	-	ug/l	None	1	-	-	-	-	-	-	16	3	4	2
Aromatics >EC12-EC16 (Aqueous)	-	ug/l	None	3	-	-	-	-	-	-	150	5	8	3
Aromatics >EC16-EC21 (Aqueous)	-	ug/l	None	5	-	-	-	-	-	-	10	6	14	13
Aromatics >EC21-EC35 (Aqueous)	-	ug/l	None	9	-	-	-	-	-	-	12	13	37	14
Aromatics >EC8-EC10	-	ug/l	None	<0.1	-	-	-	-	-	-	<0.1	<0.1	<0.1	<0.1
Aromatics C6-C7	1	ug/l	DWS 2010	<0.1	-	-	-	-	-	-	<0.1	<0.1	<0.1	<0.1
Arsenic Total	10	ug/l as As	DWS 2010	2	38.2	25.9	78	219	-	10	<1	<1	<1	<1
Asulam	-	ug/l	None	-	-	<0.01	-	-	-	-	-	-	-	-
Atrazine { }	0.1	ug/l	DWS 2010	-	<0.04000	<0.00300	<0.08000	<0.08000	-	<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	-	-	-	-	-	-	-	-
Azobenzene	-	ug/l	None	-	-	-	-	-	-	-	<1	-	-	-

Source of data*				SI	TT	TT	TT	TT	TT	TT	SI	SI	SI	SI
Name				SR1055	SR1055	SR1055	SR1055	SR1055	SR1055	SR1055	SR1054A	SR1053	SR1052	SR1051
Hydrogeological unit**				SCK	CK	CK	CK	CK	CK	CK	SCK	SCK	SCK	SCK
Distance from site	EQS Criteria			362m	362m	362m	362m	362m	362m	362m	543m	719m	867m	1050m
Chemical	Value	Units	Source	2009	15/8/2011	28/9/2011	4/11/2011	30/1/2012	18/4/2012	16/5/2012	1/1/2010	1/1/2010	1/1/2010	1/1/2010
Barium Dissolved	100	ug/l as Ba	SW Regs 96	-	-	140	-	-	69	-	-	-	-	-
Barium Total	100	ug/l as Ba	SW Regs 96	-	-	140	-	-	81	-	13	-	-	-
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	-	<0.00800	-	-	-	-
Benz[a]-Anthracene	-	ug/l	None	-	-	<0.01	-	-	<0.01	-	-	-	-	-
Benzene	1	ug/l	DWS 2010	<1	<0.07	0.14	<0.07	<0.07	<0.07	< 0.07	<1	<1	<1	<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	-	-	<0.06	-	-	<0.06	-	-	-	-	-
Benzo (a) anthracene	-	ug/l	None	<0.01	-	-	-	-	-	-	<0.01	<0.01	<0.01	<0.01
Benzo[a]Pyrene	0.01	ug/l	DWS 2010	<0.01	<0.00500	<0.01	<0.00500	<0.00500	<0.01	<0.00500	<0.01	<0.01	<0.01	<0.01
Benzo[b]Fluoranthene	0.03	ug/l	WFD D 10	<0.01	-	<0.01	-	-	<0.01	-	<0.01	<0.01	<0.01	<0.01
Benzo[g,h,i]Perylene	0.002	ug/l	WFD D 10	<0.01	-	<0.01	-	-	<0.01	-	<0.01	<0.01	<0.01	<0.01
Benzo[k]Fluoranthene	0.03	ug/l	WFD D 10	<0.01	-	<0.01	-	-	<0.01	-	<0.01	<0.01	<0.01	<0.01
Beryllium Total	0	ug/l as Be	GW Regs 98	-	-	<3	-	-	-	-	<1	-	-	-
Bifenthrin	-	ug/l	None	-	-	<0.00500	-	-	0.00280	-	-	-	-	-
Bis (2 - chloroethoxy) methane	-	ug/l	None	-	-	-	-	-	-	-	<1	-	-	-
Bis (2 - chloroethyl) ether	-	ug/l	None	-	-	-	-	-	-	-	<1	-	-	-
Bis(2-chloroisopropyl)ether	-	ug/l	None	-	-	-	-	-	-	-	<1	-	-	-
Boron Dissolved	1000	ug/l as B	DWS 2010	-	-	408	-	-	390	-	-	-	-	-
Boron Total	1000	ug/l as B	DWS 2010	320	430	400	380	380	-	0.41	310	420	390	470
Bromate	10	ug/l as BrO3	DWS 2010	-	<0.5	<0.5	<0.5	<0.5	-	< 0.5	-	-	-	-
Bromide ion	2	ug/l as Br	FW List II	-	-	513	-	-	-	-	-	-	-	-
Bromobenzene	-	ug/l	None	-	-	-	-	-	-	-	<1	-	-	-
Bromochloromethane	-	ug/l	None	-	-	-	-	-	-	-	<1	-	-	-
Bromodichloromethane	100	ug/l	WS Regs 20	-	-	<0.4	-	-	-	-	<1	-	-	-
Bromoform	100	ug/l	WS Regs 20	-	-	<0.7	-	-	-	-	<1	-	-	-
Bromoxynil	0.1	ug/l	DWS 2010	-	-	<0.01000	-	-	-	-	-	-	-	-
Bupirimate	-	ug/l	None	-	-	<0.00500	-	-	-	-	-	-	-	-
Butyl benzyl phthalate	-	ug/l	None	-	-	-	-	-	-	-	<1	-	-	-
Cadmium Dissolved	5	ug/l as Cd	DWS 2010	-	-	<1.5	-	-	-	-	-	-	-	-
Cadmium Total	5	ug/l as Cd	DWS 2010	<2	2.3	<1.5	3.1	15	<1.5	< 1.5	<2	<2	<2	<2
Calcium Dissolved	250	mg/l as Ca	DWS 2010	-	-	170	-	-	-	-	-	-	-	-
Calcium Total	250	mg/l as Ca	DWS 2010	-	170	170	78	96	-	98	-	-	-	-
Carbaryl	-	ug/l	None	-	-	<0.01	-	-	-	-	-	-	-	-
Carbazole	-	ug/l	None	-	-	-	-	-	-	-	<1	-	-	-
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	-	-	97500	-	-	54300	-	-	-	-	-
Carbon Organic Dissolved	-	mg/l as C	None	-	-	4.91	-	-	0.7	-	-	-	-	-
Carbon tetrachloride	3	ug/l	DWS 2010	-	<0.07	<0.07	<0.07	<0.07	-	< 0.070	<1	-	-	-
Carbophenothion	-	ug/l	None	-	-	<0.01300	-	-	-	-	-	-	-	-
Cations	-	meq/l	None	-	-	22.926	-	-	-	-	-	-	-	-
Chlordane (cis)	0.1	ug/l	DWS 2010	-	-	<0.00500	-	-	-	-	-	-	-	-
Chlordane Trans	0.1	ug/l	DWS 2010	-	-	<0.00500	-	-	-	-	-	-	-	-

