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: **6.2.26**

Volume 26: Beckton Sewage Treatment Works appendices

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

Hard copy available in

Box **40** 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 26 Beckton Sewage Treatment Works site assessment

List of contents

Thames Tideway Tunnel
Thames Water Utilities Limited

Application for Development Consent

Application Reference Number: WWO10001

Environmental Statement

Doc Ref: **6.2.26**

Volume 26: Beckton Sewage Treatment Works appendices

Appendix A: Introduction

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

Hard copy available in

Box **40** Folder **B**
January 2013

Thames Tideway Tunnel

Creating a cleaner, healthier River Thames

This page is intentionally blank

Thames Tideway Tunnel

Environmental Statement

Volume 26 Beckton Sewage Treatment Works 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 26 Beckton Sewage Treatment Works 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: **6.2.26**

Volume 26: Beckton Sewage Treatment Works appendices

Appendix B: Air quality and odour

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

Hard copy available in

Box **40** Folder **B**
January 2013

Thames Tideway Tunnel

Creating a cleaner, healthier River Thames

This page is intentionally blank

Thames Tideway Tunnel

Environmental Statement

Volume 26 Appendices: Beckton Sewage Treatment Works 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

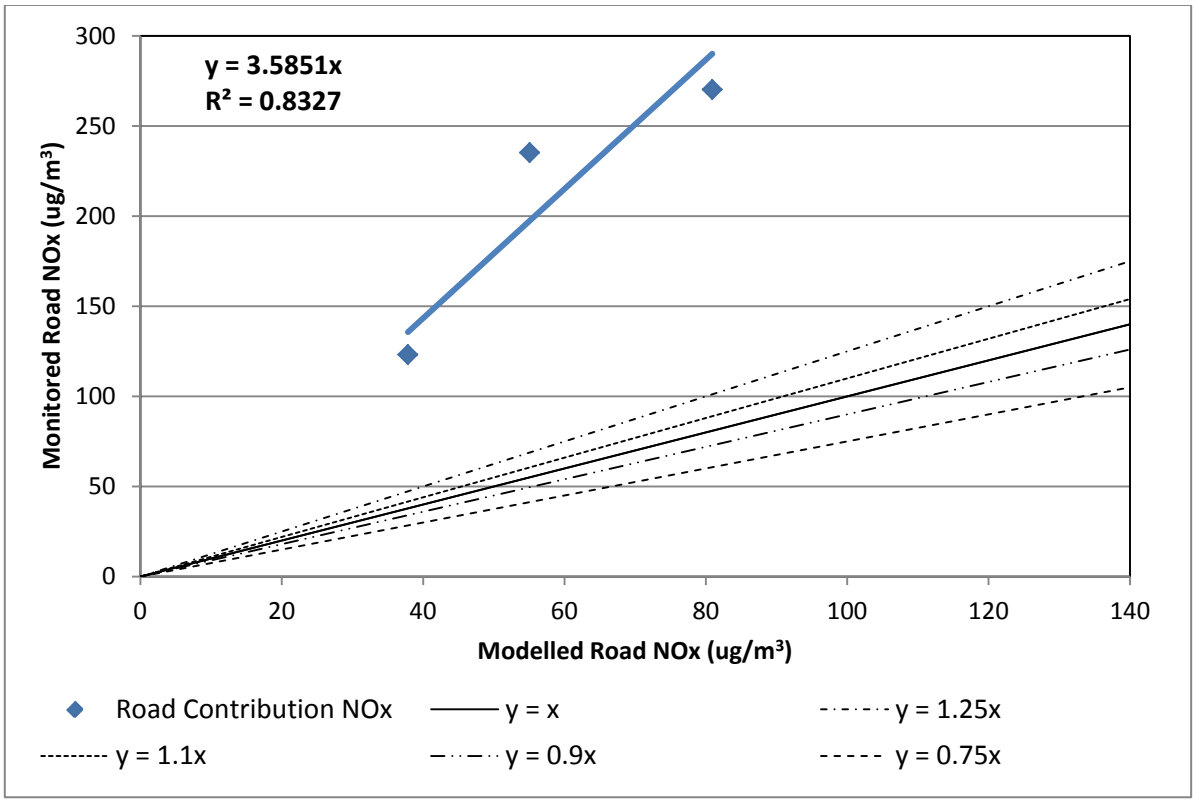
B.1.1 Modelled NO_2 concentrations have been plotted against monitored concentrations at three diffusion tube sites (BSTM1-BSTM9) as shown in Vol 26 Figure 4.4.1 (see separate volume of figures).

B.1.2 This showed that the modelled results underestimated NO_2 concentrations by between 36% and 47%. 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.

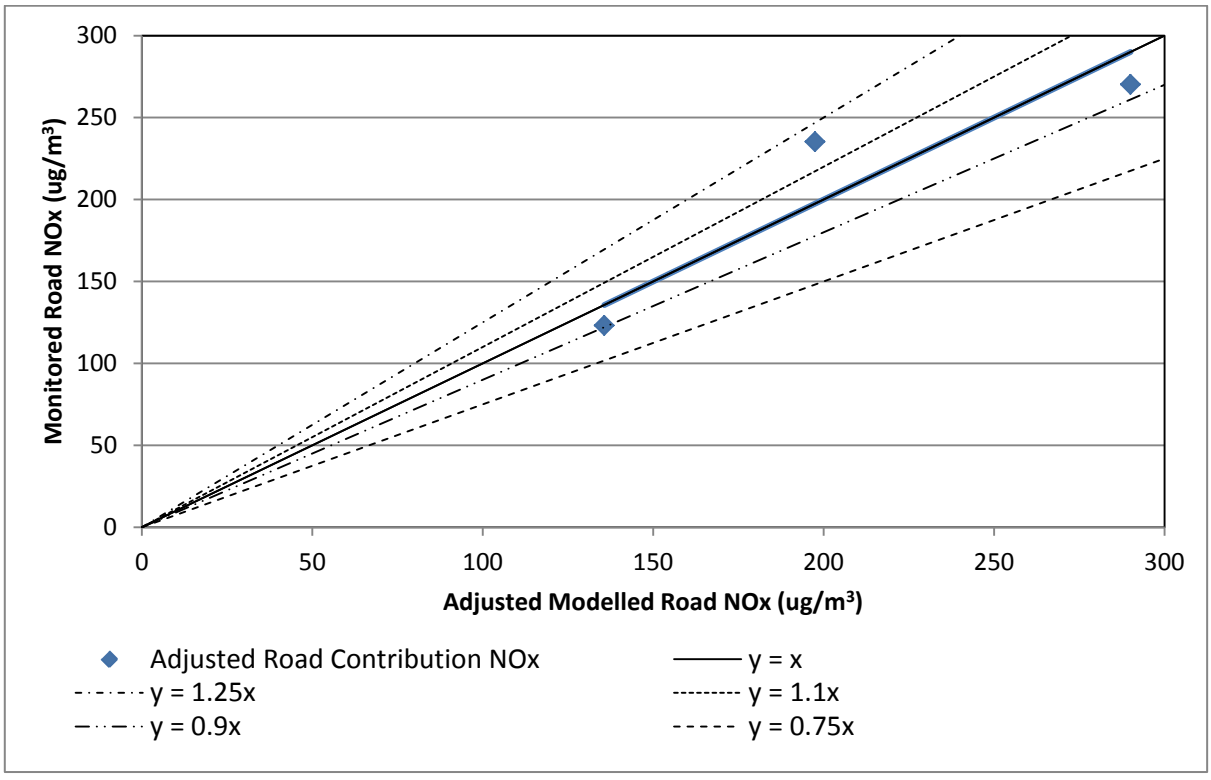
B.1.3 To derive the adjustment factor, modelled road NO_X concentrations were plotted against calculated monitored road NO_X concentrations (see Vol 26 Plate B.1 below). An adjustment factor of 3.59 was calculated for adjusting modelled roadside NO_X concentrations, in accordance with LAQM.TG(09)[1] 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 26 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 26 Plate B.3, indicated that all three modelled concentrations were within 10% of the measured value.

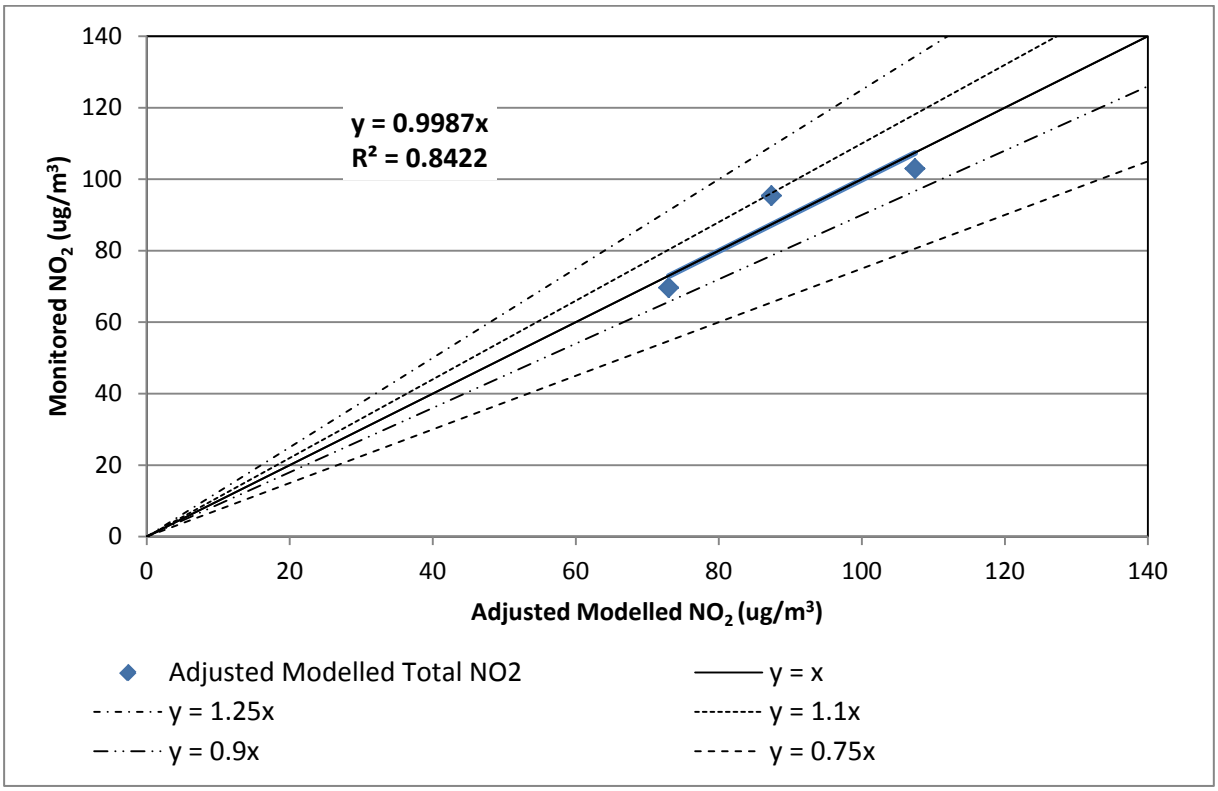
Vol 26 Plate B.1 Air quality – monitored road NO_x vs. modelled road NO_x



Vol 26 Plate B.2 Air quality – monitored road NO_x vs. adjusted modelled road NO_x



Vol 26 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 Beckton Sewage Treatment Works site are shown in Vol 26 Table B.1.

Vol 26 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** survey	Jenkins Lane	3515	31.6	30	23.4	12.1	3940	26	3966	32.0
CTC*** survey	Spur Road	3415	25.7	30	23.4	12.1	3827	13	3840	25.9
CTC survey	Jenkins Lane	3072	23.4	30	23.4	12.1	3443	13	3456	23.7
CTC survey	Jenkins Lane	3096	22.5	30	23.4	12.1	3469	13	3482	22.8
CTC survey	Unnamed	3629	23.6	30	23.4	12.1	4067	13	4080	23.8
CTC survey	Jenkins Lane	1485	24.8	30	23.4	12.1	1664	0	1664	24.8
TFL model	Royal Docks Road	23715	19.9	40	40	12.1	26577	0	26577	19.9

Source	Road link	2010 baseline AADT*	Baseline % HGV >3.5t	Speed limit (mph)	Model input speed (mph)	Growth factor % (2009 - 2018)	Peak const-ruction year AADT	Peak construction year AADT scheme construction HGV (HGV >3.5t)	Peak construction year development case (total AADT)	Peak construct-ion year develop-ment case AADT % HGV (>3.5t)
TFL model	Newham Road	141052	9.7	40	40	12.1	158079	26	158137	9.7
TFL model	Newham Road through roundabout	89612	9.5	40	40	12.1	100429	0	100461	9.5
TFL model	Newham Road	128375	9.2	40	40	12.1	143872	36	143940	9.2
TFL model	A406	108986	11.3	50	40	12.1	122142	4	122146	11.3
ATC survey	Jenkins Lane	3515	31.6	30	23.4	12.1	3940	26	3966	32.0
CTC survey	Spur Road	3415	25.7	30	23.4	12.1	3827	13	3840	25.9
CTC survey	Jenkins Lane	3072	23.4	30	23.4	12.1	3443	13	3456	23.7
CTC survey	Jenkins Lane	3096	22.5	30	23.4	12.1	3469	13	3482	22.8
CTC survey	Unnamed	3629	23.6	30	23.4	12.1	4067	13	4080	23.8
CTC	Jenkins Lane	1485	24.8	30	23.4	12.1	1664	0	1664	24.8

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)
survey										
TfL model	Royal Docks Road	23715	19.9	40	40	12.1	26577	0	26577	19.9
TfL model	Newham Road	141052	9.7	40	40	12.1	158079	26	158137	9.7
TfL model	Newham Road through roundabout	89612	9.5	40	40	12.1	100429	0	100461	9.5
TfL model	Newham Road	128375	9.2	40	40	12.1	143872	36	143940	9.2
TfL model	A406	108986	11.3	50	40	12.1	122142	4	122146	11.3

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

B.3 Construction plant emission factors

B.3.1 For the purpose of the assessment, the following listed equipment in Vol 26 Table B.2 at Beckton Sewage Treatment Works has been modelled for the peak construction year at Beckton STW site.

Vol 26 Table B.2 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	1.7×10^{-8}	1.1×10^{-9}
	Ground level behind hoarding	Generator - 200kVA	1	100	160	5.4×10^{-8}	3.4×10^{-9}
	Ground level behind hoarding	JCB with hydraulic breaker	1	50	67	1.1×10^{-8}	7.0×10^{-10}
	Ground level behind hoarding	Cutting equipment (diamond saw)	2	10	2.3	3.9×10^{-10}	8.6×10^{-10}
	Ground level behind hoarding	Telescopic handler / FLT**	1	30	60	6.1×10^{-9}	3.8×10^{-10}
	Ground level behind hoarding	Hiab*** lorry/crane	1	5	56	9.4×10^{-10}	5.9×10^{-11}
	Ground level behind hoarding	Well drilling rig	1	50	403	6.8×10^{-8}	4.2×10^{-9}
Connection Tunnel - Pipejack	Ground level behind hoarding	100t crawler crane	1	50	240	4.0×10^{-8}	2.5×10^{-9}
	Ground level behind hoarding	Service crane 40t mobile crane	1	25	81	2.3×10^{-8}	1.4×10^{-9}

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	Dumper	1	25	63	6.8×10^{-9}	4.3×10^{-10}
	Ground level behind hoarding	Loading shovel	1	30	125	6.4×10^{-9}	4.0×10^{-10}
Shaft secondary lining	Ground level behind hoarding	100t crawler crane	1	50	240	4.0×10^{-8}	2.5×10^{-9}
	Ground level behind hoarding	Service crane 40t mobile crane	1	25	275	2.3×10^{-8}	1.4×10^{-9}
	Ground level behind hoarding	Concrete deliveries (discharging)	1	20	223	1.5×10^{-8}	9.4×10^{-10}
	Ground level behind hoarding	Concrete pump	2	20	223	3.0×10^{-8}	1.9×10^{-9}
Culvert works	Ground level behind hoarding	Service crane – 100t mobile crane	1	50	280	4.7×10^{-8}	2.9×10^{-9}
	Ground level behind hoarding	25t excavator	1	50	125	2.1×10^{-8}	1.3×10^{-9}
	Ground level behind hoarding	Dumper	1	50	81	1.4×10^{-8}	8.5×10^{-10}
	Ground level behind hoarding	Concrete deliveries (discharging)	1	20	223	1.5×10^{-8}	9.4×10^{-10}
	Ground level behind hoarding	Concrete boom pump	1	20	223	1.5×10^{-8}	9.4×10^{-10}
Piling for culvert support	Ground level behind hoarding	100t crawler crane	1	50	240	4.0×10^{-8}	2.5×10^{-9}

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	25 tonne mobile crane	1	50	275	4.6×10^{-8}	2.9×10^{-9}

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

References

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

Thames Tideway Tunnel
Thames Water Utilities Limited

Application for Development Consent

Application Reference Number: WWO10001

Environmental Statement

Doc Ref: **6.2.26**

Volume 26: Beckton Sewage Treatment Works appendices

Appendix C: Ecology - aquatic

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

Hard copy available in

Box **40** Folder **B**
January 2013

Thames Tideway Tunnel

Creating a cleaner, healthier River Thames

This page is intentionally blank

Thames Tideway Tunnel

Environmental Statement

Volume 26 Beckton Sewage Treatment Works

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: **6.2.26**

Volume 26: Beckton Sewage Treatment Works appendices

Appendix D: Ecology - terrestrial

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

Hard copy available in

Box **40** Folder **B**
January 2013

Thames Tideway Tunnel

Creating a cleaner, healthier River Thames

This page is intentionally blank

Thames Tideway Tunnel

Environmental Statement

Volume 26 Beckton Sewage Treatment Works appendices

Appendix D: Ecology – terrestrial

List of contents

Page number

List of plates

Page number

List of tables

Page number

Appendix D: Ecology – terrestrial

D.1 Notable species survey report

Introduction

D.1.1 A Phase 1 Habitat Survey was carried out on 25 November 2010 at the Beckton Sewage Treatment Works site with results shown on Vol 26 Figure 6.1.2 (see separate volume of figures). Based on this, surveys for the following species have been undertaken:

a. bats

b. breeding birds

c. barn owls (*Tyto alba*)

d. wintering birds

e. black redstarts (*Phoenicurus ochruros)*

f. reptiles

g. 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.1.8). The results from the surveys are then presented (paras D.1.21 to D.1.42). The final section provides an interpretation of the results (paras. to D.1.43 to D.1.56). Figures referred to in this report are contained within Vol 26 Beckton Sewage Treatment Works Figures.

D.1.4 Information on legislation, policy and methodology can be found in Volume 2 Environmental assessment methodology 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 and their potential to support foraging, commuting or roosting bats,

one location was chosen for the installation of the remote recording devices as shown on Vol 26 Figure 6.4.3 (see separate volume of figures).

D.1.7 Location 1 is to the north east of Site B. This location was selected to record potential bat activity associated with roosting within the tree line and buildings near this location, in addition to foraging and commuting along the tree-lines in this area and vegetation.

D.1.8 The bat activity recorded during the remote recording surveys triggered the need for an additional dawn survey (see Vol 2 for bat triggering criteria). Therefore, a second stage of bat surveying was undertaken, comprising one dawn survey visit by four ecologists to assess the usage of the site and immediate surrounds by bats. The survey area for the bat activity (dawn) surveys, is shown in Vol 26 Figure 6.4.3 (see separate volume of figures).

Breeding birds

D.1.9 Breeding birds forage and nest within a range of habitat including grassland, scrub, trees and marginal aquatic habitats. Birds can also nest on and within buildings. The survey area includes the tall ruderal, scattered scrub, grassland and buildings at Site A on and immediately adjacent to the site, buildings on Site B, structures to the east and west of Site B, the tree line to the west of Site B and the jetties to the south of Site B, as shown in Vol 26 Figure 6.4.4 (see separate volume of figures).

D.1.10 The survey area comprises buildings, hardstanding, ephemeral/short perennial vegetation, tall ruderals, amenity grassland, dense scrub, scattered broad-leaved trees and jetties within the Thames Estuary.

Barn owls

D.1.11 Barn owls are typically supported by areas of rough grassland, which in turn support small mammals that the barn owls feed on. The edges of watercourses and strips of grassland adjacent to woodland, provide optimal habitat for barn owls to forage in. They typically nest within holes in trees, or within undisturbed buildings such as barns and outbuildings, ruins and, in some areas, mines, cliffs and quarries (RSPB website, 2012[1]).

D.1.12 The survey area comprised buildings associated with the inlet works in the south of Site A and surrounding scrub habitat immediately adjacent to the site, as shown in Vol 26 Figure 6.4.5). This area was selected because The London Peregrine Falcon Group has been monitoring this site for Barn Owls for several years and an active barn owl nest site was known to be within the inlet works at Site A.

Wintering birds

D.1.13 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 includes the proposed development site and habitats in close proximity to the site that

have potential for wintering birds, as shown in Vol 26 Figure 6.4.6 (see separate volume of figures).

D.1.14 The survey area mainly comprises intertidal mudflats and a number of jetties within the Thames Estuary. Within the survey area, there is a minor road on the flood defence bank adjacent to the Beckton Sewage Treatment Works, which is occasionally used by cars and vans. There is also an outfall from Beckton Sewage Treatment Works, which discharges warm water enriched with organic matter into the Thames Estuary.

Black redstarts

D.1.15 Black redstart nest on and within buildings and structures (mostly those that are derelict), and forage on sparsely-vegetated open areas. The survey area is shown in Vol 26 Figure 6.4.7 (see separate volume of figures).

D.1.16 The survey area includes those buildings, areas of hardstanding and other features which lie in the immediate vicinity of Beckton Sewage Treatment Works and includes the section of foreshore and river which lie adjacent to the proposed development site.

Reptiles

D.1.17 Reptiles are associated with a variety of habitats including open woodland, abandoned and derelict land, large gardens, heathland, grassland, scrub and riparian habitats. Reptiles are usually found where there is a mosaic of these habitats that provide a range of conditions that provide shelter, foraging areas and areas for basking. They also require sheltered locations for hibernating in winter, such as piles of wood or stone

D.1.18 The survey area comprises rank grassland and scrub habitats on Site A that connect to optimal reptile habitat to the west of the site, as shown on Vol 26 Figure 6.4.8 (see separate volume of figures).

Invasive plants

D.1.19 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.1.20 The invasive plants survey area comprises the proposed development site, and an area within 10m of the proposed development site boundary, as shown on Vol 26 Figure 6.4.9 (see separate volume of figures). The 10m zone beyond the site boundary was surveyed to record any invasive plants present adjacent to the site that could potentially spread onto the site, or that could have roots that extend into the site below ground (eg Japanese knotweed (*Fallopia japonica)*).

Results

D.1.21 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 paras D.1.43 to D.1.56.

Desk study

D.1.22 Species data recorded within 500m of the site from 2001 to 2011, as supplied by Greenspace Information for Greater London (GIGL), including the results of species surveys undertaken between 2005-2008 at Beckton Sewage Treatment Works to inform the *Lee Tunnel Environmental Statement* (ES) are summarised in Vol 4 Table D.1.

D.1.23 The site has been monitored by local ornithologists (bird specialists) with observations of barn owls at the site since 2004. Local ornithologists have confirmed that barn owl have been successfully breeding at this location for the last three years.

Vol 26 Table D.1 Terrestrial ecology – species found within 500m of the site between 2001 - 2011

Common name	Latin name	Record count
Mammals		
Noctule bat	*Nyctalus noctula*	2
Pipistrelle sp.	*Pipistrellus*	2
Birds		
Arctic tern	*Sterna paradisaea*	11
Bar-tailed Godwit	*Limosa lapponica*	2
Barn owl	*Tyto alba*	7
Bearded tit	*Panurus biarmicus*	3
Black-tailed Godwit	*Limosa limosa*	44
Black poplar	*Populus nigra subsp. Betulifolia*	2
Black redstart	*Phoenicurus ochruros*	14
Black tern	*Chlidonias niger*	26
Caspian gull	*Larus cachinnans*	93
Cetti's warbler	*Cettia cetti*	2
Cinnabar	*Tyria jacobaeae*	1
Common cuckoo	*Cuculus canorus*	10
Common goldeneye	*Bucephala clangula*	3
Common greenshank	*Tringa nebularia*	7
Common kingfisher	*Alcedo atthis*	9
Common linnet	*Carduelis cannabina*	20
Common pipistrelle	*Pipistrellus pipistrellus*	4
Common quail	*Coturnix coturnix*	2
Common redpoll	*Carduelis flammea*	4

Common name	Latin name	Record count
Common scoter	*Melanitta nigra*	1
Common starling	*Sturnus vulgaris*	4
Common tern	*Sterna hirundo*	50
Corn bunting	*Emberiza calandra*	2
Eurasian curlew	*Numenius arquata*	16
Eurasian hobby	*Falco subbuteo*	8
Eurasian marsh harrier	*Circus aeruginosus*	1
Eurasian tree sparrow	*Passer montanus*	2
European golden plover	*Pluvialis apricaria*	1
European turtle dove	*Streptopelia turtur*	6
Fieldfare	*Turdus pilaris*	5
Greater scaup	*Aythya marila*	8
Green sandpiper	*Tringa ochropus*	9
Grey partridge	*Perdix perdix*	64
Greylag goose	*Anser anser*	1
Hedge accentor	*Prunella modularis*	1
Herring gull	*Larus argentatus*	46
Little egret	*Egretta garzetta*	1
Little gull	*Larus minutus*	19
Little plover	*Charadrius dubius*	5
Little tern	*Sternula albifrons*	4
Mediterranean gull	*Larus melanocephalus*	13
Merlin	*Falco columbarius*	3
Northern goshawk	*Accipiter gentilis*	2
Northern lapwing	*Vanellus vanellus*	40
Northern pintail	*Anas acuta*	10
Peregrine falcon	*Falco peregrinus*	34
Pied avocet	*Recurvirostra avosetta*	7
Reed bunting	*Emberiza schoeniclus*	8
Ring ouzel	*Turdus torquatus*	1
Roseate tern	*Sterna dougallii*	1

Common name	Latin name	Record count
Ruddy shelduck	*Tadorna ferruginea*	10
Ruff	*Philomachus pugnax*	1
Sand martin	*Riparia riparia*	3
Sandwich tern	*Sterna sandvicensis*	19
Short-eared Owl	*Asio flammeus*	4
Sky lark	*Alauda arvensis*	13
Song thrush	*Turdus philomelos*	3
Spotted flycatcher	*Muscicapa striata*	2
Stone-curlew	*Burhinus oedicnemus*	2
Tree pipit	*Anthus trivialis*	1
Whimbrel	*Numenius phaeopus*	9
Wood warbler	*Phylloscopus sibilatrix*	1
Yellow wagtail	*Motacilla flava*	7

Bats surveys

Bat triggering (remote recording) surveys

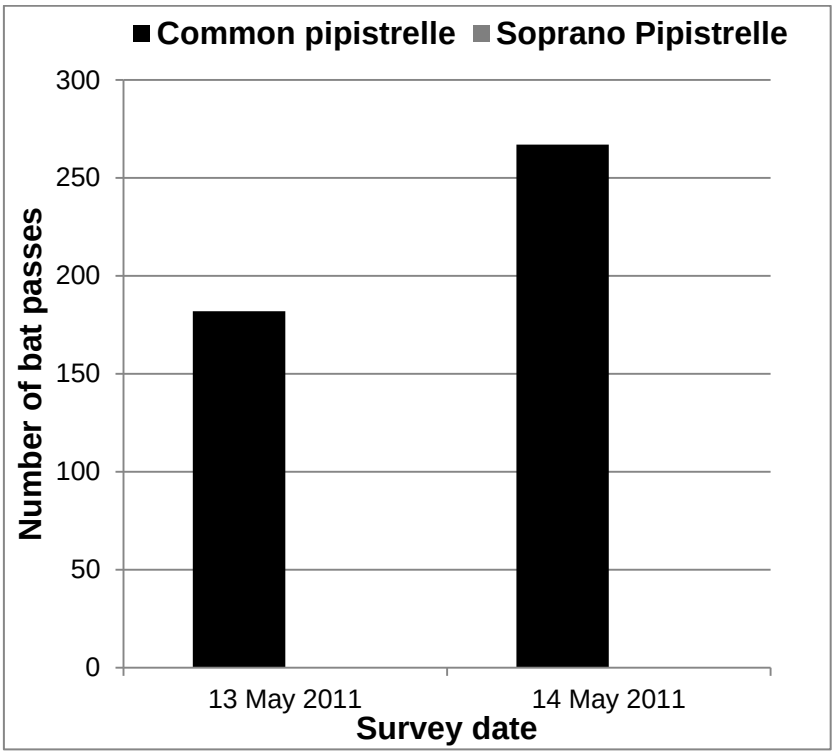
D.1.24 The bat triggering (remote recording) surveys were undertaken on 13 and 14 May 2011 in suitable weather conditions (Vol 4 Table D.2).