Source of data*				SI	TT	TT	TT	TT	TT	TT	SI	SI	SI	SI
Name				SR1055	SR1055	SR1055	SR1055	SR1055	SR1055	SR1055	SR1054A	SR1053	SR1052	SR1051
Hydrogeological unit**				SCK	CK	CK	CK	CK	CK	CK	SCK	SCK	SCK	SCK
Distance from site	EQS Criteria			362m	362m	362m	362m	362m	362m	362m	543m	719m	867m	1050m
Chemical	Value	Units	Source	2009	15/8/2011	28/9/2011	4/11/2011	30/1/2012	18/4/2012	16/5/2012	1/1/2010	1/1/2010	1/1/2010	1/1/2010
Chlorfenvinphos	0.1	ug/l	DWS 2010	-	<0.00900	<0.00900	<0.00900	<0.00900	-	<0.00900	-	-	-	-
Chloridazon	-	ug/l	None	-	-	<0.01	-	-	-	-	-	-	-	-
Chloride	250	mg/l as Cl	DWS 2010	160	126	178	206	188	-	188	370	210	210	160
Chlormequat	-	ug/l	None	-	-	<0.05	-	-	-	-	-	-	-	-
Chlorobenzene	-	ug/l	None	-	-	-	-	-	-	-	<1	-	-	-
Chlorodibromomethane	-	ug/l	None	-	-	<0.5	-	-	-	-	-	-	-	-
Chloroform	100	ug/l	WS Regs 20	-	<0.6	<0.6	<0.6	<0.6	-	< 0.600	<1	-	-	-
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	-	-	<0.07	-	-	-	-	-	-	-	-
Chlorthalonil	-	ug/l	None	-	-	<0.01800	-	-	-	-	-	-	-	-
Chlortoluron	2	ug/l	FW List II	-	<0.00400	<0.00400	<0.10000	<0.00400	-	<0.01000	-	-	-	-
Chromium Dissolved	50	ug/l as Cr	DWS 2010	-	-	16	-	-	12	-	-	-	-	-
Chromium Total	50	ug/l as Cr	DWS 2010	<5	16	16	8	14	-	12	<10	<5	<5	<5
Chrysene	-	ug/l	None	<0.01	-	<0.01	-	-	<0.01	-	<0.01	<0.01	<0.01	<0.01
cis-1,3 - Dichloropropene	-	ug/l	None	-	-	-	-	-	-	-	<1	-	-	-
cis-1-2-Dichloroethene	-	ug/l	None	-	-	<0.12	-	-	-	-	-	-	-	-
Clopyralid	-	ug/l	None	-	<0.01900	<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	1420	-	-	-	-	-	-	837	2180	1660	1180
Copper Dissolved	2000	ug/l as Cu	DWS 2010	-	-	<5.5	-	-	-	-	-	-	-	-
Copper Total	2000	ug/l as Cu	DWS 2010	3	<5.5	<5.5	<5.5	<5.5	-	< 5.5	15	<2	<2	<2
Coumaphos	0.1	ug/l	DWS 2010	-	-	<0.00500	-	-	0.01720	-	-	-	-	-
Cresols	-	ug/l	None	<0.1	-	-	-	-	-	-	<0.1	<0.1	<0.1	<0.1
Cyanazine	0.1	ug/l	DWS 2010	-	<0.00700	<0.00700	<0.12000	<0.00700	-	<0.00800	-	-	-	-
Cyanide (Free)	50	ug/l as CN	DWS 2010	<20	-	-	-	-	-	-	<20	<20	<20	<20
Cyanide (Total)	50	ug/l as CN	DWS 2010	<40	-	<1	-	-	-	-	<40	<40	<40	<40
Cyfluthrin	0.1	ug/l	DWS 2010	-	-	<0.005	-	-	-	-	-	-	-	-
Cypermethrin	0.0001	ug/l	WFD 2010	-	20	<0.007	<0.1	<0.1	-	< 0.100	-	-	-	-
Cypermethrin ID	-	Code	None	-	-	-	-	-	<5.00	-	-	-	-	-
Dalapon	-	ug/l	None	-	<0.05000	<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	-	-	-	-	-	-	-	-
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	-	-	-	-	-	-	-	-
Di - n - octyl phthalate	-	ug/l	None	-	-	-	-	-	-	-	4.2	-	-	-
Diazinon	0.1	ug/l	DWS 2010	-	<0.00900	<0.00900	<0.00900	<0.00900	-	<0.00900	-	-	-	-
Dibenz-[A,H]-Anthracene	-	ug/l	None	<0.01	-	<0.01	-	-	<0.01	-	<0.01	<0.01	<0.01	<0.01
Dibenzofuran	-	ug/l	None	-	-	-	-	-	-	-	<1	-	-	-
Dibromochloromethane	100	ug/l	WS Regs 20	-	-	-	-	-	-	-	<1	-	-	-
Dibromoethane	-	ug/l	None	-	-	-	-	-	-	-	<1	-	-	-
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	-	-	-	-	-	-	-	-

Source of data*				SI	TT	TT	TT	TT	TT	TT	SI	SI	SI	SI
Name				SR1055	SR1055	SR1055	SR1055	SR1055	SR1055	SR1055	SR1054A	SR1053	SR1052	SR1051
Hydrogeological unit**				SCK	CK	CK	CK	CK	CK	CK	SCK	SCK	SCK	SCK
Distance from site	EQS Criteria			362m	362m	362m	362m	362m	362m	362m	543m	719m	867m	1050m
Chemical	Value	Units	Source	2009	15/8/2011	28/9/2011	4/11/2011	30/1/2012	18/4/2012	16/5/2012	1/1/2010	1/1/2010	1/1/2010	1/1/2010
Dichloromethane	20	ug/l	WFD 2010	-	<3	<3	<3	<3	-	< 3.0	<1	-	-	-
Dichlorprop	0.1	ug/l	DWS 2010	-	<0.01100	<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	-	-	-	-	-	-	-	-
Diethyl phthalate	-	ug/l	None	-	-	-	-	-	-	-	<1	-	-	-
Diflurobenzuron	-	ug/l	None	-	-	<0.02000	-	-	-	-	-	-	-	-
Dimethoate	-	ug/l	None	-	-	<0.01500	-	-	-	-	-	-	-	-
Dimethyl phthalate	-	ug/l	None	-	-	-	-	-	-	-	<1	-	-	-
Di-n-butyl phthalate	-	ug/l	None	-	-	-	-	-	-	-	1.7	-	-	-
Diuron	0.1	ug/l	DWS 2010	-	<0.20000	<0.00500	<0.10000	-	-	<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	-	-	-	-	-	-	-	-
Escherichia coli (Confirmed)	0	Nr/100ml	WS Regs 20	-	-	0	-	-	-	-	-	-	-	-
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	-	-	-	-	-	-	<1	<1	<1	<1
Fenchlorphos {Ronnel.}	0.1	ug/l	DWS 2010	-	-	<0.00300	-	-	-	-	-	-	-	-
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	-	-	<0.01	-	-	<0.01	-	-	-	-	-
Flumethrin	-	ug/l	None	-	-	<0.00500	-	-	-	-	-	-	-	-
Fluoranthene	0.2	ug/l	EEC MAC	0.01	-	<0.01	-	-	<0.01	-	<0.01	0.01	0.02	<0.01
Fluorene	-	ug/l	None	<0.01	-	<0.01	-	-	<0.01	-	<0.01	<0.01	<0.01	<0.01
Fluoride	1.5	mg/l as F	DWS 2010	-	0.18	0.5	1.03	1.22	-	0.939	-	-	-	-
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	-	<0.01400	-	-	-	-
Hardness Total - As CaCO3	-	mg/l as CaCO3	None	-	-	547	-	-	380	-	-	-	-	-
Heptachlor	0.03	ug/l	DWS 2010	-	-	<0.00300	-	-	-	-	-	-	-	-
Hexachloro 1,3 Butadiene	0.1	ug/l	WFD 2010	-	-	<0.01000	-	-	-	-	<1	-	-	-
Hexachlorobenzene	0.01	ug/l	WFD 2010	-	-	<0.00100	-	-	-	-	<1	-	-	-
Hexachlorocyclohexane (alpha)	0.1	ug/l	DWS 2010	-	-	<0.01000	-	-	-	-	-	-	-	-
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	-	-	-	-	-	-	-	-
Hexachlorocyclopentadiene	-	ug/l	None	-	-	-	-	-	-	-	<1	-	-	-
Indeno-[1,2,3-Cd]-Pyrene	0.002	ug/l	WFD D 10	<0.01	-	<0.01	-	-	<0.01	-	<0.01	<0.01	<0.01	<0.01
Iodide Ion	-	ug/l as I	None	-	-	36	-	-	27	-	-	-	-	-
Iodofenphos	-	ug/l	None	-	-	<0.06	-	-	-	-	-	-	-	-
Ionic Balance (Anions/Cations)	-	%	None	-	-	14.2	-	-	-	-	-	-	-	-