D.1.25 The remote recording surveys undertaken at the Beckton Sewage Treatment Works site recorded one species of bat at Location one (northeast of Site B); common pipistrelle (*Pipistrellus pipistrellus)*. A maximum number of bat passes of 267 was recorded on 14 May 2011 (see Vol 4 Plate D.1).

Vol 26 Table D.2 Terrestrial ecology – bat survey weather conditions

Survey visit	Weather conditions
13 May 2011	10-15°C, gentle breeze, 10% cloud cover, dry
14 May 2011	12-14°C, gentle breeze, 10% cloud cover, dry

Vol 26 Plate D.1 Terrestrial ecology – bat passes recorded during remote recording surveys at three locations at Beckton STW



Bat activity (dawn) surveys

D.1.26 As there were high numbers of bats recorded during the remote recording survey, this triggered the need for a bat activity (dawn) survey to be undertaken (based on bat triggering criteria in Vol 2 Section 6). The bat activity survey was undertaken on 28 June 2011 in suitable weather conditions (20^{o}C, light breeze, 50% cloud cover, dry). The bat activity survey results are shown on Vol 26 Figure 6.4.3 (see separate volume of figures).

D.1.27 The dawn survey did not record any bat activity in relation to either Site A or Site B, although common pipistrelle were recorded in small numbers foraging in the southeast of the Sewage Treatment Works (off-site).

Breeding bird surveys

D.1.28 A total of three surveys were conducted, during suitable weather conditions between May and June 2011 by an experienced ornithologist (bird specialist). The results of the breeding bird survey are shown in and on Vol 6 Figure 6.4.4 (see separate volume of figures). 128 breeding territories comprising 22 breeding bird species were recorded within the survey area. Of these, five species recorded are of nature conservation importance and are included on the Birds of Conservation Concern 3 (RSPB, 2009[i]) Red or Amber List and/or UK and London BAP (Vol 26 Section 6, Vol 26 Table 6.4.3):

[i] The UK's birds can be split into three categories of conservation importance - red, amber and green. Red is the highest conservation priority, with species needing urgent action. Amber is the next most critical group, followed by green.

a. The scattered scrub and trees on and adjacent to the site within the Greenway and Old Ford SINC provided suitable nesting and foraging habitat for 12 whitethroat (*Sylvia communis)* breeding territories. Three of these breeding territories are within the proposed site boundary. A further whitethroat breeding territory was recorded within trees to the north of Site B.

b. Two linnet (*Carduelis cannabina)* breeding bird territories were recorded within scrub vegetation within the Greenway and Old Ford SINC. Both of these breeding territories are within the proposed site boundary.

c. A disused jetty, which is located on the foreshore 230m to the south of Site B, was found to support approximately 46 breeding pairs of lesser black-backed gull *(Larus fuscus)* and 18 breeding pairs of herring gull *(Larus argentatus)*.

d. One dunnock (*Prunella modularis)* breeding territory was recorded within the survey area and was positioned within the site boundary in the northwest of Site A.

e. Green spotted woodpecker *(Picus viridis)* was observed foraging in the northwestern corner of the survey area and is considered to be breeding nearby.

Vol 26 Table D.3 Terrestrial ecology – breeding bird survey weather conditions

Survey visit	Weather conditions
13 May 2011	14°C, 25% cloud cover, light breeze, dry
7 June 2011	12°C, 100% cloud cover, light breeze, dry
17 June 2011	16°C, 10% cloud cover, light breeze, dry

Vol 26 Table D.4 Terrestrial ecology – breeding bird territories recorded within the survey area

Species name	Latin name	Conservation designation[ii]	Estimated number of breeding territories
Lesser black-	*Larus fuscus*	Amber List	46

[ii] 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[ii]	Estimated number of breeding territories
backed gull			
Herring gull	*Larus argentatus*	Red List	18
Feral pigeon	*Columba livia*	None	10
Wood pigeon	*Columba palumbus*	None	4
Green spotted woodpecker	*Dendrocopos major*	Amber List	1
Pied wagtail	*Motacilla alba*	None	1
Wren	*Troglodytes troglodytes*	None	11
Dunnock	*Prunella modularis*	Amber List UK BAP Priority List	1
Robin	*Erithacus rubecula*	Green List	5
Blackbird	*Turdus merula*	Green List	4
Blackcap	*Sylvia atricapilla*	Green List	2
Whitethroat	*Sylvia communis*	Amber List	12
Sedge warbler	*Acrocephalus schoenobaenus*	Green List	1
Chiffchaff	*Phylloscopus collybita*	Green List	1
Long-tailed tit	*Aegithalos caudatus*	Green List	1
Great tit	*Parus major*	Green List	1
Blue tit	*Parus caeruleus*	Green List	1
Magpie	*Pica pica*	Green List	1
Greenfinch	*Carduelis chloris*	Green List	3
Goldfinch	*Carduelis carduelis*	Green List	2
Linnet	*Carduelis cannabina*	Red List UK BAP Priority List	2
Chaffinch	*Fringilla coelebs*	Green List	1

Barn owls

D.1.29 A survey for barn owls was undertaken on 27 July 2012. The survey was undertaken by an experienced ornithologist (bird specialist) at an

appropriate time of year. The weather conditions were suitable for surveying (17°C, light breeze, 75% cloud cover, dry

D.1.30 A barn owl nest was recorded within the north side 'undercroft' of the elevated inlet works (within Site A) where barn owls are using an old pipe for nesting purposes (Vol 26 Figure 6.4.5). Whilst no birds were recorded during the survey, recent evidence of barn owls was identified in the form of fresh pellets and droppings.

D.1.31 Thames Water personnel confirmed that the birds had successfully bred on site in 2012.

Wintering bird surveys

D.1.32 A total of six surveys were undertaken at monthly intervals during December 2010 to March 2011 and between October and November 2011 by an experienced ornithologist (bird specialist). The survey visits were undertaken in suitable weather conditions (see Vol 4 Table D.5). The main foraging and resting areas for wintering birds are indicated on Vol 26 Figure 6.4.6 (see separate volume of figures). The numbers of individuals of each species recorded in each month are provided in Vol 4 Table D.6.

Vol 26 Table D.5 Terrestrial ecology – wintering bird survey weather conditions

Survey visit	Weather conditions
23 December 2010	-1°C, moderate breeze, 75% cloud cover, dry
28 January 2011	1°C, east-north-easterly wind, 100% cloud cover, dry
14 February 2011	6°C, light breeze, 75% cloud cover, dry
14 March 2011	0°C, calm, 100% cloud cover, dry
28 October 2011	12°C, light breeze, 50% cloud cover, dry
18 November 2011	10°C, light breeze, 75% cloud cover, dry

D.1.33 A small number of common bird species including feral pigeon (*Columba livia* (domest.)), wren (*Troglodytes troglodytes)*, robin (*Erithacus rubecula)* and blackbird (*Turdus merula)* were recorded in the bramble and elder scrub within Site A on a few occasions.

D.1.34 No wintering birds were recorded on Site B. It is likely that Site B is unattractive to wintering birds because there are no areas of vegetation that could be used for shelter or as a foraging resource, and there was disturbance from personnel and machinery associated with construction of the Lee Tunnel.

D.1.35 Within the wider survey area, a number of wintering bird species was also recorded. Further information is summarised as follows:

a. Trees and scrub adjacent to both Site A and Site B support a low abundance and diversity of common bird species, including feral pigeon, wren, robin, thrushes and finches.

b. Two rock pipits (*Anthus petrosus)* were recorded on the sea wall and jetties above the foreshore. This species is a regular, but scarce visitor to East London, with six winter records from near the site at Creekmouth, Barking in 2007[1].

c. A total of 25 waterbird[iii] species were recorded on the intertidal mudflats which are located approximately 30m south of Site B. Of these, 20 species are of nature conservation importance because they are included on the Birds of Conservation Concern Red or Amber List and/or UK and London BAP as priority species.

d. Shoveler (*Anas clypeata)*, pochard (*Aythya farina)*, tufted duck (*Aythya fuligula)*, scaup (*Aythya fuligula)* and black-headed gull *(Larus ridibundus)* foraging activity was restricted to the scour pool by the Beckton CSO, approximately 230m to the east of Site B.

e. The intertidal mud along the foreshore, particularly around the CSO was used for foraging by shelduck (*Tadorna tadorna)*, gadwall (*Anas strepera)*, teal (*Anas crecca)*, mallard (*Anas platyrhynchos)*, black-tailed godwit (*Limosa limosa)* and redshank (*Tringa tetanus)*.

f. The mudflats beyond 100m of the CSO were used mainly for resting by oystercatcher (*Haematopus ostralegus),* golden plover (*Pluvialis apricaria)*, lapwing (*Vanellus vanellus)*, snipe (*Gallinago gallinago)*, curlew (*Numenius arquata)*, and common gull (*Larus canus)* in single species flocks. The nearby jetties were favoured resting sites for lesser black-backed gull, herring gull, and great black-backed gulls (*Larus marinus)*.

[iii] 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.

Vol 26 Table D.6 Terrestrial ecology – species and numbers of wintering waterbirds recording during monthly wintering bird surveys

Species name	Latin name	Conservation designation[iv]	Monthly wintering waterbird counts					
			23 December 2010	28 January 2011	14 February 2011	14 March 2011	28 October 2011	18 November 2011
Cormorant	*Phalacrocorax carbo*	None	30	24	22	32	18	38
Grey heron	*Ardea cinerea*	None	-	1	-	-	1	-
Mute swan	*Cygnus olor*	None	-	2	2	2	-	-
Canada goose	*Branta canadensis*	None	-	4	1	4	-	-
Shelduck	*Tadorna tadorna*	Amber List	33	30	37	46	22	20
Gadwall	*Anas strepera*	Amber List	6	28	16	13	-	3
Teal	*Anas crecca*	Amber List	75	174	108	187	125	177
Mallard	*Anas platyrhynchos*	Amber List	74	34	29	45	60	36
Shoveler	*Anas clypeata*	Amber List	8	68	28	22	6	14
Pochard	*Aythya ferina*	Amber List	2	2	-	-	-	-

[iv] 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[iv]	Monthly wintering waterbird counts					
			23 December 2010	28 January 2011	14 February 2011	14 March 2011	28 October 2011	18 November 2011
Tufted duck	*Aythya fuligula*	Amber List	254	46	-	-	-	-
Scaup	*Aythya marila*	Red List and UK BAP Priority List	-	2	-	-	-	-
Coot	*Fulica atra*	None	5	20	28	21	-	-
Oystercatcher	*Haematopus ostralegus*	Amber List	-	-	2	5	-	-
Golden plover	*Pluvialis apricaria*	Amber List	-	4	-	-	-	-
Lapwing	*Vanellus vanellus*	Red List and UK BAP Priority List	1	-	-	-	-	-
Snipe	*Gallinago gallinago*	Amber List	4	-	-	-	-	-
Black-tailed godwit	*Limosa limosa*	Red List and UK BAP Priority List	4	8	-	-	72	202
Curlew	*Numenius arquata*	Amber List and UK BAP Priority List	1	-	2	1	-	1
Redshank	*Tringa totanus*	Amber List	11	8	2	29	6	23
Black-headed gull	*Chroicocephalus ridibundus*	Amber List	8	178	650	326	221	367
Common gull	*Larus canus*	Amber List	-	3	8	-	-	-

Species name	Latin name	Conservation designation[iv]	Monthly wintering waterbird counts					
			23 December 2010	28 January 2011	14 February 2011	14 March 2011	28 October 2011	18 November 2011
Lesser black-backed gull	*Larus fuscus*	Amber List	-	3	3	42	2	5
Herring gull	*Larus argentatus*	Red List UK BAP Priority List	4	8	8	39	5	6
Great black-backed gull	*Larus marinus*	Amber List	3	1	1	-	-	2

Black redstart surveys

D.1.36 A total of five back redstart surveys were undertaken between 13 May and 5 July 2011 by an experienced ornithologist, for a minimum of three hours each during the early morning period and when weather conditions were suitable, as detailed below in Vol 4 Table D.7.

D.1.37 The July visit is outside of the optimum survey period for black redstart. However, surveys can be undertaken during July as breeding usually continues into this month (Brown A. and Grice P, 2005)[2]. The other four 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, a single survey visit in July is not considered to limit the results of the survey.

D.1.38 No black redstarts were recorded during any of the five survey visits.

Vol 26 Table D.7 Terrestrial ecology – details of black redstart surveys

Date	Weather conditions
13 May 2011	10°C, light breeze, 100% cloud cover, dry
7 June 2011	12°C, light breeze, 75% cloud cover, dry
17 June 2011	15°C, light breeze, 50% cloud cover, dry
28 June 2011	20°C, light breeze, 50% cloud cover, dry
5 July 2011	16°C, calm, 75% cloud cover, dry

Reptile surveys

D.1.39 A total of ten reptile surveys were conducted by experienced ecologists at an appropriate time of year and during suitable weather conditions (see Vol 4 Table D.8).

D.1.40 No reptiles were recorded during the surveys

Vol 26 Table D.8 Terrestrial ecology – reptile survey weather conditions

Date	Weather conditions
20 May 2011	Weather not relevant. Equipment setup (Mat placement)
07 June 2011	17°C, calm, 25% cloud cover, dry
17 June 2011	19°C, calm, 25% cloud cover, dry
05 July 2011	16°C, calm, 75% cloud cover, dry
14 July 2011	13°C, light breeze, 75% cloud cover, dry
02 September 2011	18°C, light breeze, 25% cloud cover, dry
08 September 2011	16°C, light breeze, 25% cloud cover, dry
14 September 2011	19-23°C, light breeze, 40% cloud cover, dry

Date	Weather conditions
20 September 2011	15-17°C, light breeze , 40% cloud cover, dry
22 September 2011	17-20°C, moderate breeze, 90% cloud cover, dry
27 September 2011	17-19°C, moderate breeze, 20% cloud cover, dry

Invasive plants survey

D.1.41 The invasive plant survey was undertaken on 16 August 2011 by an experienced ecologist. The results of the survey are shown on Vol 26 Figure 6.4.9 (see separate volume of figures) with a corresponding description given in Vol 4 Table D.9.

D.1.42 Two invasive plant species were recorded during the survey. All of the invasive plant species present were recorded within or in the immediate vicinity of Site A. Japanese knotweed (*Fallopia japonica)* was recorded in eight locations of the site both within and immediately outside the site boundary. Some of these stands had been treated, but viable growth within each of these stands was recorded. Virginia Creeper (*Parthenocissus inserta)* was recorded in one location on the site along a fenceline and within one of the aforementioned Japanese knotweed stands.

Vol 26 Table D.9 Terrestrial ecology – invasive species

Common and latin name	Location/description	NGR	Stand size
Virginia creeper *(Parthenocissus inserta)*	Inside boundary of Site A. Linear belt along fenceline adjacent to an access road and entwined within a stand of the invasive species Japanese knotweed.	TQ4438181955	40m x 10m
Japanese knotweed *(Fallopia japonica)*	Inside boundary of Site A. Linear stand situated adjacent to a fenceline and access road. Stand is entwined with the invasive species Virginia creeper.	TQ4438181955	30m x 10m
	Inside boundary of Site A. Dense stand within triangular piece of land between two access roads.	TQ4432081966	45m x 7m
	Inside boundary of Site A at its western end. Stand located due south of pylons.	TQ4411782010	10m x 10m
	Outside and due immediately west of Site A boundary, on the embankment facing the retail	TQ4406781993	10m x 10m

Common and latin name	Location/description	NGR	Stand size
	park.		
	Inside the boundary of Site A at its northwestern corner. Small stand due south of an access track beneath pylons.	TQ4414482066	10m x 5m
	Inside the boundary of Site A at its northwestern corner. Small stand due south of an access track beneath pylons.	TQ4413482066	10m x 5m
	Mainly outside and partially inside the boundary of Site A at its northwestern corner. Stand on cutting supporting the access road, immediately north of it.	TQ4413382084	30m x 10m
	Outside the boundary of Site A at its northwestern corner. Stand on cutting supporting the access road, immediately north of it.	TQ4412082081	10m x 5m

Interpretation

Bats

D.1.43 Peak activity of common pipistrelle was observed during the bat triggering survey on 14 May 2011 with 267 passes recorded. All of the bat passes for this species were recorded off-site from around midnight. Therefore it can be determined that the survey area is being used as a foraging and/or commuting resource rather than for roosting purposes.

D.1.44 A dawn activity survey did not record any bat activity associated with the proposed works sites.

D.1.45 Due to the high number of bat passes during the triggering survey, the habitat within and adjacent to the survey area is considered to be of importance for a large population of common pipistrelle bats. Based on observations during the dawn bat survey, this activity is likely to be associated with vegetation near to the site and the River Thames to the south. However, neither Site A nor Site B is considered to be important for bats.

Breeding birds

D.1.46 Of the 22 bird species which occupied breeding territories within the survey area, none are listed on Schedule 1 of the Wildlife and Countryside Act 1981 (as amended), although five species are of nature conservation importance and are included in the Birds of Conservation Concern Red or

Amber List and/or UK BAP Priority Species: mallard (2 breeding territories), kestrel (1 breeding territory), lesser black-backed gull (46 breeding territories), herring gull (18 breeding territories), green woodpecker (1 breeding territory), dunnock (1 breeding territory), whitethroat (12 breeding territories) and linnet (2 breeding territories).

D.1.47 The derelict jetty provides a suitable undisturbed site for lesser black-backed gulls and herring gulls. Areas of short grass providing foraging habitat for green woodpecker and are considered part of its breeding territory. The bramble scrub provides nest sites and foraging habitat for dunnock, whitethroat and linnet.

Barn owls

D.1.48 The survey visit confirmed that a pair of barn owl use buildings within Site A for nesting purposes. Anecdotal evidence from Thames Water personnel confirmed that the birds had successfully bred in 2011 and 2012. It is likely that the birds will return year after year (where the nest site remains suitable) as barn owls typically use the same nest site for life.

D.1.49 It is likely that the scrub and rough grassland habitat, on and adjacent to the site, supports small mammals, which in turn supports the barn owls.

Wintering birds

D.1.50 Of the 25 waterbird species that were recorded within the survey area, 20 are of nature conservation importance and are included in the Birds of Conservation Concern Red or Amber List and/or UK BAP Priority Species: shelduck, gadwall, teal, mallard, shoveler, pochard, tufted duck, scaup, oystercatchesr, golden plover, lapwing, snipe, black-tailed godwit, curlew, redshank, black-headed gull, common gull, lesser black-backed gull, herring gull and great black-backed gull.

D.1.51 Within the survey area, the intertidal mud was used for foraging by shelduck, teal, oystercatcher, golden plover, lapwing, snipe, black-tailed godwit, curlew, redshank, black-headed gull, common gull, lesser black-backed gull, herring gull and great black-backed gull. The waste water being discharged from the outfall at low tide was used for foraging by gadwall, mallard, shoveler, pochard, tufted duck and scaup.

D.1.52 Of particular note are the populations of shelduck, teal, mallard, gadwall and shoveler, and the presence of waders such as redshank and black-tailed godwit.

Black redstart

D.1.53 The five surveys were undertaken over a period of approximately seven weeks at a time of year when black redstarts are most likely to be recorded if present. However, the lack of observations of this species throughout the course of the survey period strongly suggests they do not currently utilise the proposed development site for either foraging or breeding purposes.

D.1.54 While there are many opportunities for black redstart to nest and forage in London, not all of 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, 2008)[3].

Reptiles

D.1.55 Although some of the habitat appeared suitable for reptiles within Site A, no reptiles were found within the survey area. Surveys undertaken for the 2008 Lee Tunnel ES (Scott Wilson, 2008)[4] identified a low population of grass snake (*Natrix natrix*) within habitat to the south of Site A. As part of the assessment for the ES, mitigation was proposed to ensure that reptiles were not affected by construction works. This included a translocation exercise to move the reptiles off site. This is likely to have resulted in the removal of the grass snake resource from suitable habitat on and adjacent to the Site A.

Invasive plants

D.1.56 Two invasive plant species listed on Schedule 9 of the Wildlife and Countryside Act 1981 are recorded at the site; Japanese knotweed and Virginia creeper. It is illegal to cause the spread of these species. Therefore, it would be necessary to control these species before works commence on site.

References

[1] *Royal Society for the Protection of Birds website* (2012). http://www.rspb.org.uk/. Accessed 14 November 2012.

[2] Brown A. and Grice P. *Birds in England.* Poyser, London (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).

[4] Scott Wilson. *Lee Tunnel and Beckton STW Extension Environmental Statement* (May 2008).

Thames Tideway Tunnel
Thames Water Utilities Limited

Application for Development Consent

Application Reference Number: WWO10001

Environmental Statement

Doc Ref: **6.2.26**

Volume 26: Beckton Sewage Treatment Works appendices

Appendix E: Historic environment

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

Hard copy available in

Box **40** Folder **B**
January 2013

Thames Tideway Tunnel

Creating a cleaner, healthier River Thames

This page is intentionally blank

Thames Tideway Tunnel

Environmental Statement

Volume 26 Beckton Sewage Treatment Works 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 26 Table E.1 below, with their location shown on the historic environment features map (Vol 26 Figure 7.4.1, see separate volume of figures).

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

Vol 26 Table E.1 Gazetteer of known heritage assets within the site and assessment area

HEA Ref no.	Description	Site code/ HER ref/ List Entry Number
1a	The site of a grade II listed chimney, constructed in 1887–9 for the Metropolitan Board of Works, by Sir Joseph Bazalgette as part of the London sewage works with minor alterations at a later date. The chimney has been removed temporarily as mitigation for the Lee Tunnel works and will be reinstated.	100791 1393160
1b	Line of the Bazalgette Northern Outfall Sewer. Built in the late 19th century.	---
1c	Beckton Sewage Works. The UK's biggest sewage works, responsible for much of the waste from the London area. Bazalgette designed a treatment system at Beckton and Crossness where the sewage was treated before the remains were loaded on to ships and discharged into the sea. Buildings date from the late 1880s to the mid 20th century. After this date there are only minor alterations.	99424
1d	Old Engine House, Jenkins Lane (Beckton Sewage Treatment Works), Newham. Historic building recording was undertaken by Scott Wilson in 2009 on structures at the 1880s Engine House off Royal Docks Road. The building has subsequently been demolished.	BSJ08

HEA Ref no.	Description	Site code/ HER ref/ List Entry Number
1e	Sewage treatment works building north of the Northern Outfall Sewer, first shown on the Ordnance Survey 2nd edition 25" map of 1896–9. Hachures immediately to the north of the building indicate that it was probably built at the top of the raised sewer embankment rather than at the base of the slope. Not shown on the Ordnance Survey 1:10,000 map of 1954–69.	___
1f	The site of 'Car Shed' and north-south tramway servicing the sewage works to the west of the shed. First shown on the Ordnance Survey 2nd edition 25" map of 1896–9. Not shown on the Ordnance Survey 1:10,000 map of 1954–69.	---
1g	An archaeological evaluation by Museum of London Archaeology (MOLA) in 2009. A single evaluation trench was excavated on the site of The Lee Tunnel access shaft at Thames Water Beckton Sewage Treatment Works (STW). Root bowls and tree bases (probably alder) were recorded truncating the layer along the east face of the trench. Peat was present throughout the trench extent to a height of 99.8m ATD. The characteristics of the peat reflect the site location within, or adjacent to, ancient river channels. Alluvial clays and silts accumulated above the organic deposits, probably during the Iron Age and later historic periods which might represent seasonally flooded meadowland or estuarine environments. A compressed layer of topsoil and turf represented (undated) historic open grassland survived at the top of the alluvial profile at 101.2m ATD. Modern made ground, *c.* 1.3m thick sealed the alluvial sequence. The trench showed no evidence of prehistoric human activity. This trench formed part of a wider geoarchaeological deposit model (see HEA 31).	LBT09
2	Debden Wharf, Barking Creek, 54–58 River Road. An archaeological watching brief by Wessex Archaeology (WA) in 2007 revealed alluvium overlain by modern silts that contained an abundance of modern debris. No archaeological remains were recorded.	DDW07
3	The site of Barking Magazine, constructed in *c.* 1719. It was built to store gunpowder and was transferred to private ownership by 1881. Recorded on the Greater London Historic Environment Record (GLHER).	060625

HEA Ref no.	Description	Site code/ HER ref/ List Entry Number
4	Unspecified works in Barking Creek prior to 1914 revealed a stone axe-hammer dating to the late Neolithic/early Bronze Age. Recorded on the GLHER. The remains of a bronze sword hilt dating to the Bronze Age were found in the River Roding 1.5km to the west of Barking. Recorded on the GLHER. Unspecified works near Barking Creek revealed a bronze socketed axe dating to the Bronze Age. Recorded on the GLHER. Unspecified works in the Barking Marshes around 1862 revealed a bronze looped square socketed axe dating to the Bronze Age. Recorded on the GLHER.	060625 060195 060193 060194
5	The site of the Dampers Dock dating to the medieval period through to the 17th century. Recorded on the GLHER.	061084
6	Beckton Sewage Works, Precipitation and Re-Aeration Lanes, Alfred's Way. An archaeological standing structure record by Oxford Archaeology (OA) in 2004. The original works at Beckton, forming the end of the Northern Outfall of Joseph Bazalgette's London's sewage system, were examined and found to have been constructed in the 1860s. In 1887, precipitation lanes were constructed to treat the sewage chemically, with the sludge being removed in ships and dumped at sea. These structures, as well as the valve and pump rooms, were recorded along with the eastern section of these lanes, which were largely demolished in the 1960s to form re-aeration lanes.	AFW04
7	The site of a medieval and post-medieval house called Galyonshope, probably associated with the families of John and Richard Galyan (Galyon) in 1466. In 1906 the house was called Gallions. Recorded on the GLHER.	061080
8	Beckton Sewage Works, East Ham, E6. An archaeological excavation by Pre-Construct Archaeology (PCA) in 1994. Two trenches were excavated. The first revealed part of a north-south river channel filled with alluvial clays. Other features were modern. The 2nd trench contained deposits of peat lying on silty sand at a depth of about 7m from ground level. At the interface between these layers a water-worn burnt flint was found. Higher in the peat were the remains of four yew trees, all naturally fallen, probably part of the great yew forest that grew along the Thames in the prehistoric period.	HE-SW94

HEA Ref no.	Description	Site code/ HER ref/ List Entry Number
9	The chance find of Mesolithic animal remains and a Bronze Age axe from the site of the Beckton Sewage Works. Recorded on the GLHER.	061748 061749
10	The site of a Roman dock along the Barking Creek Recorded on the GLHER.	061648
11	The chance find of a Neolithic axe. Recorded on the GLHER.	060189
12	Marley Waterproofing, 8 River Road, Barking IG11. An archaeological watching brief by Museum of London Archaeology Service (MoLAS) in 2007. Monitoring of sheet piling along the eastern bank of Barking Creek (River Roding) revealed a timber revetment.	RIE07
13	A pile or post obstruction recorded by Seazone.	---
14	A group of posts which previously formed part of a jetty. Recorded by Seazone.	---
15	The chance find of a Palaeolithic flint flake. Recorded by the GLHER.	060573
16	The site of a post-medieval landfill site. Recorded on the GLHER.	062763
17	A13/A406 road junction, Newham Way, E6. An archaeological evaluation by MoLAS in 1999. Gravel, peat and alluvial horizons were mapped from borehole data. The lower horizon of a thick layer of peat was dated to 2,475-2,040 BC (Neolithic); the upper horizon was date to 1,880-1,450 BC (Bronze Age).	NEY99
18	The site of the 13th-century wall of St Margaret's churchyard. This is an error on the GLHER: the Barking parish church of St Margaret (formerly the Barking Abbey formed in the 7th century) lies some distance to the northwest of this location, outside the assessment area.	060939
19	Two obstructions recorded by Seazone. One has been removed while the other is believed to still be extant.	
20	An obstruction of debris which is still extant has been recorded by Seazone.	
21	The site of the Barking Jute Factory. Recorded on the GLHER. Jute is a fibrous plant grown in India that can be processed to make rope and coarse canvas material.	060663
22	The site of a dangerous wreck which is thought to no longer be extant by Seazone	

HEA Ref no.	Description	Site code/ HER ref/ List Entry Number
23	An obstruction comprising a pile or post recorded by Seazone.	
24	The remains of a number of posts which previously formed a jetty. Recorded by Seazone.	
25	Thames Gateway Bridge, Gallions Reach. An archaeological diving survey by Wessex Archaeology (WA) in 2004. Targeted diving revealed timber planks and frames, possibly the remains of a steam boiler, which formed part of a substantial 19th- or early 20th-century vessel.	GDK05
26	The chance find of a Bronze Age sword from the River Thames. Recorded on the GLHER.	060197
27	The chance find of an unspecified Palaeolithic flint artefact. Recorded on the GLHER.	061771
28	The recorded location of a wreck called the Halo. The ship sank in 1941 and the wreck subsequently removed. Recorded by Seazone.	___
29	The site of the Princess Alice wreck. In 1878, the paddle steam collided with an iron-built collier and sank with the loss of between 550–650 lives. It was one of the country's worst ever inland waterway disasters. Recorded on Seazone.	___
30	19th-century wall, close to Site Area B and probably associated with the Bazalgette scheme.	---
31	Lee Tunnel, Triangle site Beckton Sewage Treatment Works, Jenkins Lane. A geoarchaeological deposit model by Museum of London Archaeology (MOLA) in 2009. This mapped the presence of late Pleistocene gravels at 97.8m ATD (above Tunnel Datum; 4.5m below ground level). The surface of (fluvial) sandy clay/clay sand channel deposits of potential late Pleistocene/early Holocene date were noted at 99.1m ATD. Modern made ground, *c.* 1.3m thick sealed the alluvial sequence.	LBT09
32	A Roman ceramic vessel and an Iron Age cosmetic mortar have been recorded at this location by the portable antiquities scheme (PAS)	LON-1C6226 LON-512E43

HEA Ref no.	Description	Site code/ HER ref/ List Entry Number
33	The site of an enclosure with several small buildings and yards first shown on the Ordnance Survey 3rd edition map of 1909–20. Not shown on the Ordnance Survey 1:10,000 map of 1954–69. The size of the buildings suggests that they are possibly offices or accommodation, perhaps for the sewage work staff/supervisor.	___
34	Creekside Backwater, Beckton Sewage Treatment Works. A watching brief by MOLA in 2011. Work on the construction of a new ecological habitat was monitored. The natural estuarine alluvium was sealed by made ground composed of large fragments of modern brick rubble (yellow and red stock bricks), reinforced concrete, wood and general demolition debris. No archaeological deposits, features or finds were observed.	LEE11

E.2 Site location, topography and geology

Site location

E.2.1 The site comprises large irregular-shaped area, with three distinct areas linked by access roads, referred to collectively here as the area of proposed development, or 'the site'. All of the works which would affect heritage assets would take place within the parts of the site formerly (and still) referred to as Sites A and B. Site A lies to the east of Royal Docks Road and is bounded by extensive rectangular sludge tanks of the Beckton Sewage Treatment Works (BSTW) to the north and east, and Galleons Reach shopping park to the south. Site B, 450m to the southeast of Site A, lies within the southeast of the Sewage Treatment Works site and is bounded by the mudflats of the River Thames to the south. At its closest point, the River Roding (Barking Creek) lies 300m to the northeast of Site B. The current confluence of the creek with the River Thames lies 400m to the east of Site B.