Source of data*				SI	TT	TT	TT	TT	TT	TT	SI	SI	SI	SI
Name				SR1055	SR1055	SR1055	SR1055	SR1055	SR1055	SR1055	SR1054A	SR1053	SR1052	SR1051
Hydrogeological unit**				SCK	CK	CK	CK	CK	CK	CK	SCK	SCK	SCK	SCK
Distance from site	EQS Criteria			362m	362m	362m	362m	362m	362m	362m	543m	719m	867m	1050m
Chemical	Value	Units	Source	2009	15/8/2011	28/9/2011	4/11/2011	30/1/2012	18/4/2012	16/5/2012	1/1/2010	1/1/2010	1/1/2010	1/1/2010
Ioxynil	0.1	ug/l	DWS 2010	-	-	<0.00800	-	-	-	-	-	-	-	-
Iprodione	-	ug/l	None	-	-	<0.01300	-	-	-	-	-	-	-	-
Irgarol 1051	-	ug/l	None	-	-	0.00600	-	-	<0.00500	-	-	-	-	-
Iron Dissolved	200	ug/l as Fe	DWS 2010	-	-	26000	-	-	8.1	-	-	-	-	-
Iron Total	200	ug/l as Fe	DWS 2010	-	-	24000	-	-	11	-	4800	-	-	-
Isodrin	0.1	ug/l	DWS 2010	-	-	<0.00300	-	-	-	-	-	-	-	-
Isopropylbenzene (Cumene)	-	ug/l	None	-	-	-	-	-	-	-	<1	-	-	-
Isoproturon (Diip1,3Dithiolan-2-Ylidenemalonate)	0.1	ug/l	DWS 2010	-	<0.10000	<0.00300	<0.10000	-	-	<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	4	8	<5	<5	20	-	< 5	5	<4	<4	<4
Linuron	0.1	ug/l	DWS 2010	-	-	<0.00500	-	-	-	-	-	-	-	-
Lithium Dissolved	-	ug/l as Li	None	-	-	7.8	-	-	0.013	-	-	-	-	-
Lithium Total	-	ug/l as Li	None	-	-	8.6	-	-	0.015	-	-	-	-	-
Magnesium Dissolved	50	mg/l as Mg	EEC MAC	-	-	29	-	-	25	-	-	-	-	-
Magnesium Total	50	mg/l as Mg	EEC MAC	22	25	30	25	23	-	23	9	71	59	20
Malathion	0.1	ug/l	DWS 2010	-	-	<0.00600	-	-	-	-	-	-	-	-
Manganese Dissolved	50	ug/l as Mn	DWS 2010	-	-	430	-	-	0.26	-	-	-	-	-
Manganese Total	50	ug/l as Mn	DWS 2010	-	-	440	-	-	0.28	-	300	-	-	-
MCPA {2-methyl-4-chlorophenoxyacetic acid }	0.1	ug/l	DWS 2010	-	<0.00900	<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	-	<0.01000	-	-	-	-
Mercury Total	1	ug/l Hg	WS Regs 20	<0.05	0.036	0.008	0.004	0.006	-	< 0.002	<0.05	<0.05	<0.05	<0.05
Metalaxyl	-	ug/l	None	-	-	<0.01	-	-	-	-	-	-	-	-
Metazachlor	-	ug/l	None	-	<0	<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	-	-	<5	-	-	<5	-	0.3	-	-	-
Monolinuron	-	ug/l	None	-	-	<0.00600	-	-	-	-	-	-	-	-
Monuron	-	ug/l	None	-	-	<0.01	-	-	-	-	-	-	-	-
MTBE {Methyl Tert-Butyl Ether}	-	ug/l	None	<1	-	<0.13	-	-	-	-	<1	<1	<1	<1
Multi Residual Scan	-	ug/l	None	-	-	-	-	-	-	<0.10000	-	-	-	-
n - Butylbenzene	-	ug/l	None	-	-	-	-	-	-	-	<1	-	-	-
n - Propylbenzene	-	ug/l	None	-	-	-	-	-	-	-	<1	-	-	-
Naphthalene	1.2	ug/l	WFD D 10	<0.01	-	0.02	-	-	0.1	-	<1	<0.01	<0.01	<0.01
Napropamide	-	ug/l	None	-	-	<0.01	-	-	-	-	-	-	-	-
Neburon	-	ug/l	None	-	-	<0.01	-	-	-	-	-	-	-	-
Nickel Total	20	ug/l as Ni	DWS 2010	<10	10	<4	<4	21	-	5	<100	<10	11	<10
Nitrate - N	11.3	mg/l as N	WS Regs 20	1.1	0.92	0.78	<0.043	0.26	-	< 0.068	<0.1	<0.1	<0.1	<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	-	-	0.78	-	-	<0.081	-	-	-	-	-
Orthophosphate	-	mg/l as P	None	-	-	<0.18	-	-	<0.18	-	-	-	-	-