E.2.2 The distances to heritage assets given in the text below are the closest to the area of proposed development, whether it is Site A or Site B.

Topography

E.2.3 A basic understanding of the topography can be determined from current Ordnance Survey data. It was not possible to enter either Site A or B for the site visit, as these sites were active construction sites associated with the Lee Tunnel works. The proposed development is located on the Thames alluvial floodplain, the top of which is naturally flat, and any variations in level ground will be artificial.

E.2.4 Ground levels within Site A vary, generally sloping down towards the centre of the site from both east and west. The western part of Site A lies

at c. 107.0m ATD (above Tunnel Datum; the equivalent to 7.0m Ordnance Datum), the eastern part lies at c. 105.0m ATD, whilst the central area lies at c. 102.0m ATD.

E.2.5 Ground level within Site B slopes gently down from the northeast to the southwest. The northeastern edge lies at c. 106.9m ATD and the southwestern edge lies at c. 105.6m ATD.

Geology

E.2.6 The area of proposed development is located entirely on floodplain alluvium. The ground levels have been raised artificially in the past, by several metres, following drainage and reclamation of the intertidal marshes in the later medieval and post-medieval periods.

E.2.7 A recent geoarchaeological deposit model (**HEA 31**) of the area of BSTW (Halsey C, 2009)[1] including Sites A and B, gives a baseline for the deposit sequence and buried topography underlying the site. It indicates a complex sequence of channel and alluvial strata overlying subsurface gravel, which undulates and generally slopes downwards across the BSTW from a high of 98.5m ATD in the north to 91.0m ATD in the south. The potential archaeological and palaeoenvironmental sequences (where they survive) may extend to depths of c. 15m below present ground level, although the upper 5m is likely to be modern land raising and reclamation (E.4.31).

E.2.8 The gravel was probably deposited by the ancestral River Roding in a cold climate during the closing stages of the Pleistocene. The irregular surface of this braided river dictated the course of later Holocene (10,000BC to present) channels. At least four channels were identified, flowing in a roughly north to south direction towards Site A, during a borehole evaluation immediately north of and within the site (**HEA 31**; Vol 26 Plate E.1). These channels are likely to be associated with prehistoric courses of the River Roding.

E.2.9 In contrast, the northern part of Site A lies on an island of higher gravel overlain by sands. The sand surface lies at about 99.0m ATD and this is likely to have been a dry land surface until the Neolithic or later (**HEA 31**; Vol 26 Plate E.1).

E.2.10 An indication of the likely sequence of deposits surviving on Site A is provided by a transect through boreholes drilled immediately north of Site A and across its northern part (**HEA 31**; Vol 26 Plate E.2). The line of the transect is shown as Transect 2 on Vol 26 Plate E.1.

E.2.11 The ancient channels recorded to the north of Site A might extend across Site A itself. If they continue across Site A, the channel fills might be similar in character, where they were found to consist of finely laminated silts and sands indicative of deep and fast flowing water (facies 2 on Vol 26 Plate E.2). These deposits were found to be sterile of ecofact remains (such as ostracods and diatoms).

E.2.12 As the channels migrated and became abandoned they infilled with peat deposits (the rotted vegetation of a former land surface), which also spread across the wider area (facies 3 on Vol 26 Plate E.15). The peats

formed within a densely wooded alder carr environment and preserved assemblages of plant and pollen remains. Diagnostic characteristics of the pollen assemblage suggested that the peat in the area of Site A dates from the Late Neolithic to Early Bronze Age.

E.2.13 A deeper area, where floodplain gravels were overlain by estuarine clay with no peat bed, was recorded south of Site A and west of Site B. This area is likely to represent scour as a result of rising river levels and estuarine incursion. A stream or creek is shown crossing this area on a map of 1777 (Vol 26 Plate E.3).

E.2.14 Site B lies in an area of deeper gravel, generally below 94.0m ATD. Previous boreholes from this area suggest a long peat sequence overlies the gravel, with the peat surface lying around 99.0m ATD. The peat is likely to preserve environmental evidence dating from the Mesolithic to the Bronze Age. Its characteristics vary across Site B suggesting the presence of pools, channels and drier areas within 'alder carr' (wet woodland).

E.2.15 By the early Iron Age, the rate of sea level rise outstripped that of peat formation, resulting in a transition from vegetated wetland deposits to tidal mudflats and salt marsh environments (facies 4 on Vol 26 Plate E.2). These deposits preserved brackish water ostracods and diatoms, which represent the onset of estuarine environments and a transition from woodland to salt marsh and tidal mudflat conditions. The upper deposits consisted of weathered and gleyed silts and clays, which indicate a gradual transition from estuarine environments to overbank flood deposits and the formation of accretionary soils, subject to occasional flooding, which are likely to date from the later medieval period, as a result of drainage and land reclamation.

E.2.16 The estuarine clays were recorded to an average height of 101.0m ATD in the north and 102.5m ATD in the south of the investigations immediately north of Site A (**HEA 31**), with the levels recorded influenced by intrusive ground disturbance associated with the sewage works). Overlying the alluvial sequence was a substantial thickness (around 5 metres) of made ground, dumped to improve ground conditions from the mid/late 19th century onwards, which rises from 102.3m ATD in the north to a maximum of 108.0m ATD in the south.

E.3 Past archaeological investigations within the assessment area

E.3.1 In 2008, the Old Engine House of Beckton Sewage Works within Site B was subject to archaeological standing building recording prior to demolition (**HEA 1d**). This noted that the surviving buildings dated from the second phase of development of the site in the late 1880s up to the 1950s. In the second half of the 20th century there were alterations to the site but no significant buildings (Scott Wilson, 2008)[2]. The grade II listed sewage works chimney (**HEA 1a**), constructed in 1887–9 for the Metropolitan Board of Works, by Sir Joseph Bazalgette, was removed but will be reinstated. In 2004, standing structure recording (**HEA 6**), c. 390m

north of Site B, recorded other elements of the 1860s Beckton sewage works.

E.3.2 In 2009, an archaeological evaluation (**HEA 1g**) was carried out at the Triangle Site as part of the Lee Tunnel development, in the northeastern part of Site A, on behalf of Thames Water. The investigation recorded peat and alluvial deposits beneath a compressed layer of topsoil and turf representing (undated) historic open grassland. Modern made ground sealed the sequence. The evaluation trench showed no evidence of human activity. A geoarchaeological deposit model to the west of the evaluation (**HEA 31**), and which includes Site A, was produced from previous geotechnical boreholes. The model provides an indication of the nature and depth of deposits across the sewage works, along with a preliminary reconstruction of past landscapes, as described in Para. E.2.7 above.

E.3.3 Other archaeological investigations within the assessment area have revealed palaeoenvironmental and post-medieval remains. In 1994, an archaeological excavation (**HEA 8**), c. 180m to the north of Site B, recorded part of a north-south river channel filled with alluvial clays, along with peat containing the remains of four yew trees, which were probably part of the prehistoric forest. A piece of water-worn burnt flint was found on a silty sandy layer beneath the peat, and is unlikely to have been in *situ*.

E.3.4 In 1999, an archaeological evaluation (**HEA 17**), c. 140m to the west of Site A recorded a series of prehistoric peat and alluvial horizons. In 2007, a watching brief (**HEA 2**), c. 480m to the northeast of Site B, recorded alluvium. Neither investigation recorded any evidence of human activity.

E.3.5 In 2004, an archaeological diving survey (**HEA 25**), c. 650m to the southwest of Site B, recorded a sunken vessel of the late 19th to early 20th century date and mostly modern dumping within the Thames. In 2007, a watching brief (**HEA 12**), c. 970m to the northeast of Site A recorded a part of a post-medieval timber revetment.

E.3.6 The results of these investigations, along with other known sites and finds within the assessment area, are discussed by period, below.

E.4 Archaeological and historical background of the site

E.4.1 The following section provides a detailed archaeological and historical background for the area of proposed development. It should be read alongside the research framework presented in Appendix C to Vol 2 Appendix E2, and the individual site-specific assessments, within a broader historic environment context (ie, past landscapes and human activity within such landscapes). The overview 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 The Greater London Historic Environment Record (GLHER) contains a number of records for the prehistoric period. These comprise the chance find of a Palaeolithic (c 700,000–10,000 BC) flint flake (**HEA 15**), c. 540m to the south of Site A; and the chance find of an unspecified Palaeolithic flint artefact (**HEA 27**), c. 790m to the west of Site A.

E.4.3 During the Mesolithic period (10,000–4,000BC) sea levels rose after the last Ice Age and the area would have been increasingly subject to flooding and alluvial sedimentation. Radiocarbon dating of the peats in the area indicate they probably began to develop across the southern part of the site initially in the early Mesolithic as water levels in the Thames and its tributaries were rising due to the effects of relative sea level rise. The peats expanded on to the higher ground, waterlogging the previously dry land surfaces until the early Iron Age (around 3000 years ago). Pollen analysis indicated the peats represented a range of wetland environments from alder carr wet woodland to reed swamp (**HEA 1a**). These environments may have been exploited for food, water and building materials, although evidence of activity for the Mesolithic period is typically characterised by flint tools rather than structural remains. Animal remains dating to the Mesolithic period (**HEA 9**) have been recorded c. 330m to the north of Site A.

E.4.4 An investigation (**HEA 17**), c. 140m to the west of Site A, recorded a number of peat horizons dating from the Neolithic to the Bronze Age, indicating that there were episodes of lower sea levels which enabled vegetation to grow on dry land surfaces. A land surface of Neolithic and earlier date is likely to lie above the sand in the northern part of Site A.

E.4.5 The area around Site A is characterised by a network of channels, as yet undated, but thought to be channels of the Roding at its confluence with the Thames. During prehistory this area would have been a mosaic of active streams, backwaters, marsh and fen, infilling the channel courses, with drier islands in between. Such an environment, with the stream channels providing links between the interior and the Thames, was likely to have been exploited by prehistoric people using these watercourses as a means of access and transport. The local characteristics of the floodplain forest, as well as the river pattern, river regime and the dramatic changes to this environment caused by estuarine encroachment are likely to have played a significant role in the 'sense of place' as perceived by Bronze Age communities active on the floodplain. Such activity is well known in the Beckton area and the landscape evidence could add valuable interpretive information to our understanding of the archaeological remains.

E.4.6 The area would have been important 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 S, 2000)[3]. Recent discoveries in the Thames estuary include remains of well-preserved prehistoric wooden boats, fish traps, wharves and trackways sealed beneath the alluvium. Wooden trackways were uncovered during recent archaeological investigations at Barking,

Dagenham, Silvertown, (potentially of Neolithic date), Rainham and Erith (Museum of London Archaeology Service, 2000)[4]. The trackways provided access from the drier ground of the terrace across the marshy ground. They are of particular importance in understanding prehistoric settlement patterns and the economic exploitation of the intertidal marshland. Some may have been associated with ritual activity and votive deposits. Although no trackways have been recorded during archaeological investigations in the assessment area, the chance discovery of a number of Neolithic and Bronze Age artefacts might suggest some activity, such as votive deposition, in the area. A late Neolithic/early Bronze Age stone axe/hammer, a Bronze Age sword and two Bronze Age socketed axes (**HEA 4**) were found c. 800m to the north of Site B. A Bronze Age axe (**HEA 9**) was recorded c. 330m to the north of Site A, and a Bronze Age sword (**HEA 26**) was found in the river Thames c. 930m to the southwest of Site B. A Neolithic axe (**HEA 11**) has been recorded c. 930m to the northeast of Site A.

E.4.7 By the early Iron Age, sea level rise brought brackish water to the Beckton area resulting in a transition from vegetated wetland deposits to tidal mudflats and salt marsh environments. Deposits laid down by successive sea level rises, have buried earlier land surfaces at considerable depth. At the northern end of Site A, close to the drier land, prehistoric droveways for moving sheep and cattle on to the marshes may have been buried by seasonal inundation. The Portable Antiquities Scheme (PAS) has recorded the finding of an Iron Age artefact (**HEA 32**) in the River Thames c.200m to the south of Site B.

Roman period (AD 43–410)

E.4.8 The area of proposed development lay c. 11.0km to the east of the Roman town of *Londinium*. The nearest Roman road was the main road which ran northeast from London to Colchester (Margary ID, 1967)[5], and lay c. 4.5km to the north of the area of proposed development.

E.4.9 Rising water levels from the late prehistoric suggest that during the Roman period the area was prone to flooding and probably lay in open marshland or on the foreshore, or even partly within the Thames channel. As such it would not have been suitable for settlement, but may have been exploited for a number of intertidal/marshland resources, in some places on an industrial scale (eg, pottery from clay, salt production from evaporation, fish processing etc). No Roman finds or features have been recorded through archaeological investigation. The GLHER does however record the site of a possible Roman dock along the Barking Creek (**HEA 10**), c. 730m to the north of Site A, while the Portable Antiquities Scheme (PAS) has recorded the chance find of a Roman pottery vessel (**HEA 32**) in the River Thames c. 200m to the south of Site B.

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

E.4.10 The area of proposed development lies within the ancient Saxon manor of ‘Hamme’, first mentioned in AD 958 when King Edgar granted land to an Ealdorman Athelstan of East Anglia. The name Ham refers to an area of low-lying pasture and the more than half of the land, in the south and west

of the manor, lay in marshland below the level of ordinary spring tides (Victoria County History, 1966)[6].

E.4.11 The main settlement probably grew up on, or in the vicinity of, the later medieval village of East Ham, c. 1.7km to the west of the area of proposed development (Victoria County History, 1966)[7]. St Mary's church dates to the 12th century, but was probably located on the site of an earlier church, and formed the focus of the settlement (Victoria County History, 1966)[8], although no features or finds dating to this period have been identified within the vicinity of the church.

E.4.12 Neither the GLHER, nor the archaeological investigations within the assessment area, have recorded archaeological remains or finds dating to the early medieval period. Like much of the manor, the area of proposed development was probably located in marshland, which was developing into water meadows prone to seasonal overbank flooding of the Thames and the Roding. It would have provided valuable rough grazing land. It is clear that the coastal marshes were important for sheep pasture in that inland parishes on both sides of the Lower Thames estuary often owned a detached portion of the coastal marshes in order to provide quality grazing land. (Rippon S, 2000)[9]

Later medieval period (AD 1066–1485)

E.4.13 The complex inheritance pattern of the main landlords in 'Hamme' throughout the 13th and 14th centuries resulted in the sub-division of East Ham into two unequal portions. The larger manor included the area of proposed development and became known as the manor of East Ham and lay mainly in the south of the parish. The smaller estate lay in the north (Victoria County History, 1966)[10].

E.4.14 The main settlement in East Ham grew up along High Street South, approximately 1.6km to the northwest of the area of proposed development, beside the 12th century church of St Mary. The coastal marsh in the southern part of the parish (including the area of proposed development) would have been used for rough grazing.

E.4.15 It is likely that the marshland began to be drained and reclaimed in the latter part of the medieval period. Reclamation is likely to have taken place in stages, with drainage channels dug around parcels of land and a number of successive sea walls (earth embankments) being constructed as more and more of the marshland was reclaimed out from the edge of the higher ground of the gravel terrace. The embankments also provided access across the marsh, and often followed the sides of creeks. The purpose of reclamation would have been primarily economic, providing good-quality grazing for livestock and fertile land for crops (Thirsk J, 2000)[11]. Parts of the marsh that were unreclaimed may have continued to be exploited for a variety of purposes, such as fish and shellfish processing, duck decoy ponds (to capture ducks), oyster beds, and fish traps (Wilkinson TJ & Murphy PL, 1995)[12].

E.4.16 Reclamation would have improved the general living environment of those people living near the edge of the marshes or in some cases, on islands of higher ground within the marsh (Sparkes IG, 1966)[13]. Flood prevention

was sometimes hampered by the complexities of feudal tenure, which could make it difficult to assign responsibility to small landowners. Even reclaimed marshland may have been prone to flooding and in the 14th and 15th centuries the marshes in East Ham suffered from severe flooding with prolonged inundations, which would have greatly reduced the amount of pasture (Victoria County History, 1966)[14]. This probably led to the abandonment of the settlement of *Hammarsh* at East Ham. The GLHER records the site of a medieval house (**HEA 7**) known as Galyonshope (possibly associated with the Galyan family in c. 1466) c. 420m to the north of Site B, and a medieval dock called "Dampers Dock" (**HEA 5**) on the banks of the Barking Creek c. 740m to the north of Site B. None of the archaeological investigations within the assessment area have recorded evidence of later medieval activity.

E.4.17 The area of proposed development would have been in open fields of reclaimed marsh, possibly with drainage ditches and river embankments. Any such features would lie beneath late 19th century and later ground raising carried out as part of the Sewage Treatment Works development.

Post-medieval period (AD 1485–present)

E.4.18 Despite the construction of sea defences, flooding continued to be a problem. The issue of sea defence was important enough for a commission of sewers to be set up in 1532, to enforce maintenance of sea walls (Victoria County History, 1966)[15].

E.4.19 The earliest map of the area of proposed development is by Chapman and André in 1777 (Vol 26 Plate E.3) and shows that half of Site A and all of Site B were at that time considered a detached part of the County of Kent. Whilst no detail is shown on this part of the map, the area would have comprised reclaimed marshland with a river wall running along the river embankment. The northern half of Site A was located in Essex and is shown as marsh.

E.4.20 The Ordnance Survey 1":mile map of 1805 (Vol 26 Plate E.4),which shows the area of proposed development within the reclaimed marshland. The map shows a number of linear north-south trackways/droveways ('manor ways') across the marsh from the higher gravel terrace to the north. These would have been on raised embankments, which would also have served as flood defence embankments, and are probably of medieval origin. None appear to cross either Site A or B.

E.4.21 The Ordnance Survey 1st edition 25":mile map of 1862 (Vol 26 Plate E.5) shows the area of proposed development in detail, within reclaimed marshland of 'East Ham Level'. Drainage ditches cross Site A, with a strip of marshy land in the eastern part, which is probably a former creek which has silted up. The western end of a river wall crosses the northern tip of Site A. The Bazalgette Northern Outfall Sewer (**HEA 1b**) crosses the southern edge of Site A; it was under construction during the period when this map was produced. The map shows Site B in open ground with irrigation dams at its southeast corner. These formed part of a river wall and part of the northern outfall reservoir of the Bazalgette scheme.

E.4.22 Sir Joseph Bazalgette's London sewage system, one of the greatest pieces of Victorian civil engineering, was constructed in the later 19th century. It forms one of the project-wide themes and is discussed in more detail in Vol 3. The hugely ambitious system was constructed from the mid 1850s as a response to the appalling social conditions created by the growth of London during the industrial revolution. The original BSTW works (**HEA 1c**) at the terminus of the Northern Outfall Sewer (**HEA 1b**) were established by 1864 although there are no available plans of the complex. In the 1880s, the BSTW complex changed from the simple reservoir function of storing then releasing raw sewage into the Thames, to a sewage treatment works. This entailed a significant amount of building and construction to implement the processing of sewage, including the construction of extensive reservoir tanks and aeration lanes, to northeast of Site A and the north of Site B. The principal buildings from this second phase of development in the late 1880s included the Engine House (**HEA 1d**) and boiler house chimney (**HEA 1a**). The latter is grade II listed and has been temporarily removed and is due to be reinstated at its original location. The 'Old' Engine House was recently demolished following archaeological building recording. Archive plans show that the Engine House (Vol 26 Plate E.6) was broadly set in a 'T' shape plan with a workshop projecting north from it, constructed on steel 'I' section columns set on deep piles (Vol 26 Plate E.7). The boiler house chimney (Vol 26 Plate E.9) was situated to the east of this and constructed on a deep, stepped concrete base with a submerged flue to the boiler house. Immediately south of the chimney was a pair of sludge settling tanks, possibly overflows from the main settling trenches (Vol 26 Plate E.9 and Vol 26 Plate E.10).

E.4.23 In 1878, at Gallions Reach, a bend in the River Thames adjacent to the area of proposed development, one of the worst inland waterway disasters in the country's history occurred. A pleasure boat paddle steamer, the Princess Alice (**HEA 29**), collided with an iron-built collier, the Bywell Castle. Between 550–650 are thought to have drowned and only 69 passengers were saved (Weinreb B, Hibbert C, Keay J and Keay J, 2008)[16]. The collision took place where the Northern and Southern Outfalls discharged into the river, and the polluted water was thought to have been responsible for many of the deaths.

E.4.24 The Ordnance Survey 2nd edition 5ft:mile map of 1896–9 (Vol 26 Plate E.11) shows the area of proposed development in the completed BSTW. The Northern Outfall Sewer (**HEA 1b**) extends along the southern side of Site A, along with a number of drainage ditches. The map shows strips of marsh, which are probably former creeks that have silted up. 'Posts' and a 'Stone' are marked beside some of the ditches and banks, possibly delineating land ownership/administration. Just north of the Outfall Sewer is a small sewage works building (**HEA 1f**). Hachures immediately to the north of the building indicate that the building was probably built at the level of the top of the raised sewer embankment rather than at the base of the slope. The map shows a small complex of sewage works buildings within Site B, including the Old Engine House (**HEA 1d**) and rectangular sludge tanks to the southwest and south. Hachures indicate extensive

ground disturbance, probably associated with ground raising for improved drainage.

E.4.25 The Ordnance Survey 2nd edition map also shows an extensive new gasworks owned by the Gas Light and Coke Company (GLCC) to the south and west of Site B and south of Site A, on the opposite side of the outfall sewer. The GLCC formed in the early 19th century as one of many competing gas suppliers and each had their own small scale gas works in central London. In 1868, the company began work on a new purpose built gas works, much larger and more modern than any of the other concerns, on low-lying marshland south of Barking. The site and surrounding area was named Beckton after Simon Adams Beck, the Governor of the GLCC, and it steadily grew to become Europe's largest gasworks, with its own riverside piers and railway. Huge by-products works produced tar, ammonia, fertilizers and dyes (Weinreb B, Hibbert C, Keay J and Keay J, 2008)[17].

E.4.26 The Ordnance Survey 3rd edition 25":mile map of 1909–1920 (Vol 26 Plate E.12) shows a new north-south tramway within the middle of Site A, along with an associated tram 'Car Shed' to the east (**HEA 1f**). Rails are also shown extending from the sewage works building on the outfall sewer (**HEA 1e**) eastwards along the top of the sewer to Site B. The map shows areas of poor drainage, as previously and several ponds, indicating that ground water was an issue. To the northwest part of Site A (probably just outside the site), a complex of small buildings and yards has been built (**HEA 33**). The size of the buildings suggests that these are offices and/or accommodation associated with the works superintendent and workers. The map shows no significant change within Site B, other than rail lines which connect the Engine House to Site A and the river outfall to the south. The Ordnance Survey 1:10,000 scale map of 1934–46 (not reproduced) shows no change. The maps all show further development of the gasworks to the south of Site A and west of Site B.

E.4.27 The Ordnance Survey 1:10,000 scale map of 1954–69 (Vol 26 Plate E.13) shows massive development of the BSTW to the east of Site A and the north of Site B. This reflects the continued development and refining of the sewage treatment process. BSTW was at this time the largest of its kind in Europe (Weinreb B, Hibbert C, Keay J and Keay J, 2008)[18]. Its evolution is significant because it began with development under Sir Joseph Bazalgette and has continued to modernise and adopt new technology and methods of processing as they arose. Alterations since the 1950s have been relatively minor. The 1954–69 map shows rows of new rectangular sewage reservoir tanks and groups of circular tanks and rows of aeration lanes. The map shows some change within within Site A. The former buildings within the site have been demolished, including the works building at sewer level (**HE A 1e**), the tramshed (**HEA 1f**) and tram lines, (the latter replaced by a road), and the complex of small offices/accommodation to the northwest of Site A (**HEA 32**). The boundary posts/stones are no longer shown. There are areas of hardstanding and hachures indicate landscaping, possibly drainage improvement. The map shows overhead power lines across Site A. The map shows considerable development in Site B, with additional sewage works buildings in the

northwest of the Engine House, and the replacement of the rectangular sludge tanks with groups of circular tanks. The tram lines have been replaced by roads and hardstanding.

E.4.28 The Ordnance Survey 1:10,000 scale map of 1972–7 (Vol 26 Plate E.14) shows further massive expansion of the BSTW, with more rectangular and circular tanks to the north. In the western part of Site A, a stippled area appears to indicate dumping, probably further ground improvement. In the southeastern part of Site A two parallel linear buildings have been constructed beside the north-south access road. There is no change within Site B, although a considerable number of additional circular tanks have been built to the southwest. The large Beckton gasworks complex to the south of Site A has shrunk considerably. The gasworks had closed in 1967 after the discovery of natural gas in the North Sea made coal gas uncompetitive, although a storage and distribution plant remained until the late 1990s (Weinreb B, Hibbert C, Keay J and Keay J, 2008)[19].

E.4.29 The Ordnance Survey 1:10,000 scale map of 1979–88 (Vol 26 Plate E.15) shows that the two rectilinear buildings in the eastern part of Site A have been demolished, while there is no change to the western half of the area. There is no change within Site B.

Current area of the site

E.4.30 Site A and Site B were active construction sites as part of the Lee Tunnel works and the Sewage Works Extension at the time of site visit, and no internal inspection was possible. The Sites were viewed from accessible areas (see Vol 26 Plate E.16–Vol 26 Plate E.18). The former Engine House has been demolished and archaeologically recorded (see Para. E.3.1) and the boiler house chimney temporarily removed. At both sites the current ground level has been artificially raised above the original (early 19th century) ground level by at least 5 metres.

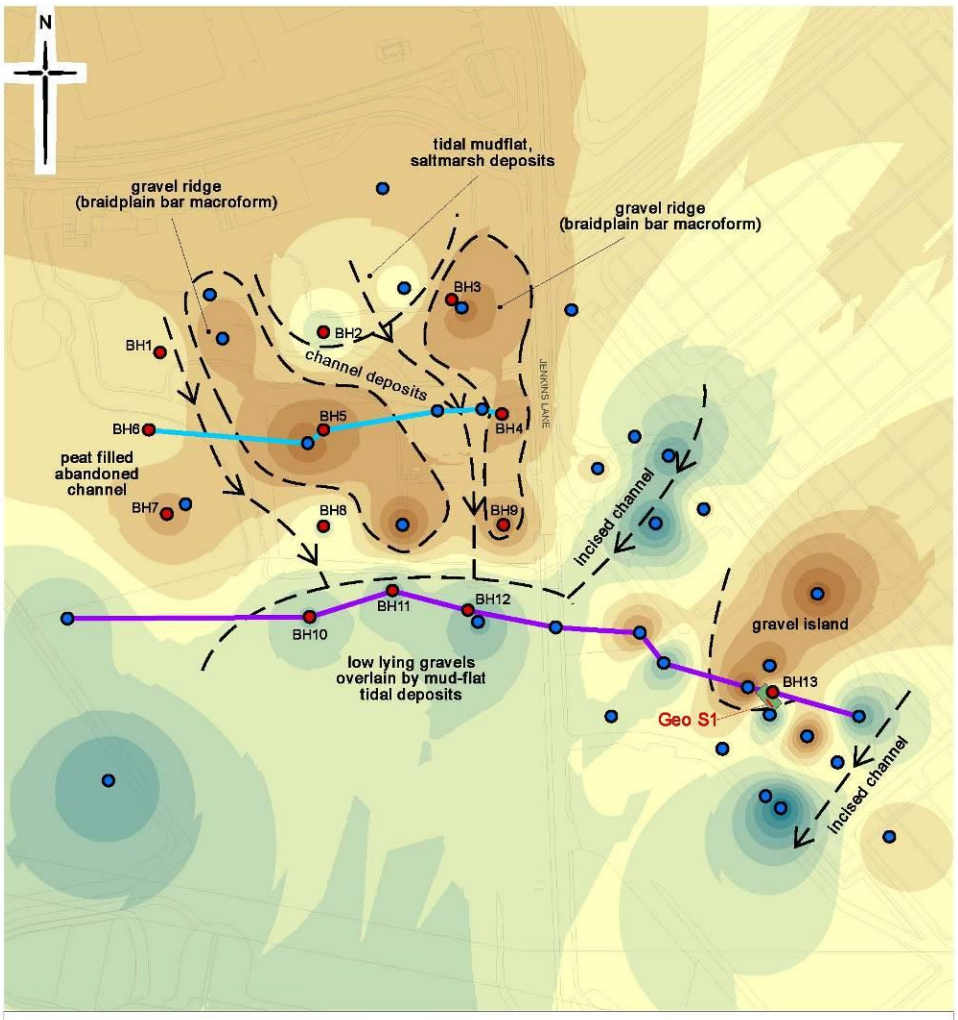
E.4.31 The Lee Tunnel works within Site A includes a drop shaft and pumping station, and a drop shaft within Site B. At both sites, the ground is understood to have been stripped by at least 0.5m prior to construction. The former sludge tanks within Site B were cut down to ground level and infilled with foam concrete. There are no above ground elements of Bazalgette infrastructure remaining within the areas of proposed Thames Tideway Tunnel construction work (David Wilkins, 2012)[20].

E.4.32 A 19th-century brick wall survives just outside the northern boundary of Site B (Vol 26 Plate E.19 and Vol 26 Plate E.20). The wall follows the curve of the site boundary and runs from the northern corner to halfway down the north-eastern boundary. The wall is constructed of yellow stock brick, in English bond, and appears to be part of a covered linear structure which runs to the south towards the Thames. The feature is formed of two lines of brick wall with a void in the centre and has been capped with a pored concrete slab. It may have once held pipes or ducting for the sewers. There is evidence of repair and tie-plates located 0.5m from the ground which suggests there were problems with the stability of the wall. Rectangular vents bounded by shuttered concrete are located at the top of the wall at regular intervals. It is likely that this feature dates to some time

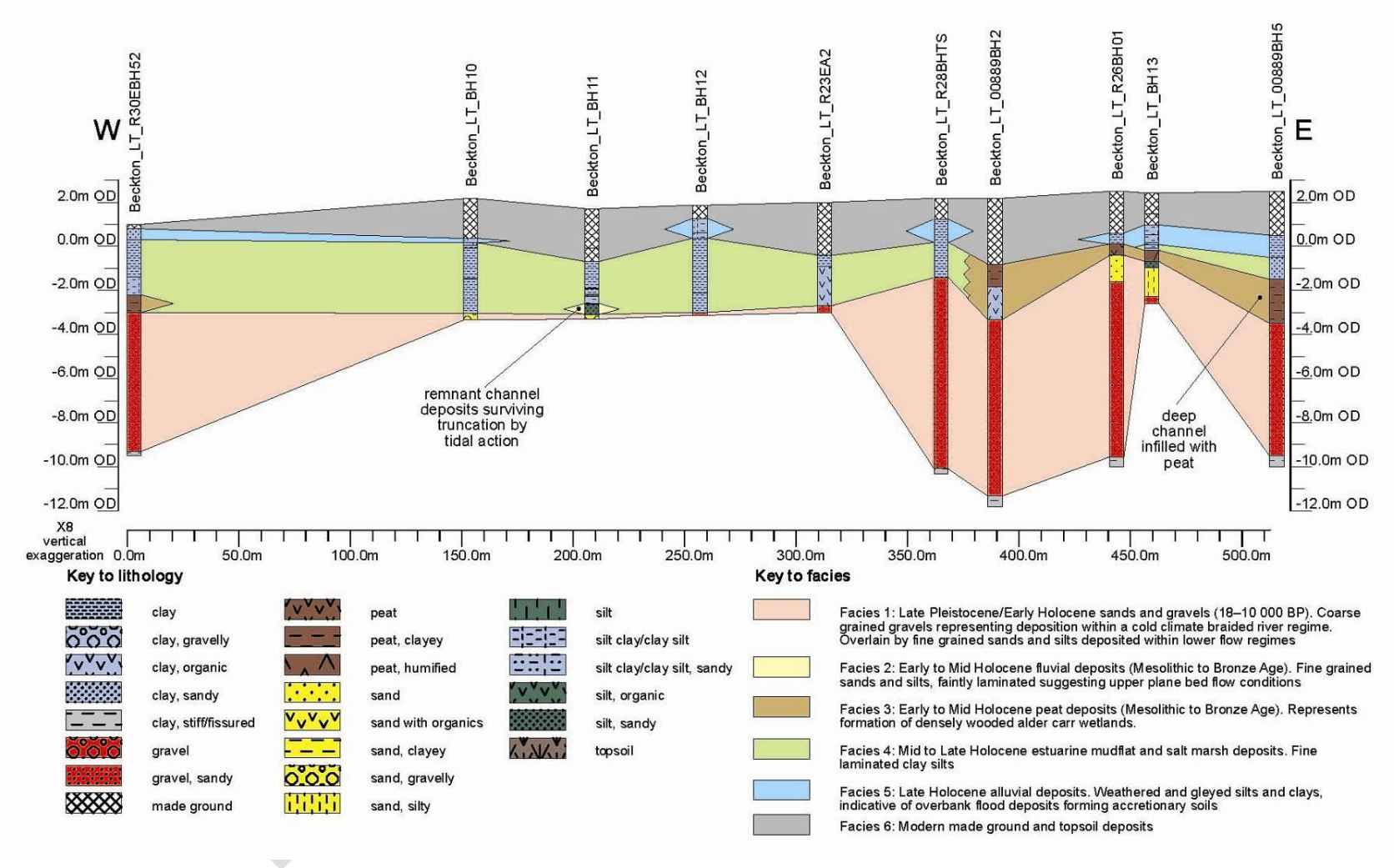
in the mid–late 19th century and relates to the pioneering Northern Outfall Sewer of Sir Joseph Bazalgette, Chief Engineer of the Metropolitan Board of Works.

E.5 Plates

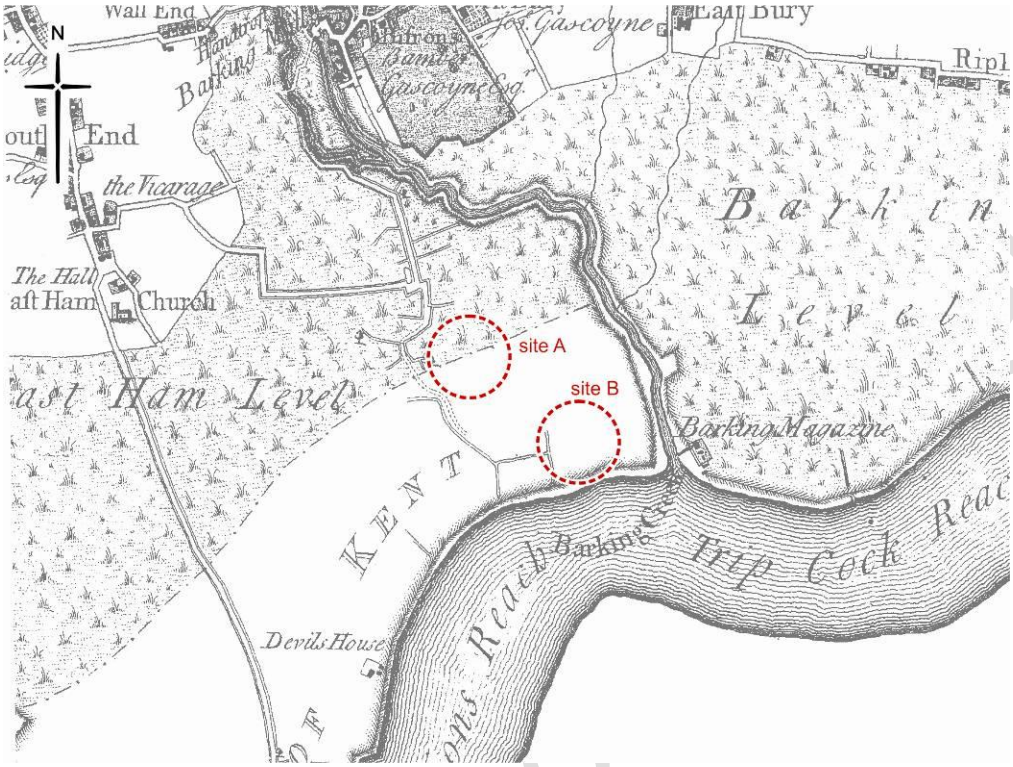
Vol 26 Plate E.1 Historic environment – The buried topography around Site A, which lies immediately south of Boreholes (BH) 10 to 12 and includes the gravel island around BH13 (taken from HEA 31 post-excavation assessment, Fig 6)



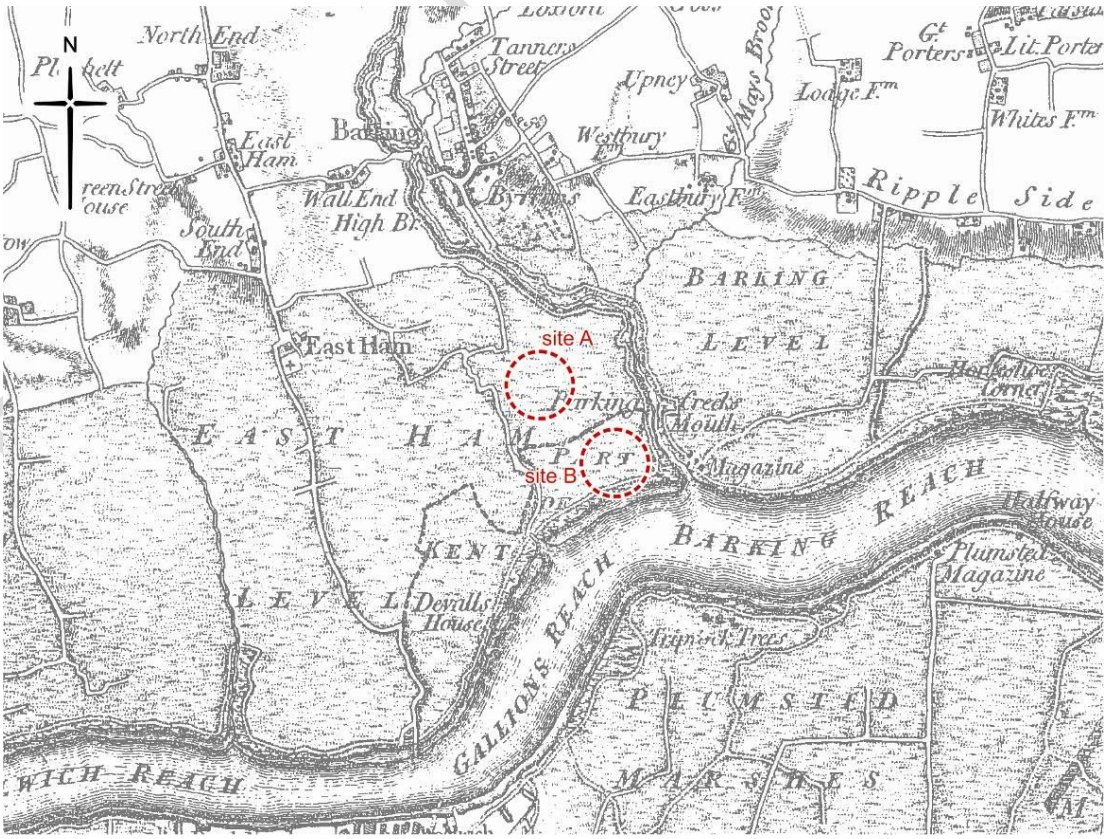
Vol 26 Plate E.2 Historic environment – Deposit sequence immediately north of, and including the northern part of, Site A. Line of transect shown as Transect 2 on Plate E.1 (Plate taken from HEA31 post-excavation assessment report, Fig 8)



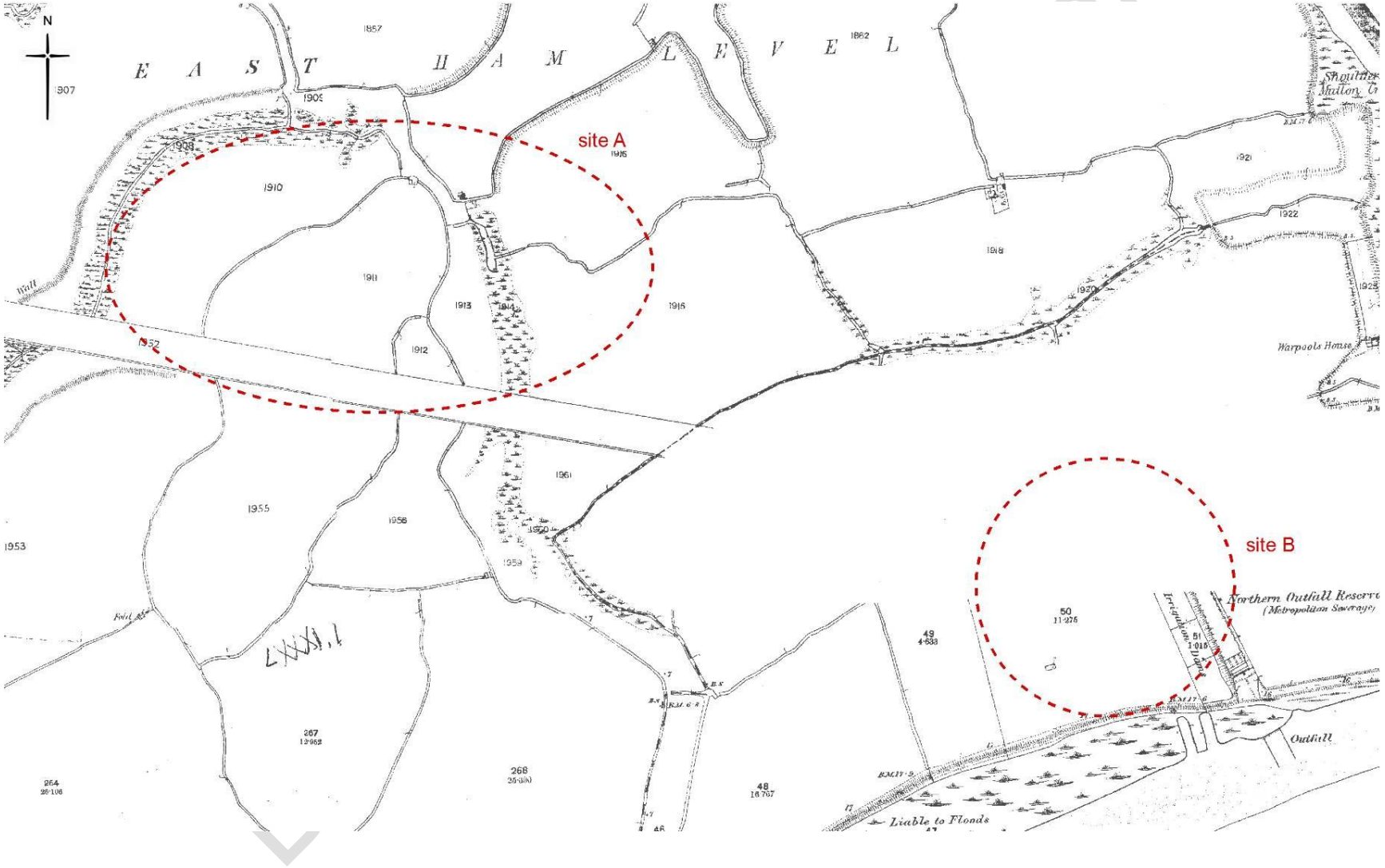
Vol 26 Plate E.3 Historic environment – Chapman and André's Map of Essex, 1777



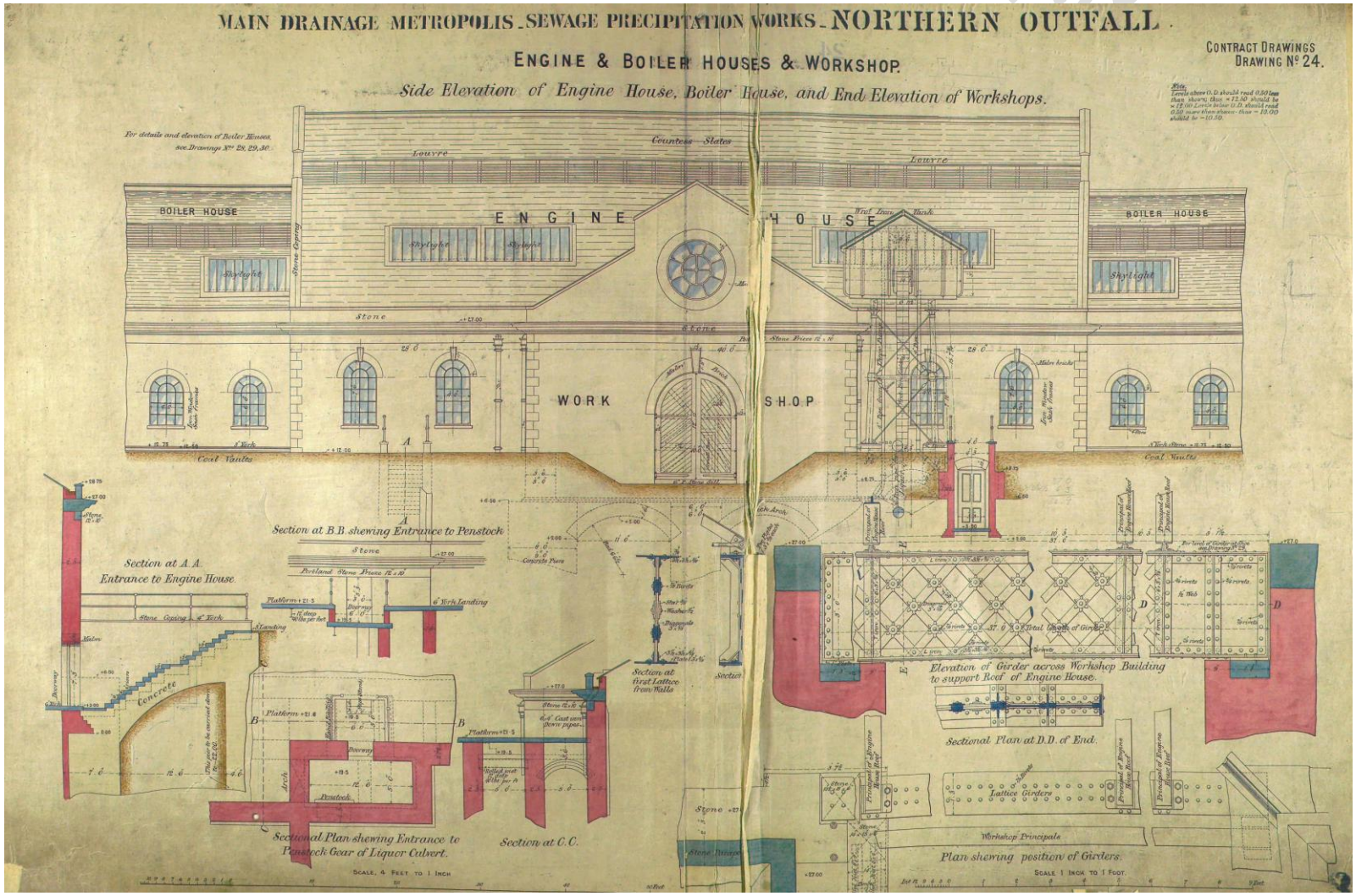
Vol 26 Plate E.4 Historic environment – Ordnance Survey 1":mile map of 1805



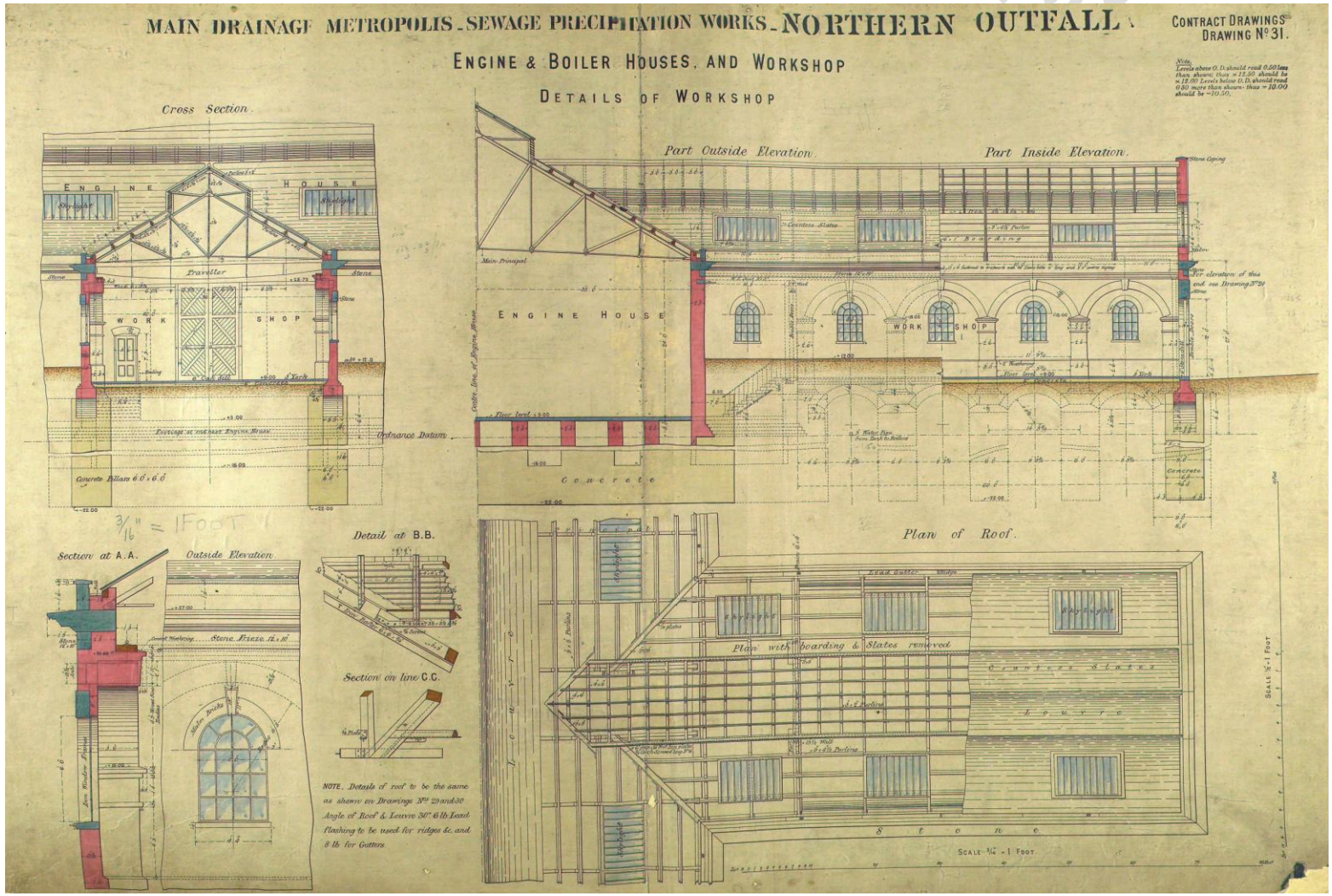
Vol 26 Plate E.5 Historic environment – Ordnance Survey 1st edition 25" scale map of 1862–95 (not to scale)



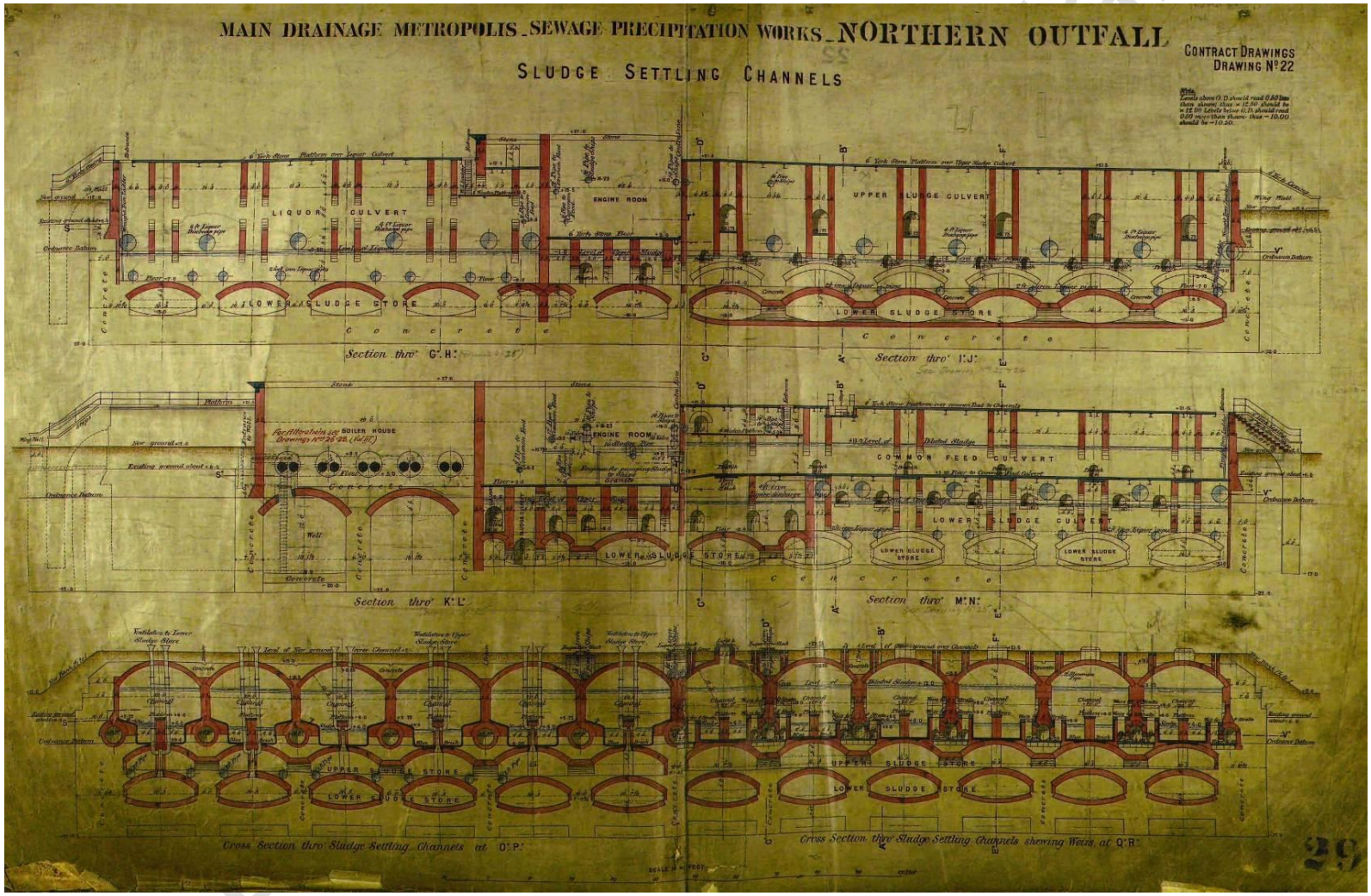
Vol 26 Plate E.6 Historic environment – The BSTW Engine House c 1887 (Thames Tunnel 'Abbey Mills Book' 32 Vol 2, p42). The building, within Site B, is no longer extant