Source of data*				SI	TT	TT	TT	TT	TT	TT	SI	SI	SI	SI
Name				SR1055	SR1055	SR1055	SR1055	SR1055	SR1055	SR1055	SR1054A	SR1053	SR1052	SR1051
Hydrogeological unit**				SCK	CK	CK	CK	CK	CK	CK	SCK	SCK	SCK	SCK
Distance from site	EQS Criteria			362m	362m	362m	362m	362m	362m	362m	543m	719m	867m	1050m
Chemical	Value	Units	Source	2009	15/8/2011	28/9/2011	4/11/2011	30/1/2012	18/4/2012	16/5/2012	1/1/2010	1/1/2010	1/1/2010	1/1/2010
Oxamyl	-	ug/l	None	-	-	<0.00500	-	-	<0.00500	-	-	-	-	-
o-Xylene	-	ug/l	None	-	-	-	-	-	-	-	<1	-	-	-
PAHs Total	0.1	ug/l	DWS 2010	-	-	0.02	-	-	0.1	-	-	-	-	-
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	-	-	-	-	-	-	-	-
Pentachlorophenol	9	ug/l	WHO 2004	-	-	-	-	-	-	-	<0.1	-	-	-
Permethrin (Cis + Trans)	0.01	ug/l	WFD D 10	-	<0.10000	-	<0.10000	<0.10000	-	-	-	-	-	-
pH	10	pH units	DWS 2010	6.9	-	7.05	-	-	-	-	7.2	7.8	7.1	7.9
Phenanthrene	-	ug/l	None	<0.01	-	<0.01	-	-	<0.01	-	<1	<0.01	0.02	<0.01
Phenol	0.5	ug/l	EEC MAC	<0.1	-	<1	-	-	-	-	<0.1	<0.1	<0.1	<0.1
Phenol (Pentachlorophenol (PCP))	-	ug/l	None	-	<0.00900	<0.00900	<0.00900	<0.00900	-	<0.00900	-	-	-	-
Phenols Total For SWAD (7 Compounds)	-	ug/l	None	-	<80.0	-	<8.0	<80.0	-	<8.0	-	-	-	-
Pichloram	-	ug/l	None	-	-	<0.00900	-	-	-	-	-	-	-	-
Pirimephos (Pirimephos-methyl)	-	ug/l	None	-	-	<0.00300	-	-	-	-	-	-	-	-
Pirimicarb	1	ug/l	FW List II	-	-	<0.00300	-	-	-	-	-	-	-	-
Polychlorinated biphenyls	0.1	ug/l	DWS 2010	-	-	-	-	-	-	-	<1	-	-	-
Polynuclear Aromatic Hydrocarbons (Total)	0.1	ug/l	DWS 2010	<0.2	-	-	-	-	-	-	<0.2	<0.2	<0.2	<0.2
Potassium Dissolved	-	mg/l as K	None	-	-	43	-	-	25	-	12	-	-	-
Potassium Total	-	mg/l as K	None	-	38	44	21	21	-	24	-	-	-	-
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	<0.08000	<0.00400	-	<0.00500	-	-	-	-
Propetamphos	0.1	ug/l	DWS 2010	-	<0.00500	<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	-	<0.01	-	-	<0.01	-	<0.01	0.05	0.1	<0.01
Qualitative Scan (Volatiles By GCMS) NP	-	Text	None	-	-	-	-	-	-	-	-	-	-	-
SECB	-	ug/l	None	-	-	-	-	-	-	-	<1	-	-	-
Selenium	10	ug/l as Se	DWS 2010	<3	-	0.7	-	-	<0.4	-	<3	<3	<3	<3
Silicate Reactive Dissolved - As SiO2	-	mg/l	None	-	-	24	-	-	18	-	-	-	-	-
Silver Total	0	ug/l	GW Regs 98	-	-	<0.8	-	-	-	-	-	-	-	-
Simazine	0.1	ug/l	DWS 2010	-	<0.04000	<0.00900	<0.08000	<0.08000	-	<0.00400	-	-	-	-
Sodium Dissolved	200	mg/l as Na	DWS 2010	-	-	200	-	-	-	-	-	-	-	-
Sodium Total	200	mg/l as Na	DWS 2010	180	150	230	230	220	-	210	170	180	190	170
Strontium Dissolved	-	ug/l as Sr	None	-	-	1600	-	-	1.9	-	-	-	-	-
Strontium Total	-	ug/l as Sr	None	-	-	1700	-	-	2	-	-	-	-	-
Styrene	-	ug/l	None	-	-	-	-	-	-	-	<1	-	-	-