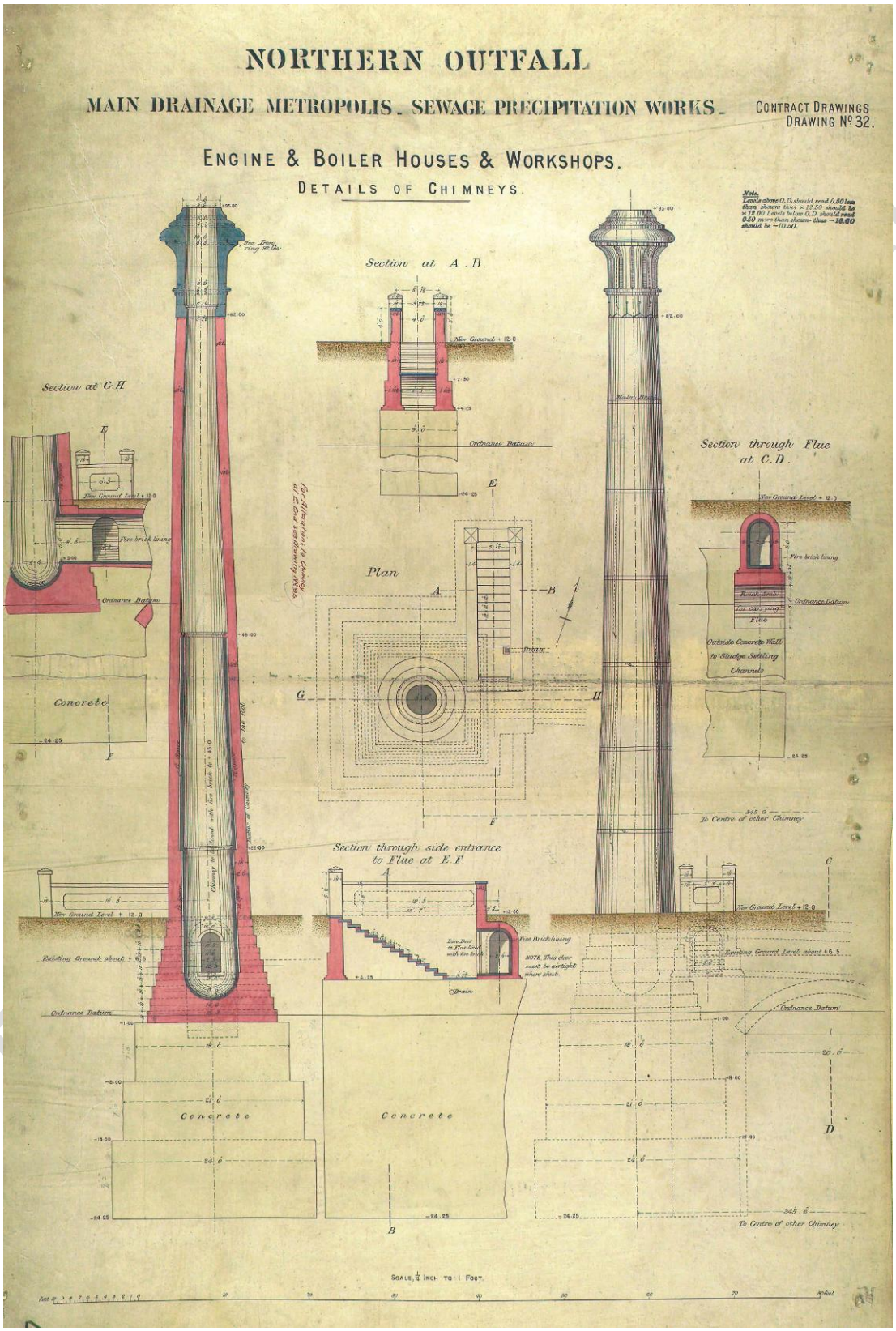
Vol 26 Plate E.7 Historic environment – Section showing the Old Engine House showing steel columns set on deep piles (Thames Tunnel 'Abbey Mills Book' 32 Vol 2, p53)



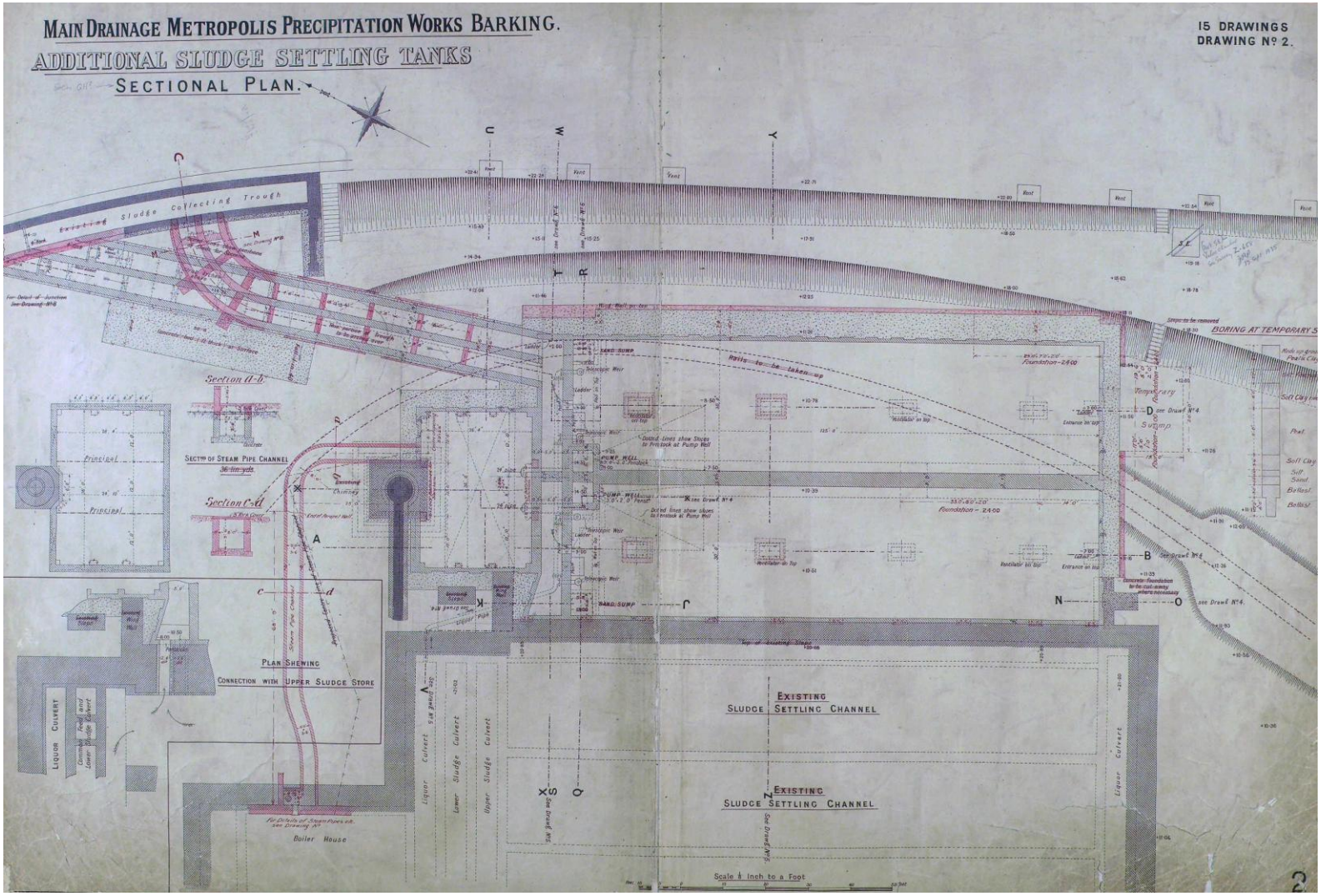
Vol 26 Plate E.8 Historic environment – Section of the former sludge tanks within Site B (–22 ft ODL ~ –7m ODN), or 28.5 ft (8.7m) below the ground level existing at the time of construction (1887) (Thames Tunnel 'Abbey Mills Book' 34)



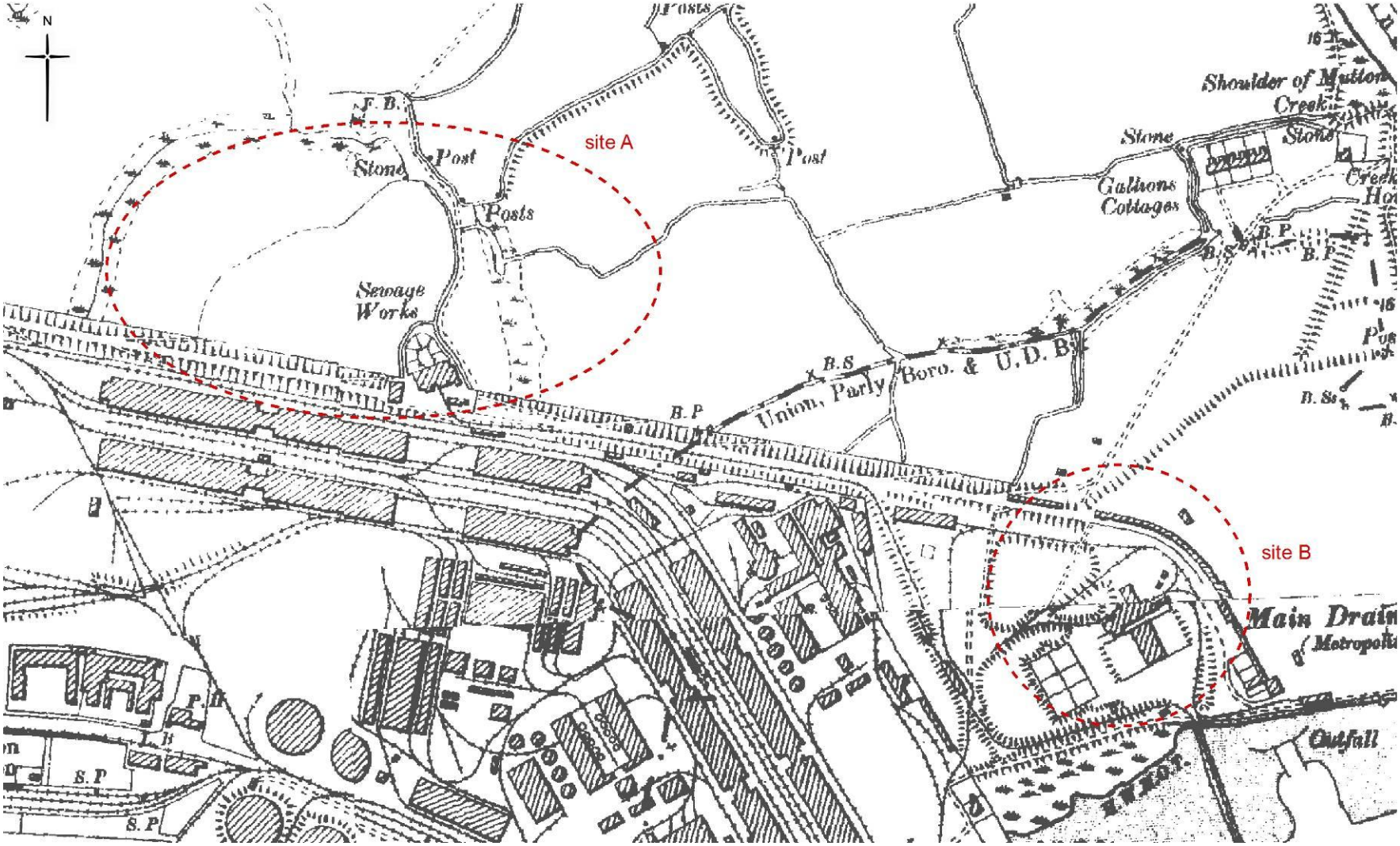
Vol 26 Plate E.9 Historic environment – Section through the chimney (HEA 1a); grade II listed and temporarily dismantled (Thames Tunnel 'Abbey Mills Book' 32 Vol 2, p47).



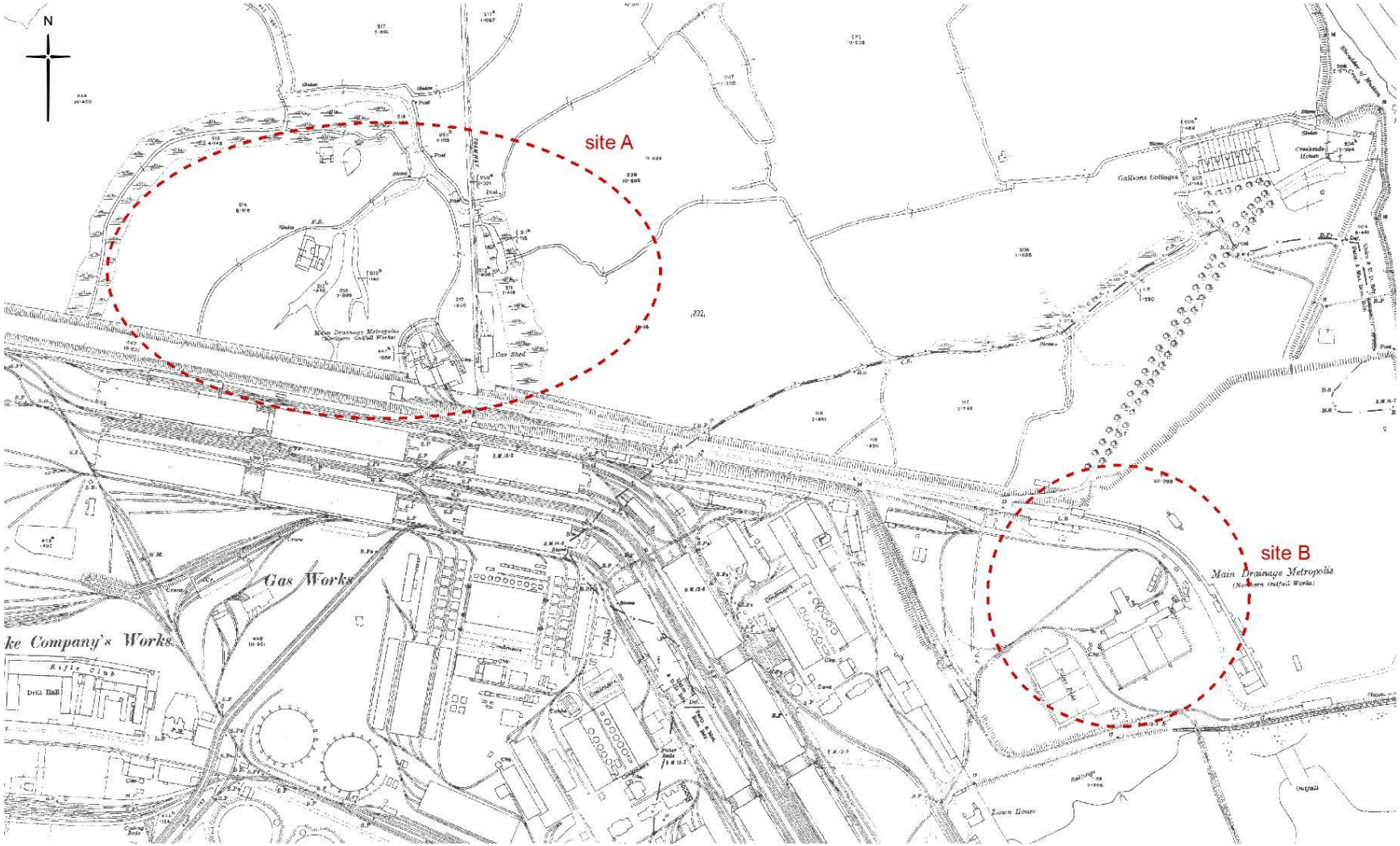
Vol 26 Plate E.10 Historic environment – A pair of sludge settling tanks south of the chimney, possibly overflows from the main settling trenches (Thames Tunnel 'Abbey Mills Book' 37, p4)



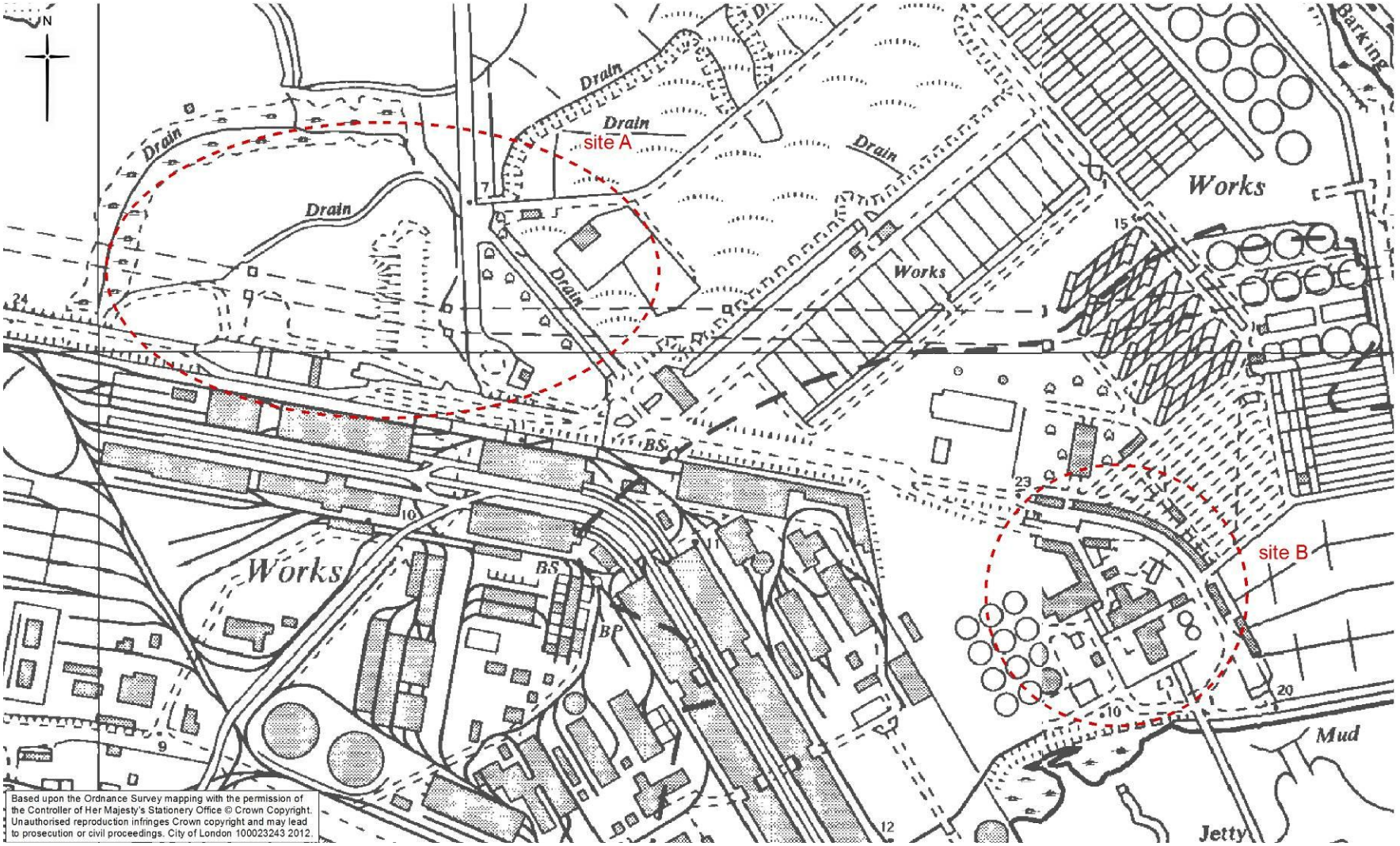
Vol 26 Plate E.11 Historic environment – Ordnance Survey 2nd edition 25" scale map of 1896–9 (not to scale)



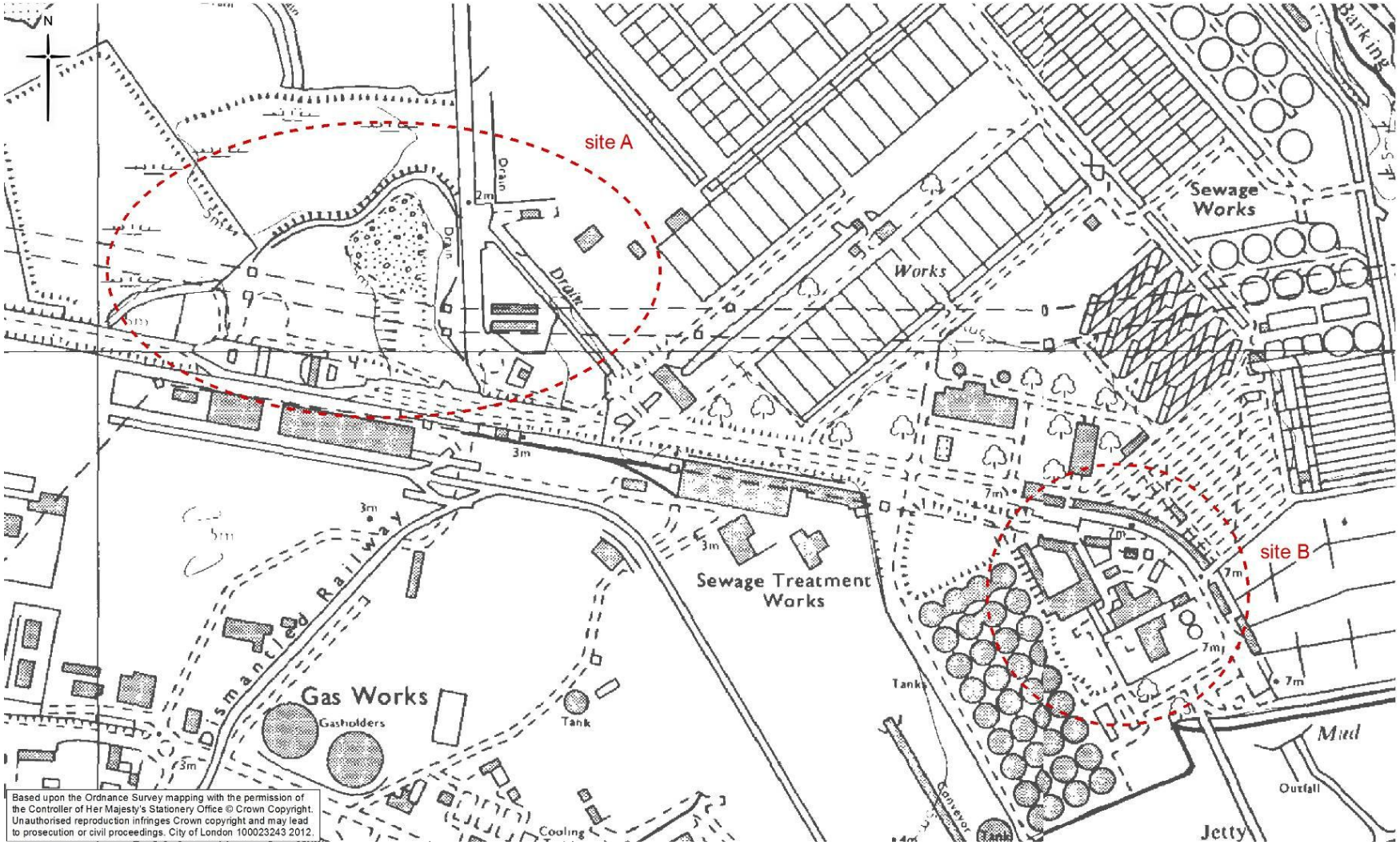
Vol 26 Plate E.12 Historic environment – Ordnance Survey 3rd edition 25" scale map of 1909–20 (not to scale)



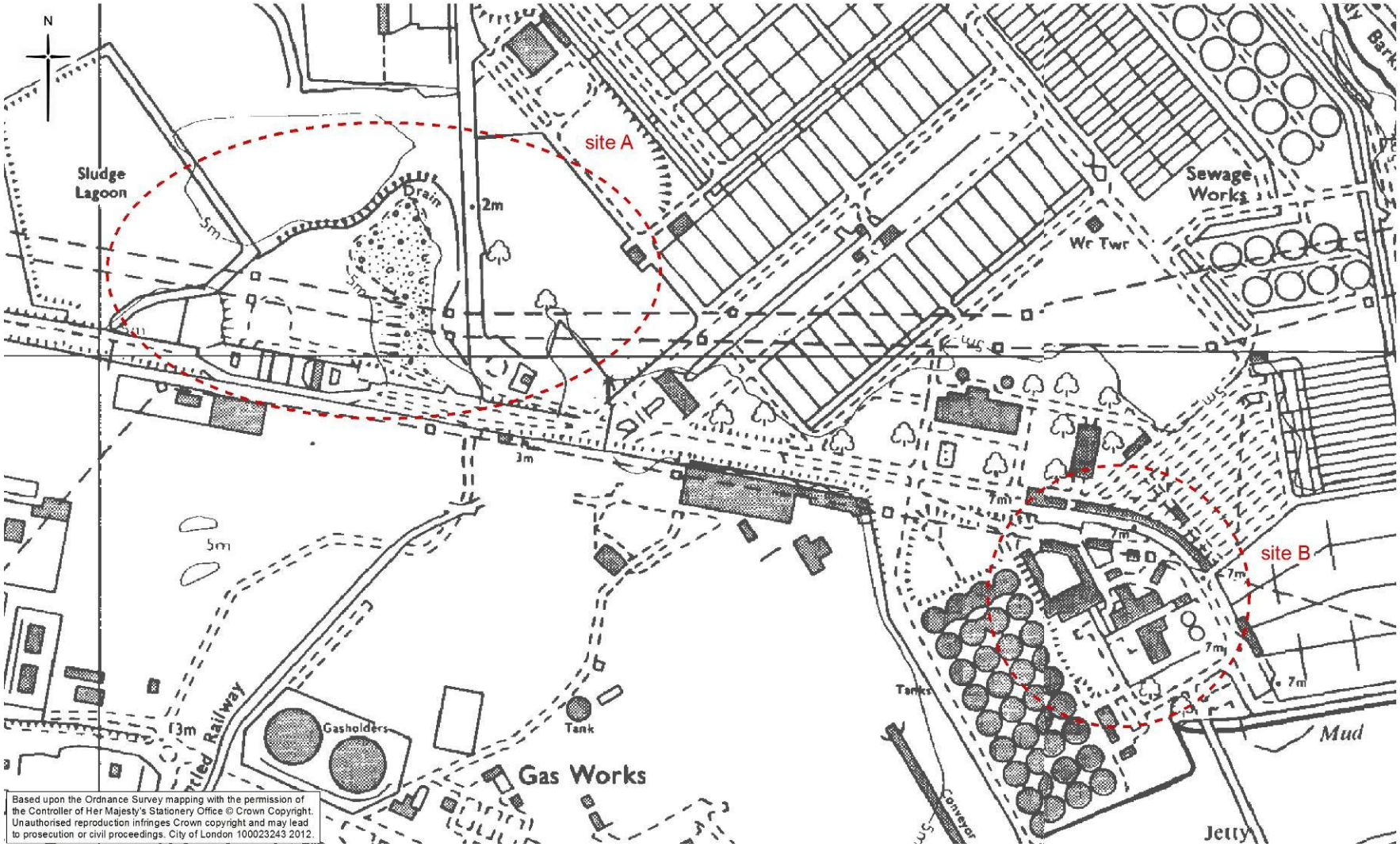
Vol 26 Plate E.13 Historic environment – Ordnance Survey 1:10,000 scale map of 1954–69 (not to scale)



Vol 26 Plate E.14 Historic environment – Ordnance Survey 1:10,000 scale map of 1972–7 (not to scale)



Vol 26 Plate E.15 Historic environment – Ordnance Survey 1:10,000 scale map of 1979–88 (not to scale)



Vol 26 Plate E.16 Historic environment – Site Area A looking southwest, standard lens

Vol 26 Plate E.17 Historic environment – Site Area B from the southern extent of the boundary, looking northwest, standard lens

Vol 26 Plate E.18 Historic environment – Site Area B from the northern extent of the boundary, looking south, standard lens

Vol 26 Plate E.19 Historic environment – 19th century wall (HEA 30) located to the northeast of Site Area B, from southeast corner of the boundary, looking northwest, standard lens

Vol 26 Plate E.20 Historic environment – 19th century wall (HEA 30) located to the northeast of Site Area B, from the northeast corner of the boundary, looking east, standard lens

References

[1] Halsey C, *Lee Tunnel Thames Water Beckton Sewage Treatment Works, A Geoarchaeological Deposit Model*. MOLA unpublished report (2009).

[2] Scott Wilson, *Building Recording and Assessment for 'Beckton Old Engine House Site'*. Thames Water report (Dec 2008).

[3] Rippon S, *The Transformation of Coastal Wetlands*. Oxford (2000), 1.

[4] Museum of London Archaeology Service. *Archaeology of Greater London*. (2000)

[5] Margary ID, *Roman Roads in Britain.* London. John Baker Publishers Ltd (1967), 56.

[6] Victoria County History, *A History of the County of Essex* Vol. v (1966), 43–50.

[7] Victoria County History. *See citation above*.

[8] Victoria County History, *A History of the County of Essex* Vol. v (1966), 25–31; GLHER 221601/02.

[9] Rippon S, *The Transformation of Coastal Wetlands*. Oxford (2000), 153–85.

[10] Victoria County History, *A History of the County of Essex* Vol. v (1966), 8–14).

[11] Thirsk J, Rural England, *An illustrative history of the landscape*. Oxford (2000), 155–69.

[12] Wilkinson TJ & Murphy PL *The Archaeology of the Essex Coast, Volume 1: The Hullbridge Survey*. Essex County Council. East Anglian Archaeology Report 71(1995)

[13] Sparkes IG *Corringham: Village and Marshes.* (1965), Thurrock Local History Reprints No. 4

[14] Victoria County History, *A History of the County of Essex* Vol. v (1966), 93–96.

[15] Victoria County History, *A History of the County of Essex* Vol. v (1966), 215.

[16] Weinreb B, Hibbert C, Keay J and Keay J, *The London Encyclopaedia*. Macmillan. London (2008), 665–666.

[17] Weinreb B, Hibbert C, Keay J and Keay J, *The London Encyclopaedia*. Macmillan. London (2008), 52.

[18] Weinreb B, Hibbert C, Keay J and Keay J. See citation above.

[19] Weinreb B, Hibbert C, Keay J and Keay J. See citation above.

[20] David Wilkins, Thames Tunnel engineer, pers. comm. 29/02/2012.

This page is intentionally blank

Thames Tideway Tunnel
Thames Water Utilities Limited

Application for Development Consent

Application Reference Number: WWO10001

Environmental Statement

Doc Ref: **6.2.26**

Volume 26: Beckton Sewage Treatment Works appendices

Appendix F: Land quality

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

Hard copy available in

Box **40** Folder **B**
January 2013

Thames Tideway Tunnel

Creating a cleaner, healthier River Thames

This page is intentionally blank

Thames Tideway Tunnel

Environmental Statement

Volume 26 appendices: Beckton Sewage Treatment Works 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.

Site walkover

F.1.2 A walkover survey was undertaken on two occasions, the 21st May 2012 and the 5th October 2012.

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

F.1.4 The Beckton Sewage Treatment Works site is located at the confluence of the River Roding and tidal River Thames in the London Borough (LB) of Newham.

F.1.5 The proposed works are primarily located within two areas at the Beckton Sewage Treatment Works sites (nominally termed Site A and Site B). These are detailed below and shown on the construction layout plans (see Vol 26 Figure 3.1.2 to 3.1.5, separate volume of figures).

Site A

F.1.6 Site A is the location of the proposed additional pumps, siphon tunnel inlet shaft as well as new above ground pipeline and a proposed construction compound (in the north).

F.1.7 At the time of the walkover survey much of Site A was being utilised as part of the Lee Tunnel works, either as the location of the main shafts or as part of the associated hard covered construction compounds and materials handling areas. Remaining areas comprise soft landscaping areas and operational parts of the wider Beckton Sewage Treatment works

F.1.8 A stand of Japanese Knotweed was recorded in two locations within and adjacent to the Site A boundary as shown on Vol 26 Figure 6.4.8 (see separate volume of figures).

F.1.9 The area to the north of the westernmost part of this site was formerly used to deposit grit screenings and at the time of the survey had been partially cleared and was being redeveloped for further waste water infrastructure.

F.1.10 The northern tip of the site is to be used as a construction compound only and is currently a car park.

Site B

F.1.11 Site B comprises the location of the proposed siphon tunnel outlet shaft and is situated in the south eastern part of the Beckton Sewage Treatment Works site. It is the location of a former derelict engine house. The area has been cleared and is presently occupied by the Lee Tunnel Beckton shaft construction work site.

F.1.12 Detailed site walkover notes from both areas are provided in Vol 26 Table F.1 below.

Vol 26 Table F.1 Land quality – site walkover report

Item (Site ref: PNM1X, Beckton Sewage Treatment Works)		Details
Date of walkover	21st May 2012 and 5th October 2012	
Site location and access	Beckton Sewage Treatment Works (STW).	
Size and topography of site and surroundings	Record elevation in relation to surroundings, any hummocks, breaks of slope etc.	Generally level. Hummocky area noted in unused grassland in centre of Site A.
Neighbouring site use (in particular note any potentially contaminative activities or sensitive receptors)	North	Sewage treatment works and commercial/light industrial land use.
	South	Gallions Reach retail park and further sewage treatment processes. River Thames located further south
	East	Sewage treatment works processes, Barking Creek/River Roding located further east.
	West	Sewage treatment, refuse transfer station. Light industrial/commercial land.
Site buildings	Record extent, size, type and usage. Any boiler rooms, electrical switchgear?	Proposed construction areas are generally free from permanent structures and previous sewage treatment structures. Current Lee Tunnel works occupy the bulk of the sites including the under-construction shafts and associated infrastructure.
Surfacing	Record type and condition	Generally hard cover (concrete) associated with existing Lee

Item (Site ref: PNM1X, Beckton Sewage Treatment Works)		Details
		Tunnel construction works. The exception being the grassed verge to the south of in 'Site A' outside of the Lee Tunnel works and to the north and eastof the exsitinginlet works.
Vegetation	Any evidence of distress, unusual growth or invasive species such as Japanese Knotweed?	Noted by terrestrial ecologists at two locations, within and adjacent to the Site A boundary.
Services	Evidence of buried services?	Manholes in numerous places,
Fuels or chemicals on-site	Types/ quantities?	No permanent storage. Local temporary storage diesel associated with construction site.
	Tanks (above ground or below ground)	Temporary diesel storage facilities: (above ground) double skinned tanks.
	Containment systems (eg, bund, drainage interceptors). Record condition and standing liquids	See above
	Refill points located inside bunds or on impermeable surfaces etc?	Impermeable surfacing.
Vehicle servicing or refuelling onsite	Record locations, tanks and inspection pits etc.	None
Waste generated/stored onsite	Adequate storage and security? Fly tipping ?	Excavated soils all removed for off-site disposal. Slurry processing plant in Site B for excavated materials associated with Lee Tunnel shaft construction
Surface water	Record on-site or nearby standing water	The site is bordered to the south by the River Thames and to the east by the River Roding/Barking Creek immediately to the east of the site. No standing water within proposed construction areas at time of survey.
Site drainage	Is the site drained, if so to	Extensive drainage at site linked

Item (Site ref: PNM1X, Beckton Sewage Treatment Works)		Details
	where? Evidence of flooding?	to existing STW.
Evidence of previous site investigations	Eg trial pits, borehole covers.	Yes numerous boreholes are monitored regularly to assess impacts from recent de-watering activities.
Evidence of land contamination	Evidence of discoloured ground, seepage of liquids, strong odours?	No obvious indicators. Majority of site is under redevelopment.
Summary of potential contamination sources		Sewage treatment works.
Any other comments	Eg access restrictions/ limitations	The majority of the two main proposed construction areas have been cleared of structures to make way for the Lee Tunnel construction compounds and new shaft construction. Access was available to these areas at the time of surveys.

Review of historical contamination sources

F.1.13 Historical mapping (dated between 1860 and 1970) has been reviewed in order to identify potentially contaminating land-uses at the site and within the 250m assessment area.

F.1.14 Vol 26 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.1.15 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.1.16 Items listed in the table are also shown on Vol 26 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 26 Appendix E.

Vol 26 Table F.2 Land quality – potentially contaminating land-uses

Ref	Item	Inferred date of operation	Potentially contaminative substances associated with item[1,2]
On-site			
1	Beckton Sewage Treatment Works	c1860s-present	Heavy metals, arsenic, free cyanide, nitrates, ammonium, phosphates, sulphates, sulphides, asbestos, oil/fuel hydrocarbons, chlorinated aliphatic hydrocarbon, chlorinated aromatic hydrocarbons, polychlorinated biphenyls (PCBs), pathogens
4	Depot	c1961-c1984	Oil/fuel hydrocarbons, aromatic hydrocarbons, polyaromatic hydrocarbons (PAHs), chlorinated aliphatic hydrocarbons, organolead compounds, heavy metals and asbestos
Off-site			
2	Gas works and railway (adjacent south)	c1879-c1970	Oil/fuel hydrocarbons, aromatic hydrocarbons, PAHs, chlorinated aliphatic hydrocarbons, organolead compounds, cyanides, ammoniacal liquors, phenols, heavy metals, asbestos
3	(a) Varnish, colour and enamel works (50m north)	c1920-c1950	Monoaromatic hydrocarbons, PAHs, n-alkanes (C5-C20),

Ref	Item	Inferred date of operation	Potentially contaminative substances associated with item[1,2]
			methyl tert-butyl ether (MTBE), lead, solvents incl. acetone
	(b) Works	c1960-c1984	Heavy metals, arsenic, boron, nitrates, sulphates, sulphides, asbestos, aromatic hydrocarbons, chlorinated aliphatic hydrocarbons, PCBs
5	Factory (195m west)	c1975-c1996	Heavy metals, sulphate, sulphur, asbestos, phenol, aromatic hydrocarbons, PAHs, hydrocarbons, solvents
6	Refuse Transfer Station (30m west)	c1984-c1996	Heavy metals, arsenic, sulphate, sulphide, asbestos, oil/ fuel hydrocarbons, chlorinated aliphatic hydrocarbons, PCBs

On-site

F.1.17 The site was first developed as a sewage treatment works in 1860 as part of Joseph Bazalgette's London sewerage system upgrade in the mid 19th Century. Although occupying a small area adjacent to the tidal Thames at that time, it has expanded considerably throughout the 19th and 20th Centuries to its modern day layout.

F.1.18 A number of activities within the waste water treatment site may have led to land contamination including land filling of waste boiler ash (from the steam engines used until the 1920s), sewage treatment processes and bulk fuel storage.

F.1.19 A depot was also noted to have existed within the northern tip of Site A during the approximate period c1961 to c1984.

Off-site

F.1.20 Within the 250m assessment area, the historical mapping has shown that the area to the south has a long history of industrialisation, notably including Beckton gas works (remnants of which is still present to the

south of Gallions Reach Shopping Centre) and various other engineering works.

F.1.21 Numerous tanks, chimneys, rail sidings and other potentially contaminative activities are present in this area. The Gallions Reach retail development was constructed in the 2000s.

Geology

F.1.22 Data from the site investigation reports undertaken as part of the Lee Tunnel project indicates the anticipated geological succession, as summarised in Vol 26 Table F.3 below.

Vol 26 Table F.3 Land quality – anticipated site geology

Geological Unit/Strata	Description	Approximate depth below ground level (m bgl)
Site A - Siphon Inlet (Drive) Shaft		
Made Ground	Clayey gravelly sand within inclusion of varying proportions of brick, ash, flint, clinker, slag and concrete to around 3mbgl. Below 3m, grey brown to black sandy gravelly clay with inclusions of clay, wood, brick, concrete and flint. Black sandy gravelly clay with inclusions of brick, ash, slag and clinker	0.00 – 1.50
Alluvium	Sandy silt and clay with frequent remains of wood and layers of fibrous peat.	1.50 – 4.50
River Terrace Deposits	Loose to medium dense to very dense, grey to brown sandy angular to sub-angular fine to coarse flint gravels, which are occasionally clayey in nature.	4.50 – 10.30
London Clay Formation	Fissured blue grey slightly sandy clay with occasional partings of fine sand, pyritic nodules, pyritised fragments of wood, white shell fragments at depth and rare clusters of selenite crystals.	10.30 – 17.80
Harwich Formation	Glauconitic sandy clays and very fine-grained glauconitic sands; marine fauna, locally brackish	17.80 – 20.30
Lambeth Group (Laminated Beds)	Sandy clay with lenses and beds of fine sand. Often containing	20.30 – 24.45

Geological Unit/Strata	Description	Approximate depth below ground level (m bgl)
	highly fossil rich beds.	
Lambeth Group (Lower Shelly Beds)		24.45-24.85
Lambeth Group (Lower Mottled Beds)		24.85-26.45
Lambeth Group (Lower Mottled Beds-Gravel)		26.45-28.05
Lambeth Group (Upnor Formation)		28.05-36.05
Site B - Siphon Outlet (Reception) Shaft		
Made Ground/Alluvium	Light brown to dark brown silty sandy clay or sandy gravel with inclusion of varying proportions of brick, concrete, charcoal, clinker, chert, rootlets, and wood. In certain areas, the inclusions were also recorded as: wire, glass, metal, cloth and plastic fragments	0.00 – 9.00
River Terrace Deposits	Loose to medium dense to very dense, grey to brown sandy angular to sub-angular fine to coarse flint gravels, which are occasionally clayey in nature.	9.00 – 13.0
Lambeth Group	Sandy clay with lenses and beds of fine sand. Often containing highly fossil rich beds.	13.00 – 21.0
Thanet Sand Formation	Very dense slightly silty fine to medium sand	21.0 – 40.0

Unexploded ordnance

F.1.23 During World Wars I and II the London area was subject to bombing. In some cases bombs failed to detonate on impact. During construction works Unexploded Ordnance (UXOs) are sometimes encountered and require safe disposal.

F.1.24 A desk based assessment for UXO threat was undertaken for the Beckton Sewage Treatment Works site (Vol 26 Appendix F.2). The report reviews information sources such as the Ministry of Defence (MoD), Public Records Office and the Port of London Authority (PLA).

F.1.25 The report advises that two high explosive bomb strikes were recorded within the site and six within the buffered site boundary. In addition, a further 19 were recorded within 100m of the buffered site boundary.

F.1.26 The report also mentions that geology of the site during WWII was conducive to the deep burial of UXO and that the low population of the area could make the identification of burial holes unlikely.

F.1.27 The site has undergone limited redevelopment since WWII, taking into account the findings of this study and the known extent of the proposed works at the Beckton Sewage Treatment Works site, it was considered that there is an overall high threat from UXO.

Thames Tideway Tunnel ground investigation data

F.1.28 No specific Thames Tideway Tunnel project ground investigation has taken place within the site boundaries, the nearest borehole from the Thames Tideway Tunnel project ground investigation is borehole SR2001 located in the River to the south of the site, as shown on Vol 26 Figure F.1.2 (see separate volume of figures).

Thames Water ground investigation data

F.1.29 Since 1996, a large number of ground investigations have been performed at Beckton Sewage Treatment Works, within the proposed development areas. The following has been summarised from Scott Wilson, 2008[3] which itself incorporates earlier work as well as relevant additional information from more recent ongoing groundwater monitoring [4] .

Ground investigation

F.1.30 Various phases of investigation have been undertaken at an in the vicinity of the site and is detailed in Scott Wilson, 2008[4]. This has included a number of boreholes and trial pits (approximately 35 locations) in both of the main Thames Tideway Tunnel proposed construction areas (Sites A and B). Soil samples have been collected from the Made Ground and underlying natural strata (mainly the Alluvium and River Te[r]race Deposits, but also the London Clay and Lambeth Group) where they have been chemically tested for a range of inorganic and organic contaminants.

F.1.31 An extensive groundwater monitoring programme is underway at Beckton Sewage Treatment Works as part of the Lee Tunnel works. This monitoring programme has thus far focused on 25 boreholes located within the proposed Lee Tunnel extension and temporary contractors stores plus a further eight boreholes located on other areas of Beckton Sewage Treatment Works. The response zones of boreholes vary from the Alluvium and River Terrace Deposits (RTD) to the White Chalk Subgroup.

F.1.32 Groundwater monitoring has been ongoing since prior to the start of construction in 2010 and is proposed to continue until 2015. At the time of writing over 25 rounds had been completed.

Soil contamination testing

F.1.33 Assessment of the soil contamination data has revealed widespread elevated concentrations of lead, the main areas of concern being as the grit screenings within the vicinity of the inlet works to the west of Site A.

F.1.34 Widespread sewage-related contamination, including microbes, ammoniacal nitrogen, nitrate and chloride, has been identified within the grit screenings, and in Made Ground and alluvial soils along the route of the siphon tunnel and at an isolated locality within the Made Ground in Site A.

F.1.35 Widespread elevated concentrations of phytotoxic copper and zinc have been encountered within the grit screenings on the secondary treatment area (to the west of Site A) and along the route of the siphon tunnel.

F.1.36 Total cyanide has been detected within topsoil located above grit screenings within to the west of Site A.

F.1.37 Occasional elevated levels of various organic compounds have also been found in different parts of the site.

Soil gas testing

F.1.38 Soil gas testing was undertaken on a number of boreholes with both Site A and Site B. Response zone of monitoring instruments were in the Thanet Sand and Chalk in Site A and variably in Made Ground, Alluvium and River Terrace Deposits in Site B. Groundwater contamination data

F.1.39 Comparing groundwater and leachate results against corresponding Environmental Quality Standards (EQS) shows that to varying degrees, all development areas have some form of significant contamination.

F.1.40 The highest contaminant concentrations have been observed within the grit screenings, which have widespread significant concentrations of copper, nickel and ammonium with isolated hotspots of arsenic, cadmium and lead. Contamination within the grit screenings and Alluvium of to the west of Site A does however not seem to be reflected in the underlying RTD.

F.1.41 Elevated ammonium concentrations in the groundwater of the RTD, Alluvium and White Chalk appear fairly consistent across the site.

F.1.42 Shallow groundwater from the Secondary Treatment area has been tested for microbial contamination. The highest populations of faecal streptococci and coliforms were found within groundwater residing in the grit screenings. Groundwater present in the Alluvium has also shown some elevated microbial concentrations, albeit to a far lesser degree.

F.1.43 A quantitative risk assessment (QRA) based on the grit screenings and reworked clay within the Beckton Rectangle has been undertaken and is provided in Scott Wilson, 20083.

F.1.44 The QRA modelled the effect of contaminants within leachate derived from the grit screenings and reworked clay on the Thames Tideway as a receptor. The Chalk Aquifer was also considered a receptor as hydraulic continuity between the aquifers is likely. The QRA was modelled using the Remedial Targets Methodology provided by the EA.

F.1.45 The report concludes that the following contaminants of concern have been identified:

a. as a worst case scenario, ammonium, zinc and nickel were identified to present a potential risk to both the Thames Tideway and the Chalk aquifer receptors

b. as a realistic scenario, the potential concentrations of ammonium and fluoranthene at the Chalk compliance point are also slightly elevated.

Remedial Measures

F.1.46 The assessment has concluded that soils within their current state cannot be reused on site within areas of soft landscaping unless some form of remediation is provided to reduce contaminants of concern. All untreated soils can, however, be reused beneath hardscaping and building footprints providing that soils are located above the (perched) water table and appropriate gas protection measures are employed (where applicable) to buildings, tunnels and other confined spaces.

F.1.47 The report advised that gas protection measures would be included as part of the design within all new buildings and service trenches located within all development areas except Site A.

F.1.48 This includes buildings even where there may only be part time personnel in attendance. Site A appears to have been omitted due to the thinning of organic rich alluvial soils and reduced contamination in this area in comparison with other parts of the Beckton Sewage Treatment Works site. The natural decomposition of grit screenings, sewage, peat, hydrocarbons and putrescible waste has the potential to generate ground gases including carbon dioxide and methane.

Other environmental records

F.1.49 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 26 Table F.4. Pertinent records are discussed in further detail in the table below.

F.1.50 The location of these records is shown on Vol 26 Figure F.1.3 (see separate volume of figures).

Vol 26 Table F.4 Land quality – hazard and waste sites

Item	On- site	Within 250m of site boundary
Active integrated pollution prevention and control	0	0
Control of major accident hazard sites	0	0
Historical landfill site	0	1
LA pollution prevention	0	0

Item	On- site	Within 250m of site boundary
and control		
Licensed waste management facility	0	4
Notification of installations handling hazardous substances	0	1
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	6
Registered waste transfer site	0	3
Registered waste treatment or disposal site	0	0

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

F.1.51 Inspection of the data has identified areas both on-site and within 250m of Beckton Sewage Treatment Works site that are classified as being of past potential contaminated industrial use and these relate to the Beckton Sewage Treatment Works and the former gas works site as shown on Vol 26 Figure F.1.1 (see separate volume of figures). Contaminants typically associated with these types of industries are identified in Vol 26 Table F.2.

F.1.52 Within 250m of the Beckton Sewage Treatment Works site, there are 6 pollution incidences to controlled water most are likely to be related to the sewage treatment works on the site. Information provided by the EA shows that there have been several significant sewage pollution incidents on the southeast border of the site in the last ten years.

F.1.53 In addition there is the presence of a historic landfill, which is judged to relate to activities associated with the Beckton Sewage Treatment Works.

Thames water operational records

F.1.54 Thames Water records of potentially contaminating substance storage at the Beckton Sewage Treatment Works site within the last five years were reviewed.

F.1.55 No bulk storage of hydrocarbons or other potentially contaminating liquids were stated to be taking place at the site (within the proposed construction areas) at the time of the request.

F.1.56 No spillages of any potentially contaminating substances to ground were recorded.

Land quality data from local authority

F.1.57 The LB of Newham was consulted with respect to land quality data they held for the specified search area.

F.1.58 LB Newham provided site investigation reports, associated correspondence, remediation statements and validation reports which related to the redevelopment of various plots of land within the former Beckton Gasworks site to the south of Beckton Sewage Treatment Works.

F.1.59 The data indicates that the underlying soils at the Beckton Gasworks site had become impacted with common contaminants associated with this type of industrial activity, such as PAHs, Total petroleum hydrocarbon (TPH), heavy metals and cyanide.

F.1.60 Various remediation schemes were adopted including source removal (soils) and the employment of capping layers.

F.1.61 Contamination of perched groundwater within the Made Ground was found, and included elevated levels of mercury, PAHs, cyanide, phenols and ammonia.

Summary of contamination sources

F.1.62 Following the review of the baseline data, the following sources of on-site contamination which may impact on the construction of the proposed development have been identified:

a. Sewage treatment works (including soil contamination with lead, microbes, ammoniacal nitrogen, nitrate and chloride, as well as phytotoxic copper and zinc in the grit screenings to the west of Site A). Total cyanide has also been recorded within topsoil and organic compounds have been noted locally across the remainder of the site.

b. Potential for UXO

c. Japanese Knotweed

d. Elevated ground gas associated with Alluvium and Made Ground.

F.1.63 Off-site sources of contamination arise from a residual groundwater contamination associated with adjacent and nearby former potentially contaminative activities. Notably, the presence of former gas works located immediately to the south of the site.

F.1.64 The main potential contaminants of concern are likely to be, but not limited to: TPH, benzene, toluene, ethylbenzene, xylene, cyanides, phenols, PAHs and 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 PNM1X – Beckton Pumping Station
Document Number: 336-RG-TPI-PNM1X-000001
Client Name: Thames Water
6 Alpha Project Number: P2853_R16_V1.0
Date: 12th June 2012

Originator: Max Chainey (12th June 2012)
Quality Review: Lisa Askham (13th June 2012)
Released by: Lee Gooderham (15th June 2012)

Contents

Figures

EXECUTIVE SUMMARY

Study Site	The Client has specified the Study Site as Work Area PNM1X, located at National Grid Reference "544533, 182060".
Key Findings	In light of the research for this report, 6 Alpha has assessed the threat on this Site based on these pertinent facts: • The Work Area is situated on what was predominantly undeveloped land during World War Two (WWII), which comprised, predominantly, of "marsh land", with "Filter Beds" located within the southeast area. • The Work Area was located adjacent to *Beckton Gas Works*, which was identified as a primary *Luftwaffe* bombing target during WWII. Numerous other primary and "opportunistic" bombing targets were located within 1,000m of the Work Area. • Two High Explosive (HE) bomb strikes have been identified within the Work Area, with six additional HE bomb strikes located within the buffered Site boundary. A further nineteen HE bomb strikes were recorded within 100m of the buffered Site boundary. The local boroughs of *Barking* and *Woolwich* recorded a bomb density of 116 and 168 HE bomb strikes per 1,000 acres. However, the "local bomb density" would appear much higher given the recorded bomb strikes. • The Official Abandoned Bomb Register identifies six abandoned bombs located within the vicinity of the Work Area. The closest abandoned bomb is located approximately 300m south of the Work Area. • The geology of the Work Area during WWII was conducive for the deep burial of aerial delivered ordnance, whilst the low population density of the area would make identification of an Unexploded Bomb (UXB) entry hole unlikely. • The Work Area has undergone limited redeveloped post WWII, which has included the introduction of fill material. This has shifted the likely "threat horizon" to between 5m and 21m below ground level (bgl). 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 (IBs) 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	**HIGH**
Recommended Risk Mitigation	**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 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.
	The following action is recommended before open excavations at depths of greater than 5m: **3. Specialist UXO Banksman Support;** this activity should be supervised by a specialist UXO banksman to identify and dispose of any items of UXO.
	The following action is recommended before tunneling at 10m depth: **4. Intrusive Magnetometer Survey;** an intrusive magnetometer survey should be conducted ahead of the tunnel route.
	The following action is recommended before piling and shaft installation works conducted between 7m and 21m in depth: **5. Intrusive Magnetometer Survey;** an intrusive magnetometer survey should be conducted ahead of the piling and shaft installation works between 7m and 21m in depth.

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 UXO 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 PNM1X, located at National Grid Reference "544533, 182060". For the purposes of this study, a 50m buffered radius will be applied to the work area to provide flexibility should it need to be relocated. See *Figures 1* and *2* for the Site location.
Location Description ***(Figure 3)***	The Work Area is situated to the east of the *City of London*, and lies within the *London Borough of Newham*. Current aerial photography has identified the Work Area as land adjacent to the western boundary of the *Beckton Sewage Works.* The Site has been partly redeveloped, predominantly to the south.
Proposed Engineering Works	*Thames Water* have summarised the proposed engineering works, including working draft plans in drawing no. 100-DA-CVL-PNM1X-337020_A1. These proposed works may not represent the full scheme, but include those elements that may present a UXO risk: • 40m deep 9m ID Siphon Tunnel Connection Shaft; • 35m deep 7m ID Siphon Tunnel Connection Shaft; • 30m deep 2.8m Siphon Tunnel; • 2m ID 10m deep pipeline or raised pipeline requiring installation of 10m deep piles; • Underground Chambers and connecting ducting and pipework. The main construction site will be located within the *Beckton Pumping Station*. The construction compound will contain offices/welfare facilities, a storage area for construction materials and a storage and handling area for excavated material including slurry separation units.
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	7.00
Alluvium	7.00	2.50
River Terrace Deposits	9.50	3.50
Lambeth Group UF	13.00	6.00

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** – The Work Area is situated predominantly within an area of "open marshland" located to the north of *Beckton Gas Works.* Some development is evident, which is located within the southeast of the Work Area and is identified as "Filter Beds". Railway infrastructure is also present to the south of the Site. **1949 OS mapping** – No significant or noticeable structural developments have occurred within the Site.
1945 Aerial Photography ***(Figure 4)***	The 1945 aerial photography shows that the southeast of the Site has been developed. The "filter beds" located within the southern portion of the Work Area are clearly defined, it also indicates the remoteness of the northern portion of the Work Area.
WWII Luftwaffe Bombing Targets ***(Figure 5)***	Primary targets have been identified as a *Beckton Gas Works* located immediately south of the Study Site and the *Royal Docks* located approximately 1,300m to the southwest. "Opportunistic" targets include industrial facilities located approximately 600m to the east.
WWII HE Bomb Strikes (***Figure 6)***	*Air Raid Precaution* (ARP) reports identify two bomb strikes located within the Work Area. One strike is located centrally within the northern portion of the Work Area and the other is located to the southwest. Additionally, six bomb strikes occurred within the buffered Site boundary and a further nineteen strikes occurred within 100m of the buffered Site boundary. V1 and V2 strikes have not been recorded within, or in close proximity to, the buffered Site boundary.
WWII Bomb Damage ***(Figure 7)***	The *London County Council* (LCC) bomb damage maps identify and describe the bomb damage sustained by numerous buildings located within the *London* area. However, these records are not considered definitive as many military and commercial facilities kept their own (private) bomb damage data, which were not recorded by the LCC. Nonetheless, the LCC maps 67 and 68, which cover the *Beckton Gas Works*, do not record any bomb damage within the Site boundary, or indeed within *Beckton Gas Works* itself. It is possible however, that the damage sustained by this facility was kept out of public records in the interests of national security. It is inevitable that damage was sustained within the gas works, based solely on the number of bomb strikes recorded within this facility.
WWII HE Bomb Density ***(Figure 8)***	The Study Site is located between the *Barking Municipal Borough* and *Woolwich Metropolitan Borough,* which recorded 116 HE bombs and 168 HE bombs per 1,000 acres respectively. 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 records six abandoned bombs on or within 1,000m of the Work Area. The closest abandoned bombs are located approximately 300m to the south of the Work Area, east of the "roundabout" between *Armada Way* and *Hornet Way* and 400m north in the vicinity of *Jenkins Lane*.

STAGE THREE – DATA ANALYSIS	
Was the ground undeveloped during WWII?	Yes; the Work Area was predominantly undeveloped, although there was limited development located to the southeast, which comprised of "Filter Beds". A "Railway Track" was located on the southern boundary.
Is there a reason to suspect that the immediate area was a bombing target during WWII?	Yes; the Work Area was located adjacent to *Beckton Gas Works*, which was a primary *Luftwaffe* bombing target. The WWII bomb strike records for this facility were compiled by *The Thames Gas Board*, which recorded 217 incidents, which included numerous HE bombs and AAA projectiles. Significant numbers of UXO have been dealt with during and after WWII within close proximity of the Work Area.
Is there firm evidence that ordnance landed on Site?	Yes; two HE bomb strikes were recorded within the Work Area, with numerous additional HE strikes recorded within the Work Area buffer.
Is there evidence of damage sustained on Site?	No; there has been no definitive evidence that bomb damage was sustained within the Work Area. As this area was predominantly undeveloped and damage to landscape and was not recorded on the LCC bomb damage maps.
Is there any reason to suspect that military training may have occurred at this location?	No; there is no evidence to suggest that military training occurred within any of the areas.
Would an UXB entry hole have been observed and reported during WWII?	Unlikely; the northern portion of the Work Area was undeveloped, with no identifiable use, which indicates a very low footfall within the area. The southern portion of the Work Area has limited development in the form of "Filter Beds" and a "Railway Track". Whilst there is limited development within this southern area it is still unlikely that a UXB entry hole would have been witnessed or recorded, as there is likely to have been limited occupation or footfall.
What is the expected UXO contamination?	The most likely source of UXO contamination is from *German* aerial delivered ordnance, which ranges from small IBs through to large HE bombs (of which the latter forms the principal threat). AAA projectiles pose a background threat.
Would previous earthworks have removed the potential for UXO to be present?	Unlikely; whilst there has been limited post WWII development, the capacity for UXO to remain on site and undiscovered, largely depends on the scale and depth of the post-WWII development, which cannot be readily established. Additionally, historic borehole logs indicate that fill material has been introduced to the Work Area post WWII and that Made Ground may not have been present during WWII.