Source of data*				SI	TT	TT	TT	TT	TT	TT	SI	SI	SI	SI
Name				SR1055	SR1055	SR1055	SR1055	SR1055	SR1055	SR1055	SR1054A	SR1053	SR1052	SR1051
Hydrogeological unit**				SCK	CK	CK	CK	CK	CK	CK	SCK	SCK	SCK	SCK
Distance from site	EQS Criteria			362m	362m	362m	362m	362m	362m	362m	543m	719m	867m	1050m
Chemical	Value	Units	Source	2009	15/8/2011	28/9/2011	4/11/2011	30/1/2012	18/4/2012	16/5/2012	1/1/2010	1/1/2010	1/1/2010	1/1/2010
Sulphate	250	mg/l as SO4	DWS 2010	170	192	179	173	177	-	213	120	360	320	160
Sulphide	-	ug/l	None	<10	-	<30.0	-	-	<29.0	-	<250	<10	<10	<10
Tecnazene	0.1	ug/l	DWS 2010	-	-	<0.01000	-	-	-	-	-	-	-	-
Terbutryn	0.1	ug/l	DWS 2010	-	<0.00300	<0.00300	0.14000	<0.00300	-	<0.00500	-	-	-	-
tert - Butylbenzene	0.1	ug/l	DWS 2010	-	-	-	-	-	-	-	<1	-	-	-
Tertiary Amyl Methyl Ether (TAME)	-	ug/l	None	-	-	<5	-	-	-	-	-	-	-	-
Tetrachloroethane	10	ug/l	DWS 2010	-	-	<0.11	-	-	-	-	-	-	-	-
Tetrachloroethene (Per/Tetrachloroethylene)	10	ug/l	DWS 2010	-	-	-	-	-	-	-	<1	-	-	-
Tetrachloroethylene	-	ug/l	None	-	<0.09	<0.09	<0.09	<0.09	-	< 0.09	-	-	-	-
Tetrachlorothioanisole	-	ug/l	None	-	-	<0.00500	-	-	<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	-	-	<5	-	-	-	-	-
Titanium	0	ug/l as Ti	GW Regs 98	-	-	59	-	-	0.04	-	-	-	-	-
Toluene (Methylbenzene)	50	ug/l	WFD 2010	<1	-	0.49	-	-	<0.55	-	<100.0	<1	<1	<1
Total Aliphatic TPH	-	ug/l	None	<10	-	-	-	-	-	-	1400	100	40	20
Total Aromatic TPH	-	ug/l	None	18	-	-	-	-	-	-	180	27	63	32
Total Chemical Oxygen Demand	-	mg/l	None	<10	-	-	-	-	-	-	290	14	10	<10
Total Dissolved Solids	-	mg/l	None	-	-	-	-	-	-	-	-	-	-	-
Total Monohydric Phenols (W)	-	ug/l	None	-	-	-	-	-	-	-	<100.0	-	-	-
Total Suspended Solids	-	mg/l	None	-	-	-	-	-	-	-	350	-	-	-
Triazophos	0.1	ug/l	DWS 2010	-	-	<0.00800	-	-	-	-	-	-	-	-
Trichloroethene (Trichloroethylene)	10	ug/l	DWS 2010	-	<0.07	<0.07	<0.07	<0.07	-	< 0.07	<1	-	-	-
Trichlorophenoxyacetic Acid (2,4,5)	-	ug/l	None	-	-	<0.01500	-	-	-	-	-	-	-	-
Triclopyr	-	ug/l	None	-	-	<0.01500	-	-	-	-	-	-	-	-
Trietazine	-	ug/l	None	-	<0.00600	<0.00600	<0.04000	<0.00600	-	<0.00800	-	-	-	-
Trifluralin	0.1	ug/l	DWS 2010	-	<0.01000	<0.01000	<0.01000	<0.01000	-	<0.01000	-	-	-	-
Turbidity	1	FTU	WS Regs 20	-	121	-	157	424	-	109	-	-	-	-
Uranium	0	ug/l as U	GW Regs 98	-	-	0.24	-	-	0.2	-	-	-	-	-
Vanadium	0	ug/l as V	GW Regs 98	-	-	<5	-	-	-	-	<10	-	-	-
Volatiles	-	ug/l	None	-	-	-	-	-	-	-	<1	-	-	-
Xylene (Meta & Para){1,3+1,4-Dimethylbenzene}	30	ug/l	WFD 2010	<1	<0.09	0.28	<0.09	<0.09	<0.180	0.13	<1	<1	<1	<1
Xylene (ortho)	30	ug/l	SW Regs 98	-	-	0.12	-	-	<0.09	-	-	-	-	-
Zinc Dissolved	50	ug/l as Zn	DWS 2010	-	-	<5	-	-	-	-	-	-	-	-
Zinc Total	50	ug/l as Zn	DWS 2010	3	7	<5	<5	17	-	< 5	120	14	20	18

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: CK – Chalk, SCK – Seaford Chalk, RTD – River Terrace Deposits*

K.8 Groundwater status

K.8.1 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.8.2 The Thames River Basin Management Plan (RBMP) (EA, 2009)[13] shows that the Lambeth Group, Thanet Sands and Chalk Formation in the area of the Chambers Wharf site are designated as the Greenwich Chalk and Tertiaries groundwater body.

K.8.3 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.8.4 The predicted quantitative and chemical quality was poor for 2015 due to treatment or improvement being disproportionately expensive or technically infeasible.

K.8.5 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.8.6 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)[13].

K.8.7 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)[13]:

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.9.1 A list of data used for the Chambers Wharf assessment is given in Vol 20 Table K.9.

Vol 20 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	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 Tunnel project	Ground Investigation (2009) borehole logs, construction details, monitoring regime and available water level records and water quality results from 2009 to 2012	Last updated September 2012	Final ES
Thames	Groundwater	Draft strategy	

Source	Data	Date received	Notes
Tunnel project	monitoring strategy	Feb 2012	
Thames 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

[1] British Geological Survey. *British geology onshore digital maps 1:50 000 scale*. Received from Thames Tunnel, February 2009.

[2] British Geological Survey. *The BGS Lexicon of Named Rock Units (Accessed May 2012).* Available at: http://www.bgs.ac.uk/Lexicon/

[3] British Geological Survey. *The Physical Properties of Minor Aquifers in England and Wales. Hydrogeology Group, Technical Report WD/00/04*, Environment Agency R&D Publication 68 (2000).

[4] Royse, K.R., 2008. *The London Chalk model. British Geological Survey*. Commissioned

Report CR/08/125.