STAGE FOUR – RISK ASSESSMENT		
Threat Items	The threat is predominately posed by WWII *German* HE bombs. Additionally, *British* AAA projectiles and *German* IBs may also be present.	
Maximum Penetration	For this particular Site, due to changes in the ground level, the likely "threat horizon" is more important to determine than just the BPD. During WWII, much of the Site consisted of "open marshland" and there was little or no Made Ground present across the Site. The maximum BPD for a 250kg bomb on the Site would have been approximately 14m, although the average BPD for both 50kg and 250kg bombs would have been between 4m-6m. Following WWII there was extensive redevelopment of the Site, including the importation of 7m of Made Ground. Therefore, the likely threat horizon is from 7m-21m bgl (although based on average BPD this threat will be at it's greatest between 11m-13m. Items such as AAA munitions and IBs have a vastly reduced penetration capability, as compared to larger HE bombs. IBs and AAA projectiles are most likely to be limited to 1m bgl in WWII (7m-8m bgl in the present day). An additional concern on this project is that fill material used to create the 7m of Made Ground on the Site could have been imported from the vicinity of the Study Site and therefore may contain items of UXO. This is considered a possible threat source, because where fill materials have been imported from areas with a high potential of UXO contamination, historically UXO has been discovered.	
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 additional costs
Site Activities	The Client has provided a specific set of construction activities for this Site and 6 Alpha has provided an analysis of the likely levels of risk posed by UXO, to each of these activities.	

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	**WORK AREA**		
	Probability (SHxEM=P)	**Consequence** (DxPSR=C)	**Risk Rating** (PxC=RR)
10m deep Tunnelling	3x2=6	2x3=6	6x6=36
30m deep Tunnelling	1x1=1	1x3=3	1x3=3
Shaft Installation	2x2=4	1x3=3	4x3=12
Piling to 10m	2x2=4	1x3=3	4x3=12
Open Excavations to 5m	1x1=1	2x3=6	1x6=6
Open Excavations below 5m	3x2=6	2x3=6	6x6=36

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 Client has identified that the first 7m bgl is Made Ground. This is likely to contain ferro-magnetic contaminants that would render a non-intrusive geophysical survey highly ineffective. **Intrusive Methods of Mitigation;** Intrusive magnetometry is expected to be possible (although limited) on this Site. It should be noted that ferro-contamination of any Made Ground/fill material, is likely to adversely affect the capability of the detection equipment. However, at depths below 7m-8m (i.e. below the layer of Made Ground), the effectiveness of intrusive geophysical survey is expected to improve dramatically.

MITIGATION MEASURES TO REDUCE RISK TO 'ALARP'

Activity	Risk Mitigation Measures	Final Risk Rating
ALL ACTIVITIES	**The following actions are recommended before undertaking all activities 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
Open Excavations (Below 5m in Depth)	**3. Specialist UXO Banksman Support;** open excavation work at depths below 5m should be supervised by a specialist UXO banksman to identify and dispose of any items of UXO. If open excavations are confined less than 5m bgl, this risk mitigation will not be required (as the Made Ground was imported post WWII).	
10m Deep Tunnelling	**4. Intrusive Magnetometer Survey;** an intrusive magnetometer survey should be conducted ahead of the tunnel route. The magnetometer will have to penetrate through the 7m layer of Made Ground, therefore it is considered likely that a "borehole" methodology would be more suitable than a "cone penetration testing" methodology. The first borehole will be surveyed "at risk" and then all subsequent boreholes should be located within previously "cleared" locations. **NB: If tunneling at this depth continues beyond the boundaries of this Work Area – 6 Alpha strongly advise that a further "Stages 2 & 3 Detailed Risk Assessment and Risk Mitigation Strategy" is undertaken to cover the length of this proposed pipeline route.**	
Shaft Installation and Piling	**5. Intrusive Magnetometer Survey;** an intrusive magnetometer survey should be conducted ahead of shaft installation and piling between 7m-21m bgl. Works above 7m and below 21m in depth are assessed to present a lower level of risk and thus an intrusive magnetometer survey in these areas is considered unnecessary.	

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

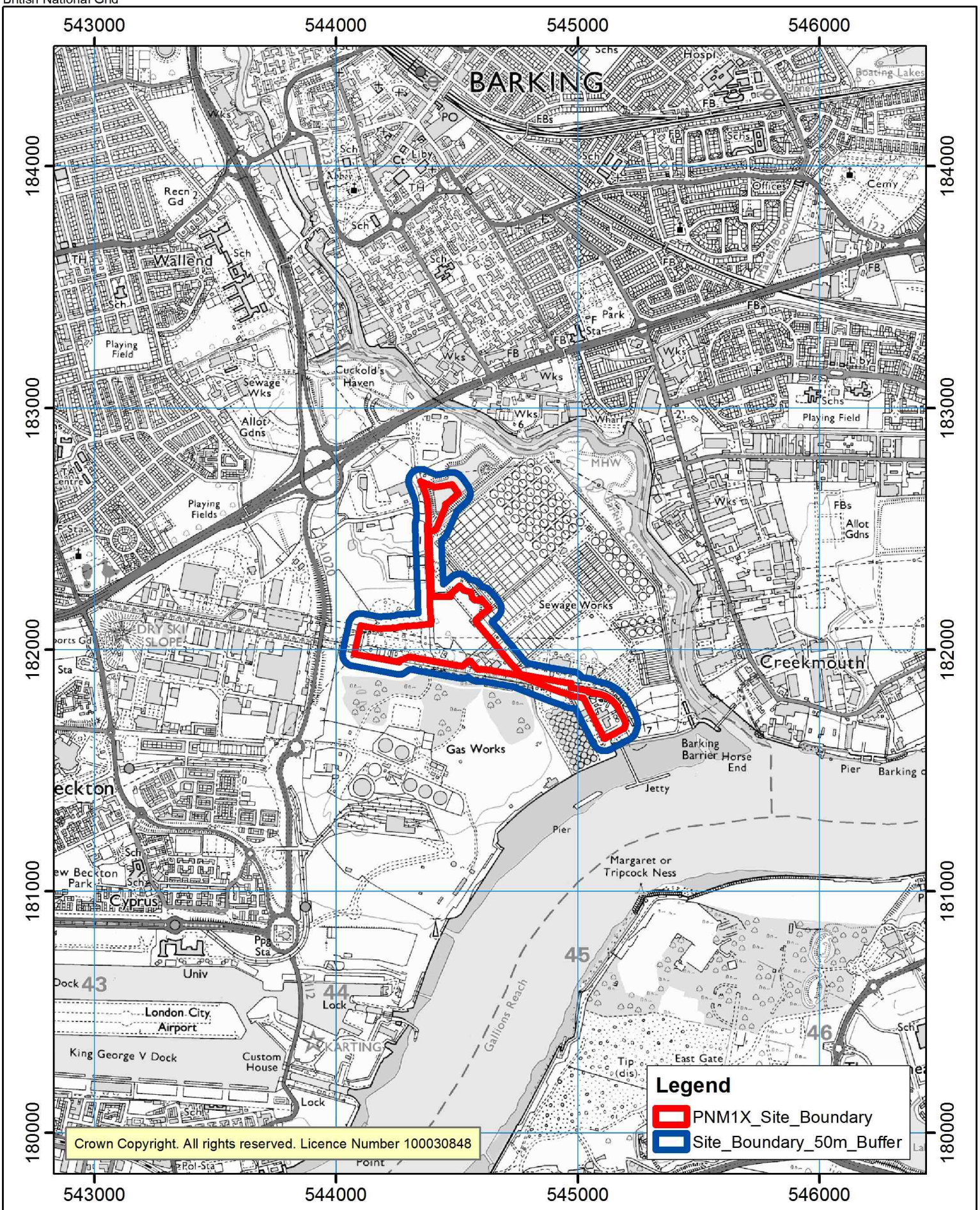
Figure One

Site Location

Thames Tideway Tunnel - Work Area PNM1X
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_PNM1X
Drawn By: Dominique René
Checked by: Lee Gooderham
Date: 1st June 2012

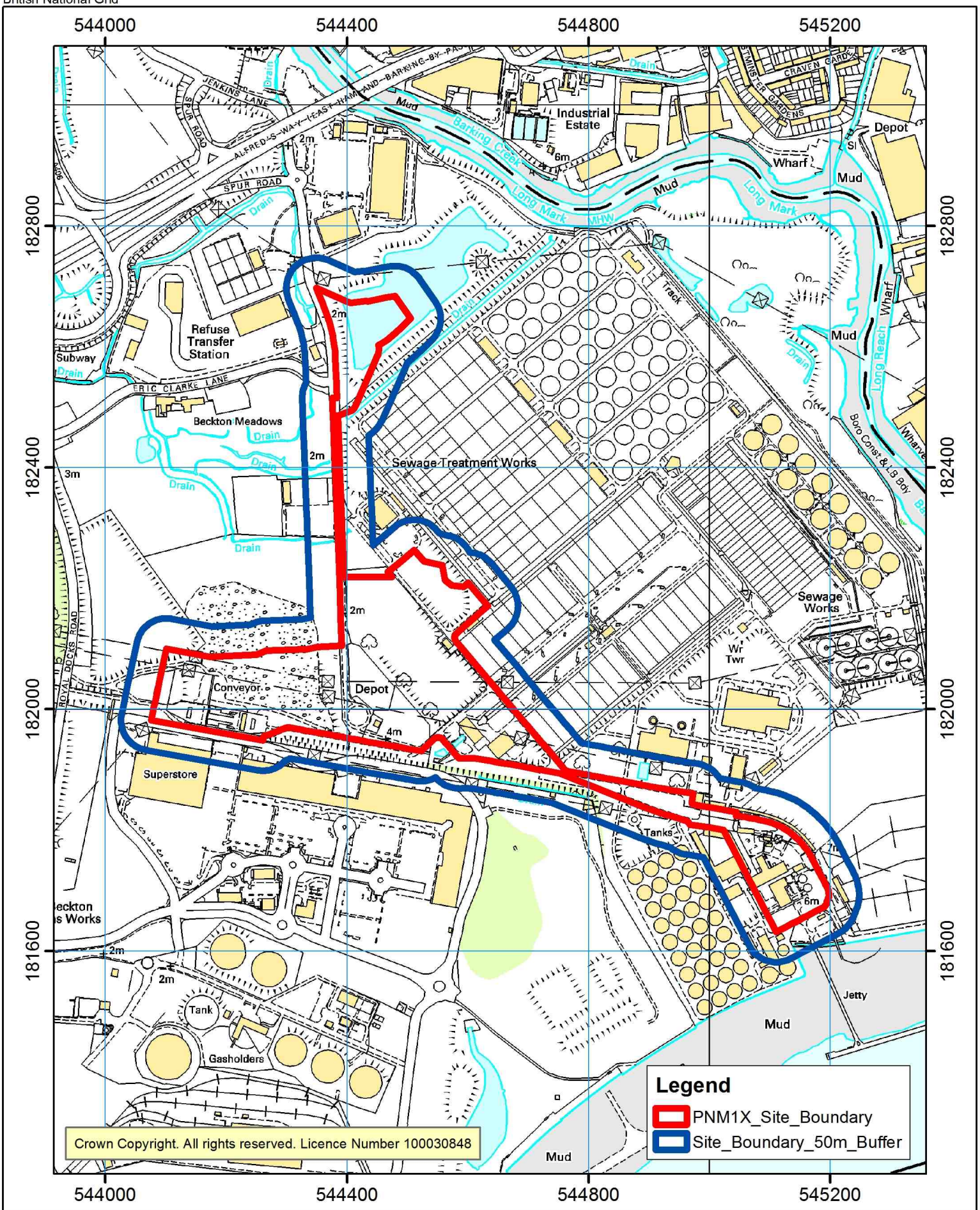
Figure Two

Site Boundary

Thames Tideway Tunnel - Work Area PNM1X Site Boundary

Figure 2

British National Grid



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 Meters

N

Project Number: P2853_PNM1X
Drawn By: Dominique René
Checked by: Lee Gooderham
Date: 1st June 2012

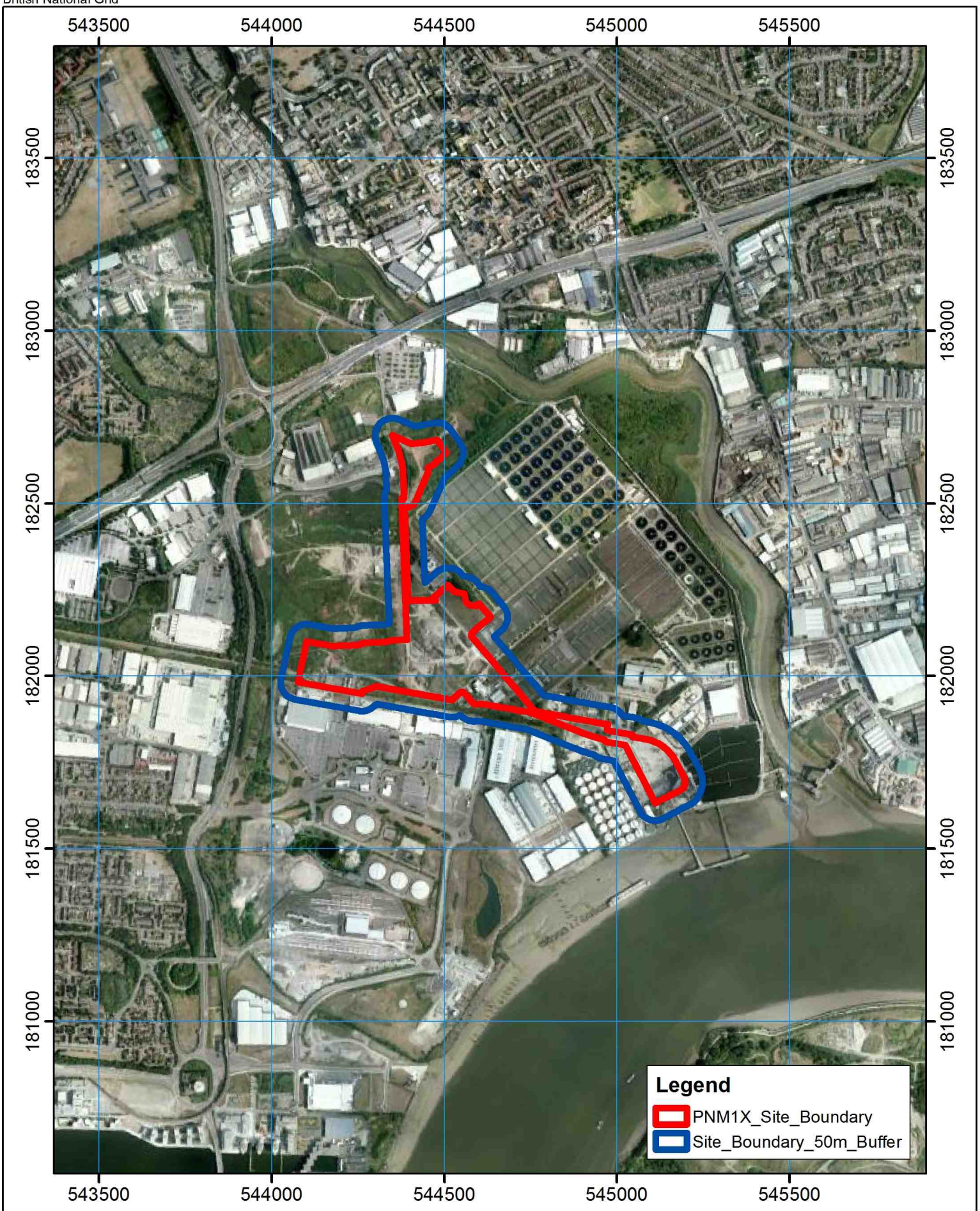
Figure Three

Current Aerial Photography

Thames Tideway Tunnel - Work Area PNM1X
Current Aerial Photography

Figure 3

British National Grid



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_PNM1X
Drawn By: Dominique René
Checked by: Lee Gooderham
Date: 1st June 2012

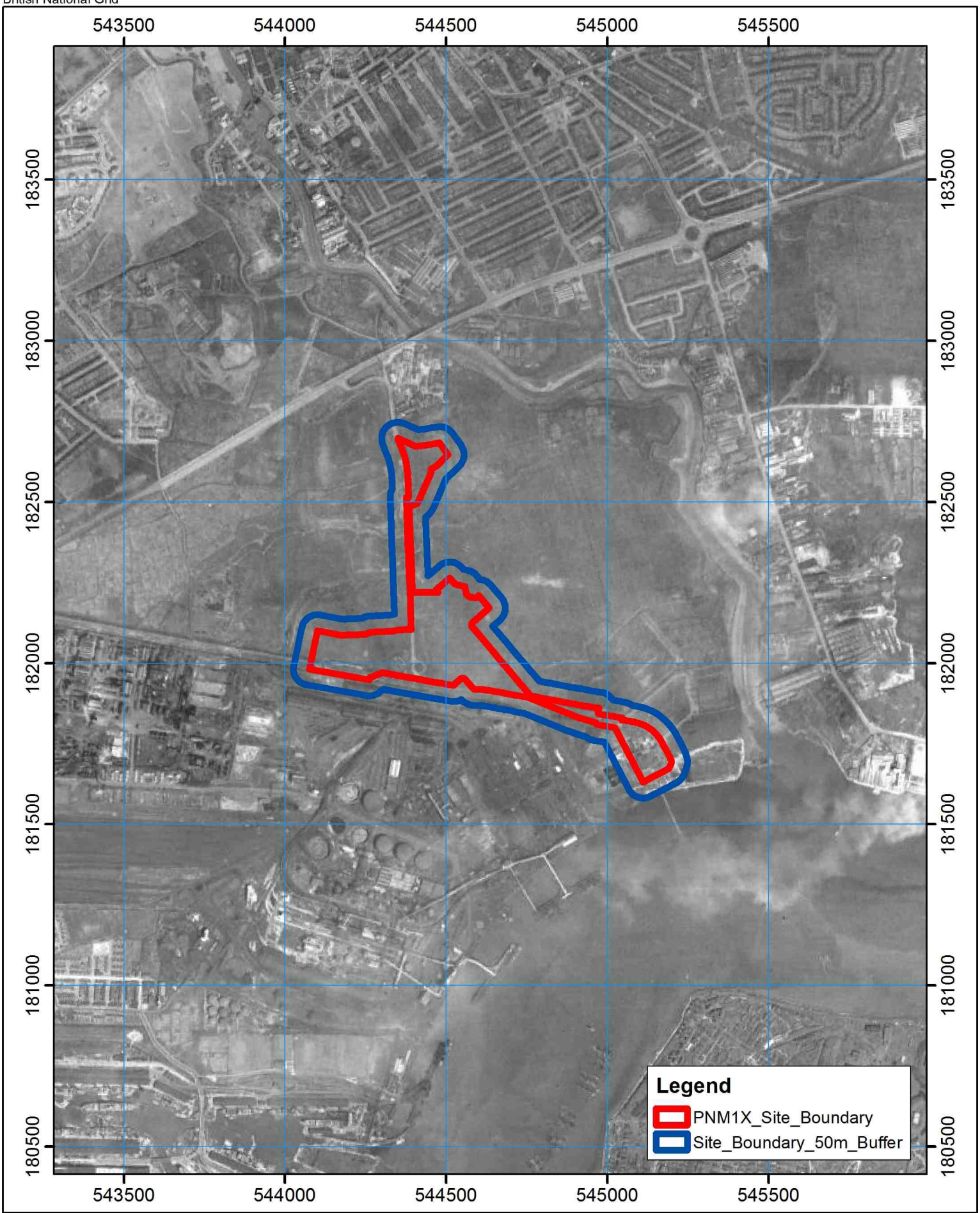
Figure Four

1945 Aerial Photography

Thames Tideway Tunnel - Work Area PNM1X
1945 Aerial Photography

Figure 4

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_PNM1X
Drawn By: Dominique René
Checked by: Lee Gooderham
Date: 1st June 2012

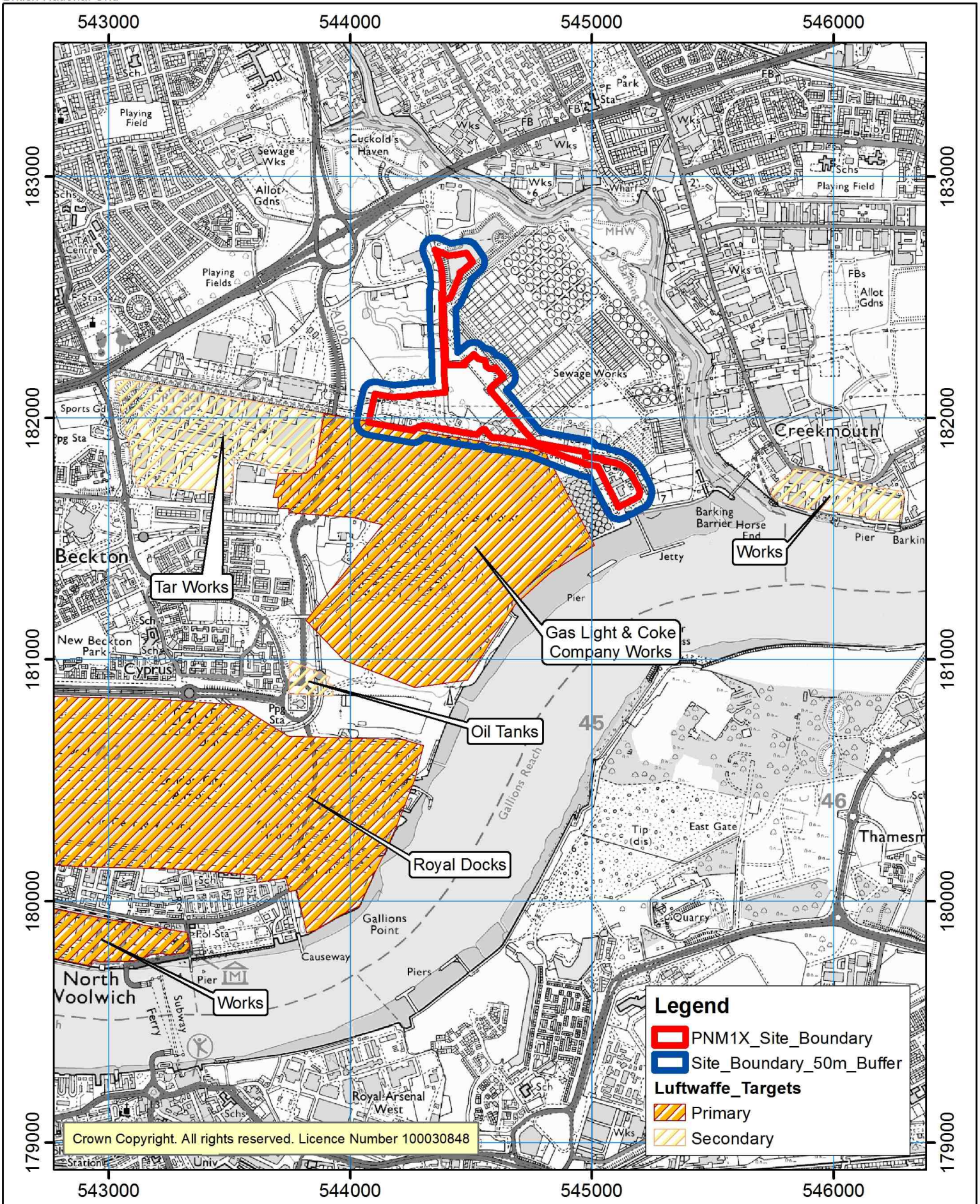
Figure Five

WWII Luftwaffe Bombing Targets

Thames Tideway Tunnel - Work Area PNM1X
WWII Luftwaffe Bombing Targets

Figure 5A

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

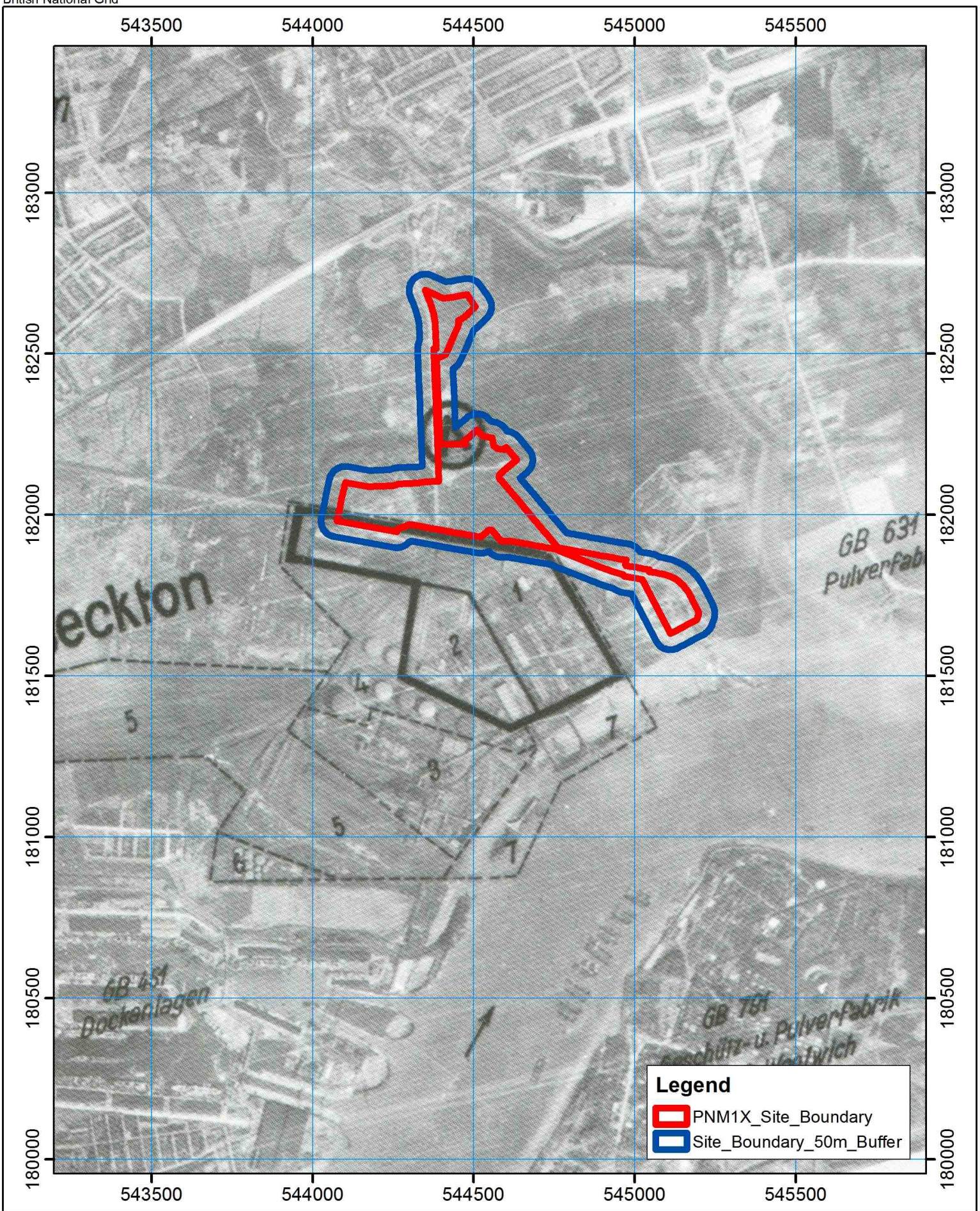
N

Project Number: P2853_PNM1X
Drawn By: Dominique René
Checked by: Lee Gooderham
Date: 1st June 2012

Thames Tideway Tunnel - Work Area PNM1X
WWII Luftwaffe Bombing Targets Aerial Photography

Figure 5B

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_PNM1X
Drawn By: Dominique René
Checked by: Lee Gooderham
Date: 1st June 2012