[5] USGS. *Glossary of Hydrologic Terms in The Federal Glossary of Selected Terms: Subsurface-Water Flow and Solute Transport"*: Department of Interior, U.S. Geological Survey, Office of Water Data Coordination, August 1989

[6] Environment Agency. *Environment Agency Website (Accessed April 2012)*. Available at: http://www.environment-agency.gov.uk/homeandleisure/117020.aspx

[7] Environment Agency and ESI. *London Basin Aquifer Conceptual Model.* ESI Report Reference 60121R1 (June 2010).

[8] Environment Agency. *Groundwater levels contours in Chalk*. Received from Environment Agency, June 2011.

[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

[10] Environment Agency. See citation above.

[11] The Water Supply (Water Quality) Regulations, 2000. Available at: http://www.legislation.gov.uk/uksi/2000/3184/contents/made

[12] *River Basin Districts Typology, Standards and Groundwater Threshold Values* (Water Framework Directive) (England and Wales) Direction 2010. Available at: http://www.defra.gov.uk/environment/quality/water/legislation/water-framework-directive/

[13] 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

This page is intentionally blank

Thames Tideway Tunnel
Thames Water Utilities Limited

Application for Development Consent

Application Reference Number: WWO10001

Environmental Statement

Doc Ref: **6.2.20**

Volume 20: Chambers Wharf appendices

Appendix L: Water resources - surface water

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

Hard copy available in

Box **34** Folder **B**
January 2013

Thames Tideway Tunnel

Creating a cleaner, healthier River Thames

This page is intentionally blank

Thames Tideway Tunnel

Environmental Statement

Volume 20 Chambers Wharf appendices

Appendix L: Water resources – surface water

List of contents

Page number

.

This page is intentionally blank

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.

This page is intentionally blank

Thames Tideway Tunnel
Thames Water Utilities Limited

Application for Development Consent

Application Reference Number: WWO10001

Environmental Statement

Doc Ref: **6.2.20**

Volume 20: Chambers Wharf appendices

Appendix M: Water resources - flood risk

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

Hard copy available in

Box **34** Folder **B**
January 2013

Thames Tideway Tunnel

Creating a cleaner, healthier River Thames

This page is intentionally blank

Thames Tideway Tunnel

Environmental Statement

Volume 20 Chambers Wharf appendices

Appendix M: Water resources – flood risk

List of contents

Page number

This page is intentionally blank

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 Chambers Wharf is provided below.

Local policy

Strategic Flood Risk Assessment

M.1.4 The Chambers Wharf site lies within London Borough (LB) of Southwark. LB of Southwark has produced a Strategic Flood Risk Assessment (SFRA) (Jacobs, 2008)[2]. This document outlines the main flood sources to the borough and presents the outcomes of the hydraulic modelling undertaken to investigate the residual risk of breaches in the River Thames flood defences at a number of locations along the River Thames.

M.1.5 The SFRA confirms that the Thames Tidal Defence network (Thames Barrier and Tidal flood defence walls) reduces the annual probability of flooding from the Thames to less than 0.1%. The risk of flooding is therefore a residual risk associated with a breach or overtopping of the defences.

M.1.6 According to the SFRA:

a. The site overlies alluvium drift geology and London Clay bedrock geology.

b. The primary risk from flooding within the LB of Southwark is tidal from the River Thames; other sources of flooding include sewer surcharging and surface water flooding as a result of heavy rainfall.

c. The permanent works area of the site (excluding foreshore area for temporary cofferdam) benefits from defences. However in the event of breach in the River Thames flood defences the area would be inundated within 6 hours. A significant degree of flood hazard is also anticipated.

d. There have been no recorded sewer flooding incidences in the vicinity of the site in the last 10 years.

e. Areas were flooded in the River Thames 1928 event when defences along the River Thames were breached.

f. The permanent works are (excluding foreshore area for temporary cofferdam) in the EA Flood Zone 3a.

M.1.7 The SFRA promotes the use of Sustainable Drainage Systems (SuDS) suitable to specific site locations within the borough, depending on underlying geology.

Surface Water Management Plan

M.1.8 The LB of Southwark, in partnership with the Greater London Authority (GLA), Thames Water and the EA has 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.1.9 According to the SWMP:

a. The site does not lie within a Critical Drainage Area (CDA)[i].

b. The site does not lie along an identified flow path for the 1% annual probability rainfall event, including an allowance for the impact of climate change (ie, 30% increase)

c. There is a recorded surface water flood incident approximately 150m to the south of the site in an area of low elevation. There is no clear flow path from this location on to the site for the 1% annual probability rainfall event, including an allowance for the impact of climate change (ie, 30% increase)

Regional policy

Thames Estuary 2100

M.1.10 The Chambers Wharf site lies within the Wandsworth to Deptford 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.1.11 The TE2100 Plan identifies the local sources of flood risk at this location including:

a. tidal flooding from the River Thames

b. 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 River Thames.

M.1.12 Flood mitigation from these sources include:

a. the Thames Barrier and secondary tidal defences along the River 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.1.13 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

[i] An area susceptible to surface water flooding.

manage the consequences of climate change is not possible,, secondary defences and floodplain management should be introduced. There is also an aspiration to increase flood risk awareness within the area.

M.1.14 There is an acknowledgement that erosion of the river bed is occurring at Southwark.

London Regional Flood Risk Appraisal

M.1.15 For the reach between Hammersmith Bridge and the Thames Barrier (City Reach) the London Regional Flood Risk Assessment (RFRA)(Greater London Authority, 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.1.16 There is particular concern surrounding confluences and the interactions between tidal and fluvial flows in the future due to climate change. .

M.1.17 The RFRA indicates that where possible 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] Jacobs. *London Borough of Southwark Strategic Flood Risk Assessment (SFRA). Final Report.* (February 2008).

[3] Greater London Authority. *London Borough of Southwark Surface Water Management Plan Final Report.* (Aug 2011).

[4] Environment Agency. *Thames Estuary 2100 Plan.* (November 2012).

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

Thames Tideway Tunnel
Thames Water Utilities Limited

Application for Development Consent

Application Reference Number: WWO10001

Environmental Statement

Doc Ref: **6.2.20**

Volume 20: Chambers Wharf appendices

Appendix N: Development schedule

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

Hard copy available in

Box **34** Folder **B**
January 2013

Thames Tideway Tunnel

Creating a cleaner, healthier River Thames

This page is intentionally blank

Thames Tideway Tunnel

Environmental Statement

Volume 20 Chambers Wharf appendices

Appendix N: Development schedule

List of contents

Page number

List of tables

Page number

This page is intentionally blank

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 20 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.

This page is intentionally blank

Vol 20 Table N.1 Development schedule for Chambers Wharf

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		2016 (Site Year 1 of construction)	2017 (peak construction traffic year)	2018 (peak construction year for T&V assessment)	2023 (Year 1 of operation)		
Chambers Wharf, Chambers Street,	On site	07/AP/1262 & 11/AP/3102 (non-material amendments to Buildings F & G)	St. James Group	The erection of six residential buildings providing 587 residential units and 275m² of flexible Class A/B1 floorspace at ground floor level along Chambers Street; 203m² of Class D1 floorspace along Llewellyn Street; basement parking; service and access roads, works of hard and soft landscaping together with other works incidental to the application	B	Phase 1 (Buildings F & G) to south of Chambers Street complete and operational. Phase 2 (Buildings A, B, C & D) not yet under construction due to presence of Thames Tunnel construction works on this part of the site (north of Chambers Street).	Phase 1 (Buildings F & G) to south of Chambers Street complete and operational. Phase 2 (Buildings A, B, C & D) not yet under construction due to presence of Thames Tunnel construction works on this part of the site (north of Chambers Street).	Phase 1 (Buildings F & G) to south of Chambers Street complete and operational. Phase 2 (Buildings A, B, C & D) not yet under construction due to presence of Thames Tunnel construction works on this part of the site (north of Chambers Street).	Phase 1 (Buildings F & G) to south of Chambers Street complete and operational. Phase 2 (Buildings A, B, C & D) under construction.	Discussions with developer Proposed Site Plan	**2016, 2017 & 2018:** Base case = Buildings F & G No cumulative **2023 :** Base case = Buildings F & G Cumulative = Buildings A, B, C & D
St. Michael's RC College, John Felton Road	25m southwest	08/CO/0112	London Borough of Southwark	Demolition of the existing school and the construction of a new secondary school within the grounds of the existing school that would be up to 3-storeys in height and with associated access, parking and amenity space.	A	100% complete & operational	100% complete & operational	100% complete & operational	100% complete & operational	Site visit	Base case (all years)
Bermondsey Spa	Approx 400m southwest	04-AP-0102	Hyde Housing Association	Outline application for demolition of Carton, Giles & Darnay Houses & the redevelopment of all 5 sites to create a mixed-use development comprising a mix of 605 residential units, with commercial & community uses including a retail foodstore, health centre & associated uses & facilities & a fitness centre, in new buildings between 3 & 10 storeys high; total of 217 new off-street car parking spaces (182 for residents & 35 for non-residential accommodation) together with all associated landscaping, infrastructure & ancillary development works	B	100% complete and operational	100% complete and operational	100% complete and operational	100% complete and operational	Bermondsey Spa Masterplan documents. This information suggests that work is well underway. Given the date of the planning application (2004), it has been assumed that all development would be complete 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		2016 (Site Year 1 of construction)	2017 (peak construction traffic year)	2018 (peak construction year for T&V assessment)	2023 (Year 1 of operation)		
Land adjacent to Lambeth College and Potters Fields	Approx 850m northwest	10/AP/1935	Berkeley Homes (South East London) Limited	44,976 sq metres of Class C3 floorspace comprising 356 residential units and ancillary residential floorspace including an Estate Management facility; 6554 sq metres of cultural floorspace (Class D1/D2 to accommodate concert hall or gallery or exhibition space or museum uses); 1707 sq metres of commercial floorspace (to accommodate Class A1, A2, A3, A4, A5, D1, D2 and B1 uses, the latter not to exceed 500 sq metres); all accommodated within buildings of up to 11 storeys (46.1 AOD) and a residential campanile of 20 storeys, plus roof garden and light box (77.8 AOD) together with 8007 sq metres of communal and private amenity space, including an extension to and improvement of Potters Fields Park; 142 car parking spaces including one surface level parking space for car club use; 436 residential cycle parking spaces (in basement/in building) and 104 visitor cycle parking spaces at surface level; together with associated highway, access and landscape works and other associated works and uses.	A	100% complete & operational	100% complete & operational	100% complete & operational	100% complete & operational	Currently under construction and will be complete by Site Year 1 of construction.	Base case (all years)

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

This page is intentionally blank

Thames Water Utilities Limited
Clearwater Court, Vastern Road, Reading RG1 8DB

DCO-DT-000-ZZZZZ-060220