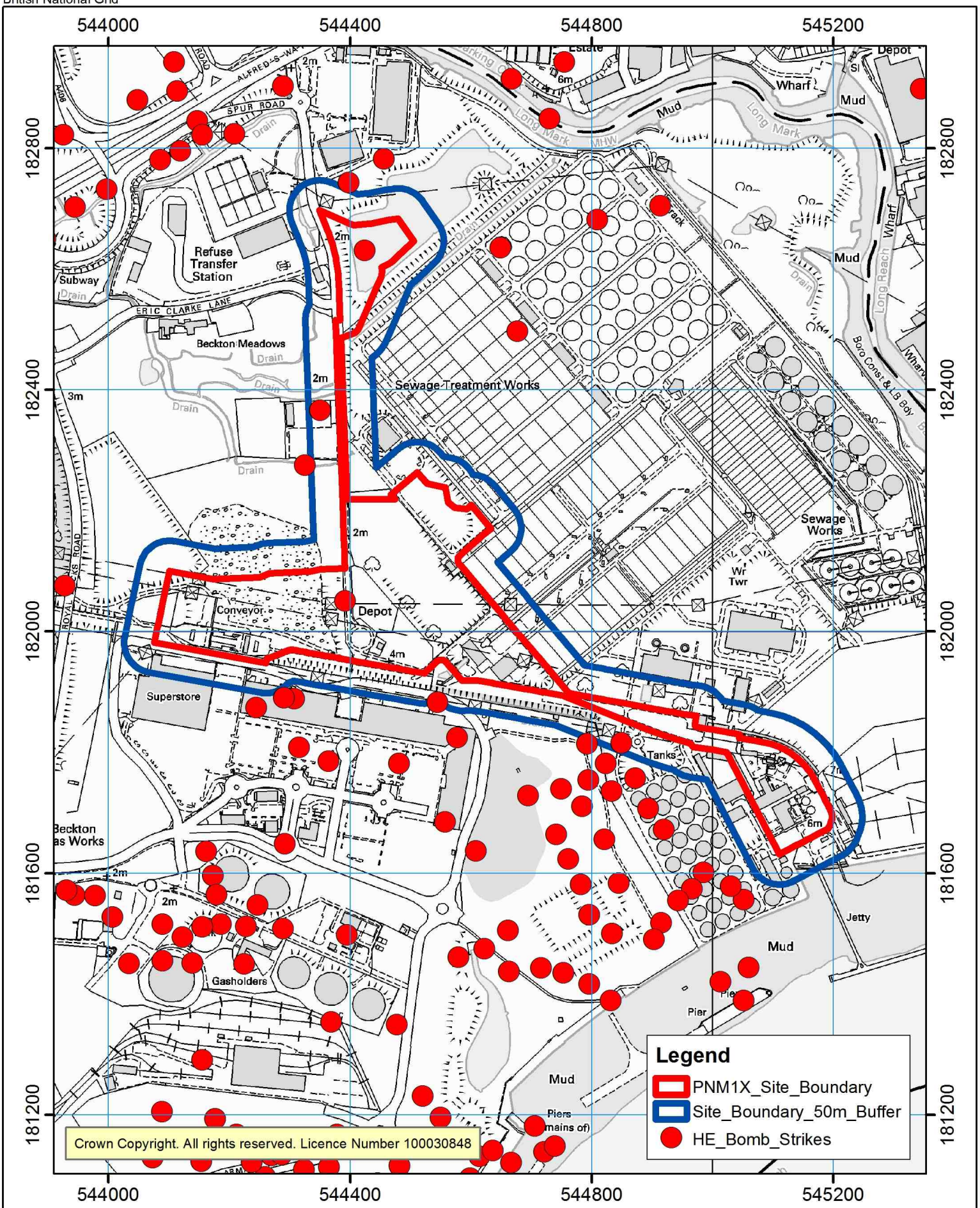
Figure Six

WWII High Explosive Bomb Strikes

Thames Tideway Tunnel - Work Area PNM1X
WWII High Explosive Bomb Strikes

Figure 6

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 Meters

N

Project Number: P2853_PNM1X
Drawn By: Dominique René
Checked by: Lee Gooderham
Date: 1st June 2012

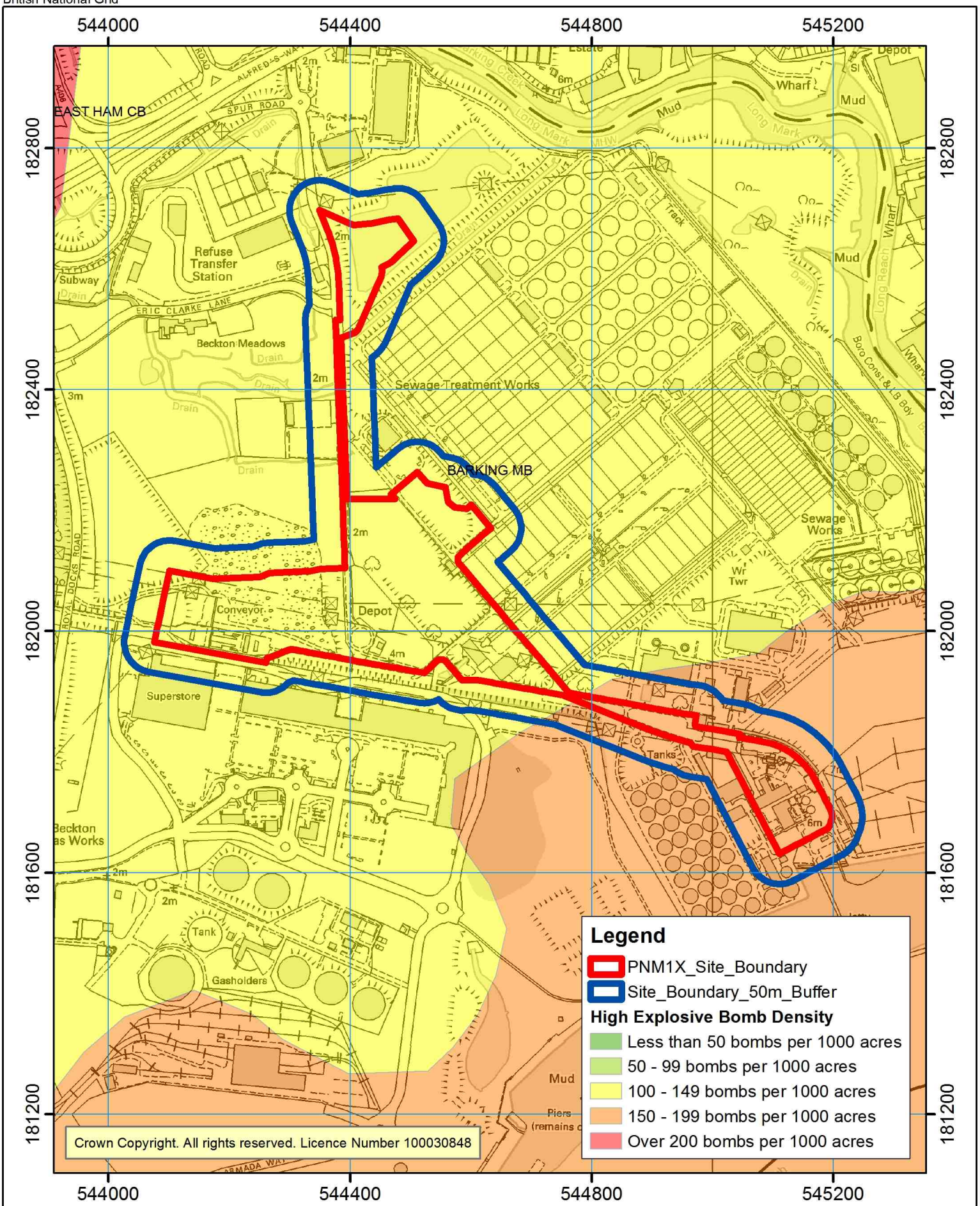
Figure Seven

WWII High Explosive Bomb Density

Thames Tideway Tunnel - Work Area PNM1X
WWII High Explosive Bomb Density

Figure 7

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 Meters

N

Project Number: P2853_PNM1X

Drawn By: Dominique René

Checked by: Lee Gooderham

Date: 1st June 2012

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] Scott Wilson, *Development Areas at Abbey Mills Pumping Station and Beckton Sewage Treatment Works, Phase 2 Contamination Assessment and Remedial Options Appraisal* (2008)

[4] MVB London Tideway Tunnels Project, *Construction Groundwater Monitoring, Eastern Tunnel Alignment Round 22 and Abbey Mills Round 11 Summary Report and Annual Review to 20 July 2012,* MVB/Mott MacDonald 2012.

This page is intentionally blank

Thames Tideway Tunnel
Thames Water Utilities Limited

Application for Development Consent

Application Reference Number: WWO10001

Environmental Statement

Doc Ref: **6.2.26**

Volume 26: Beckton Sewage Treatment Works appendices

Appendix G: Noise and vibration

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

Hard copy available in

Box **40** Folder **B**
January 2013

Thames Tideway Tunnel

Creating a cleaner, healthier River Thames

This page is intentionally blank

Thames Tideway Tunnel

Environmental Statement

Volume 26 Beckton Sewage Treatment Works appendices

Appendix G: Noise and vibration

List of contents

Page number

This page is intentionally blank

Appendix G: Noise and vibration

G.1 Introduction

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

This page is intentionally blank

Thames Tideway Tunnel
Thames Water Utilities Limited

Application for Development Consent

Application Reference Number: WWO10001

Environmental Statement

Doc Ref: **6.2.26**

Volume 26: Beckton Sewage Treatment Works appendices

Appendix H: Socio-economics

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

Hard copy available in

Box **40** Folder **B**
January 2013

Thames Tideway Tunnel

Creating a cleaner, healthier River Thames

This page is intentionally blank

Thames Tideway Tunnel

Environmental Statement

Volume 26 Beckton Sewage Treatment Works appendices

Appendix H: Socio-economics

List of contents

Page number

This page is intentionally blank

Appendix H: Socio-economics

H.1 Introduction

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

This page is intentionally blank

Thames Tideway Tunnel
Thames Water Utilities Limited

Application for Development Consent

Application Reference Number: WWO10001

Environmental Statement

Doc Ref: **6.2.26**

Volume 26: Beckton Sewage Treatment Works appendices

Appendix I: Townscape and visual

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

Hard copy available in

Box **40** Folder **B**
January 2013

Thames Tideway Tunnel

Creating a cleaner, healthier River Thames

This page is intentionally blank

Thames Tideway Tunnel

Environmental Statement

Volume 26 Beckton Sewage Treatment Works 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: **6.2.26**

Volume 26: Beckton Sewage Treatment Works appendices

Appendix J: Transport

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

Hard copy available in

Box **40** Folder **B**
January 2013

Thames Tideway Tunnel

Creating a cleaner, healthier River Thames

This page is intentionally blank

Thames Tideway Tunnel

Environmental Statement

Volume 26 Beckton Sewage Treatment Works 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: **6.2.26**

Volume 26: Beckton Sewage Treatment Works appendices

Appendix K: Water resources - groundwater

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

Hard copy available in

Box **40** Folder **B**
January 2013

Thames Tideway Tunnel

Creating a cleaner, healthier River Thames

This page is intentionally blank

Thames Tideway Tunnel

Environmental Statement

Volume 26 Appendices: Beckton Sewage Treatment Works 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 Beckton Sewage Treatment Works site is shown in Vol 26 Table K.1.

Vol 26 Table K.1 Groundwater – anticipated geological succession

Period	Series	Group	Formation
Quaternary	Holocene	Superficial deposits	Made ground
			Alluvium
	Pleistocene		River Terrace Deposits
Palaeogene	Eocene	Thames	London Clay
			Harwich
	Palaeocene	Lambeth	Laminated Beds
			Lower Shelly Beds
			Lower Mottled Beds
			Upnor
		No group	Thanet Sand

K.1.2 The superficial and solid geology in the vicinity of the site, as published by the British Geological Survey (BGS)[1], is shown in Vol 26 Figure 13.4.1 and Vol 26 Figure 13.4.2 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. In addition for the Beckton Sewage Treatment Works site, ground investigation boreholes drilled for the Lee Tunnel project have been used to derive local geological data. The depths and thicknesses of geological layers have therefore been extrapolated from ground investigation holes drilled for the Lee Tunnel located on site and up to 140m from the site; these are boreholes BH01A-1 to BH01H-1, BH02A-1 to BH02E-1, BH03, BH04-1, BHF01-L1 and BHWJSP4. The locations of boreholes around the site are shown in Vol 26 Figure 13.4.1 (see separate volume of figures). The extrapolated depths and thicknesses of the geological layers based on these boreholes are summarised in Vol 26 Table K.2 below.

Vol 26 Table K.2 Groundwater – anticipated ground conditions

Formation	Top elevation* (mATD)**	Depth below ground level (m bgl)	Thickness (m)
Beckton Sewage Treatment Works Siphon Inlet (Drive) Shaft			
Made Ground	103.50	0.00	1.50
Alluvium	102.00	1.50	3.00
River Terrace Deposits	99.00	4.50	5.80
London Clay Formation	93.20	10.30	7.50
Harwich Formation	85.70	17.80	2.50
Lambeth Group			
LtB	83.20	20.30	4.15
LSB	79.05	24.45	0.40
LMB	78.65	24.85	1.60
UPN (Gv)	77.05	26.45	1.60
UPN	75.45	28.05	8.00
Beckton Sewage Treatment Works Siphon Outlet (Reception) Shaft			
Made Ground/ Alluvium	106.00	0.00	9.00
River Terrace Deposits	97.00	9.00	4.00
Lambeth Group	93.00	13.00	8.00
Thanet Sand	85.00	21.00	19.00

** Based on an assumed ground level of 103.50mATD at siphon inlet shaft and 106.00mATD at siphon outlet shaft.*
***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).*
LtB–Laminated Beds; LSB-Lower Shelly Beds; LMB - Lower Mottled beds; UPN (Gv)-Upnor Formation (Gravel); UPN-Upnor Formation

K.1.4 The drive shaft at the Beckton Sewage Treatment Works site would extend down to 72.5mATD and would pass through the Made Ground, Alluvium, River Terrace Deposits, London Clay Formation, Harwich Formation, Lambeth Group and be founded in the Upnor Formation at the base of the Lambeth Group. The base slab would extend to approximately 69.5mATD and would also be founded in the Upnor Formation.

K.1.5 The reception shaft at the Beckton Sewage Treatment Works site would extend down to 78mATD and would pass through the Made Ground/ Alluvium, River Terrace Deposits, Lambeth Group and be founded in the

Thanet Sand. The base slab would extend to approximately 75mATD and would also be founded in the Thanet Sand.

K.1.6 The siphon tunnel would intersect a geological fault which is part of the Greenwich Fault Zone and which is expected to show a vertical displacement of approximately 10m, resulting in the different geological conditions anticipated at the drive and reception shafts.

K.1.7 The Made Ground, comprising clayey, gravely sand or gravely, sandy clay with concrete, brick, flint, ash, charcoal, slag and coal, is expected to be 1.5m thick at the drive shaft site and, in combination with the Alluvium, to be 9.0m thick at the reception shaft site. This considerable thickness reflects decades of industrial use and land reclamations at this site.

K.1.8 The Alluvium, comprising soft to firm gravely clay with pockets of organic material, is expected to be 3.0m thick at the drive shaft site and, in combination with the Made Ground, to be 9.0m thick at the reception shaft.

K.1.9 The River Terrace Deposits are formed by extensive alluvial sand and gravel deposits laid down in river terraces by a braided river system of approximately 5km width, in river terraces since the Anglian glaciation. The River Terrace Deposits are expected to be 5.8m thick at the drive shaft site and 4.0m thick at the reception shaft site.

K.1.10 The London Clay, comprises stiff to very stiff clay, is expected to be 7.5m thick at the Beckton Sewage Treatment Works drive shaft site. The London Clay is divided into sub-units referred from oldest to youngest as A to E, with some of these sub-units dividing further, for example A2, A3i-iii, B in decreasing age order.

K.1.11 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 2.5m thick at the Beckton Sewage Treatment Works drive shaft site.

K.1.12 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 4.15m thick at the Beckton Sewage Treatment Works drive shaft site.

K.1.13 The Lower Shelly Beds (LSB) of the Lambeth Group comprise dark grey to black clay with abundant shells and are expected to be 0.4m thick at the Beckton Sewage Treatment Works drive shaft site.

K.1.14 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 is expected to be 1.6m thick at the Beckton Sewage Treatment Works drive shaft site.

K.1.15 The Upnor Formation (UPN) is a variably bioturbated fine- to medium-grained sand with glauconite, rounded flint pebbles and minor clay, with distinctive pebble beds at the base and top (UPN (Gv)). The Upnor Formation is expected to be 9.6m thick at the Beckton Sewage Treatment Works drive shaft site.

K.1.16 The Lambeth Group is undifferentiated at the Beckton Sewage Treatment Works reception shaft site but is expected to be 8.0m thick.

K.1.17 The Thanet Sand Formation is described by the BGS as "marine glauconitic clayey silts and fine sands, varying in thickness" (BGS, 2012) and only occurs in the London Basin[2]. The Thanet Sand is expected to be 19.0m thick at the Beckton Sewage Treatment Works reception shaft site.

K.1.18 In terms of geological structure, it is noted that there is a series of north-south faults forming the Greenwich Fault identified as passing through the Beckton Sewage Treatment Works site around the siphon outlet shaft. The drive and reception shafts at the site are located to the southwest of the major fault; however the siphon tunnel passes through a number of minor faults and fractures associated with the Greenwich Fault. These minor faults and fractures intercepted by the siphon tunnel and close proximity to the shafts have localised displacement of up to 10m. Faults may enhance or impede groundwater movement.

K.2 Hydrogeology

K.2.1 A summary of the anticipated hydrogeological conditions at the Beckton Sewage Treatment Works site is shown in Vol 26 Table K.3.

Vol 26 Table K.3 Groundwater – anticipated hydrogeological units

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

** 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[3].*

*** 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[4].*

K.2.2 The Made Ground/ Alluvium overlie the River Terrace Deposits or upper aquifer. The ground investigation boreholes drilled in the vicinity of the site show groundwater was encountered within the Alluvium, suggesting that this formation is in hydraulic continuity with the underlying River Terrace Deposits.

K.2.3 The upper aquifer (River Terrace Deposits) is defined by the Environment Agency (EA) as a secondary A aquifer. These deposits are described as "permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important source of base flow to rivers. These are generally aquifers formerly classified as minor aquifers" (EA, 2012).

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).

K.2.5 The drive shaft would pass through the upper aquifer and then the London Clay Formation. The London Clay Formation is generally acknowledged as an aquiclude between the upper and lower aquifers. Any groundwater present in a majority of the London Clay Formation is likely to consist of localised seepages and/or minor flows. It is anticipated that below the River Terrace Deposits the shaft would be excavated in predominantly dry London Clay Formation with the exception of minor seepage at various horizons, namely silt or claystone horizons. In unit A3ii, the presence of fine sand laminea/lenses at this horizon, may act as horizontal conduits for migration of groundwater from a nearby source.

K.2.6 The drive 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 Both the drive and reception shafts would pass through the Lambeth Group, in which several confined groundwater layers are anticipated to be encountered. Groundwater inflows are expected during excavation within the Upper Shelly Beds (USB) with potentially small inflows and more significantly at sub-artesian pressures within the Laminated Beds (formerly part of the Woolwich Formation).

K.2.8 The drive shaft would extend into and the reception shaft would pass through the Upnor Formation (the top of the lower aquifer). The reception shaft would extend into the Thanet Sand Formation. These units have been considered to be in hydraulic continuity with each other and with the underlying Seaford Chalk.

K.2.9 While the London Clay Formation is likely to act as an aquiclude, separating the upper and lower aquifers at the drive shaft site, hydraulic continuity between the upper and lower aquifers is likely at the Beckton Sewage Treatment Works reception shaft site.

K.2.10 The hydrogeological properties of the Chalk (principal aquifer) are defined by its transmissivity [the ability of rock to transmit water and is a function of its permeability and aquifer thickness] and storativity [the amount of water which the aquifer releases per unit change in water level]. The Chalk in

the area around Beckton Sewage Treatment Works is expected to have a medium transmissivity value of between 20m^2/d and 200m^2/d (average of 90m^2/d). The storativity value is expected to be approximately 1 x10^{-4} (EA, 2011)[5].

K.3 Groundwater level monitoring

K.3.1 Groundwater level monitoring was undertaken at a number of ground investigation boreholes, drilled for the Lee Tunnel, across the assessment area. 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 five ground investigation boreholes drilled for the Lee Tunnel located on site; these are boreholes BH02-E, BH02D-1, BH02B-1, BH01E-2 and BHF01L-1. These boreholes have response zones[i] and monitor groundwater levels in the Alluvium/ River Terrace Deposits, Thanet Sand and Lower Mottled Beds/ Upnor Formation. The response zone depths, the monitored strata and the frequency of monitoring are detailed in Vol 26 Table K.4. The manual dip and logger data collected from these monitoring boreholes is shown in Vol 26 Table K.5.

Vol 26 Table K.4 Groundwater – monitoring boreholes

Borehole	Response zone depths mATD	Strata	Monitoring
Beckton Sewage Treatment Works Siphon Inlet (Drive) Shaft			
BH02-E	91.85 – 99.65	Alluvium/ River Terrace Deposits	Fortnightly dips
BH02B-1	64.91 – 72.91	Lower Mottled Beds/ Upnor Formation	Fortnightly dips
BH02D-1	50.94 – 66.94	Thanet Sand	Fortnightly dips
Beckton Sewage Treatment Works Siphon Outlet (Reception) Shaft			
BH01E-2	89.68 – 95.18	River Terrace Deposits	Fortnightly dips
BHF01L-1	66.23 – 71.23	Thanet Sand	Fortnightly dips
TQ48/88A	-	Chalk	Monthly dips

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

Vol 26 Table K.5 Groundwater – summary level data

Borehole	Period of record	Maximum Month Year		Minimum Month Year		Average over the period of record	
		mbgl	mATD	mbgl	mATD	mbgl	mATD
Beckton Sewage Treatment Works Siphon Inlet (Drive) Shaft							
BH02-E	01/11/2007 – 05/06/2008	2.12 (Jan. 2008)	100.53 (Jan. 2008)	2.88 (Apr. 2008)	99.77 (Apr. 2008)	2.45	100.20
BH02B-1	20/12/2007 – 05/06/2008	2.01 (Feb. 2008)	99.90 (Feb. 2008)	4.16 (Dec. 2007)	97.75 (Dec. 2007)	2.54	99.37
BH02D-1	28/11/2007 – 05/06/2008	5.68 (Feb. 2008)	97.26 (Feb. 2008)	6.27 (Mar. 2008)	96.67 (Mar. 2008)	6.08	96.86
Beckton Sewage Treatment Works Siphon Outlet (Reception) Shaft							
BH01E-2	01/11/2007 – 05/06/2008	2.67 (June 2008)	100.01 (June 2008)	4.23 (Jan. 2008)	98.45 (Jan. 2008)	3.57	99.11
BHF01L-1	14/03/2008 – 05/06/2008	2.96 (June 2008)	100.27 (June 2008)	4.21 (Apr. 2008)	99.02 (Apr. 2008)	3.67	99.56
TQ48/88A	30/11/1978 – 11/09/2012	4.46 (Dec. 1999)	100.67 (Dec. 1999)	15.02 (June 2012)	90.11 (June 2012)	5.37	99.63

K.3.3 The recorded water levels in the Alluvium/ River Terrace Deposits at BH02-E range from 99.77mATD to 100.53mATD. These water levels remain below the top of the Alluvium at 102mATD, suggesting that these formations are in hydraulic continuity and are unconfined.

K.3.4 The recorded water levels in the River Terrace Deposits at BH01E-2 range from 98.45mATD to 100.01mATD. These water levels fluctuate above and below the top of the formation at 99mATD, further suggesting that the Alluvium and River Terrace Deposits are in hydraulic continuity and are unconfined. These water levels are slightly lower than those recorded at BH02-E, indicating that the groundwater flow direction within the superficial deposits is towards the River Thames in this area.

K.3.5 The recorded water levels (piezometric head[ii]) in the Lower Mottled Beds/ Upnor Formation at BH02B-1 range from 97.75mATD to 99.90mATD. These water levels consistently remain above the top of the formation at

[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.

78.65mATD, indicating that this formation is fully saturated and confined by the overlying London Clay Formation and Lambeth Group.

K.3.6 The recorded water levels (piezometric head) in the Thanet Sand at BH02D-1 range from 96.67mATD to 97.26mATD. These water levels consistently remain above the top of the formation at 67.45mATD, indicating that this formation is fully saturated and confined by the overlying London Clay Formation and Lambeth Group.

K.3.7 The recorded water levels (piezometric head) in the Thanet Sand at BHF01L-1 range from 99.02mATD to 100.27mATD. These water levels consistently remain above the top of the formation at 67.45mATD, indicating that this formation is fully saturated and confined by the overlying London Clay Formation and Lambeth Group. These water levels are higher than those recorded at BH02D-1, suggesting that there is an upward vertical hydraulic gradient in close proximity to the River Thames.

K.3.8 A plot of groundwater levels within the Alluvium/ River Terrace Deposits, Lower Mottled Beds/ Upnor Formation and Thanet Sand in the vicinity of the site is shown in Vol 26 Figure 13.4.3 (see separate volume of figures).

K.3.9 The EA network does not include any monitoring boreholes sufficiently close by to provide representative water level in the upper aquifer at the site. However the nearest EA groundwater level monitoring borehole in the lower aquifer is TQ48/88A, which is located approximately 0.4km west of the drive shaft and 0.3km north of the reception shaft. A groundwater level hydrograph from this regional observation borehole is shown in Vol 26 Figure 13.4.4 (see separate volume of figures).

K.3.10 The hydrograph shows a long term trend of rising groundwater levels in the Chalk or lower aquifer between 1978 (or before) and mid-2000, reflecting the changes in abstractions such as reductions in groundwater abstractions in central and east London due to the closure of heavy industries. Within this trend, the annual fluctuation in Chalk piezometric level varies by around 0.3 to 0.5m. Groundwater levels dropped between mid-2000 and mid-2004, reflecting an increase in the use of groundwater in central and east London, with groundwater levels dropped to pre-1980 levels. Although rising from their 2003/4 trough, levels remain below mid-1980s levels.

K.3.11 The EA have produced regional groundwater contour plots which display the groundwater flowing in a northwesterly direction across site[6]. As the upper and lower aquifers are likely to be in hydraulic continuity at least in places, the groundwater flow direction in the River Terrace Deposits is also likely to be towards the northwest.

K.4 Groundwater abstractions and protected rights

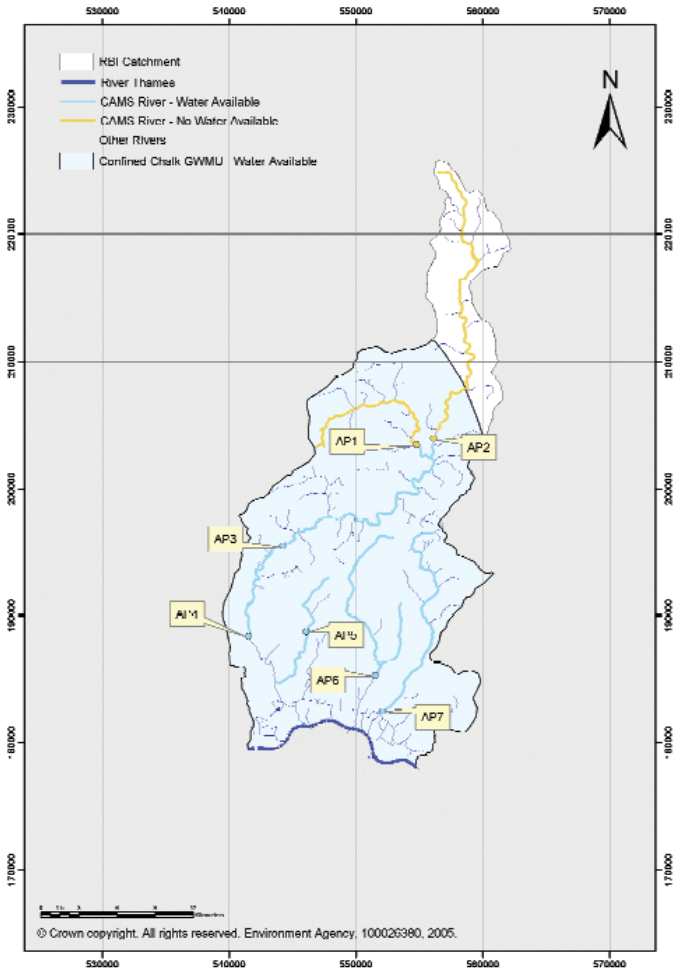
Groundwater licensing policy

K.4.1 The London Catchment Abstraction Management Strategy (CAMS), (EA, 2006)[7] 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 the Roding, Beam and Ingrebourne Catchment Abstraction

Management Strategy (CAMS), which restricts new abstractions in the lower Thames area and further abstraction in areas approaching their sustainable limit[8]. The Beckton Sewage Treatment Works drive and reception shaft sites are located within the confined Chalk groundwater management unit GWM1, which is classified as having "water available" (see Vol 26 Plate K.1) (EA, 2006). Within this area, the aim of the CAMS is to licence additional groundwater resources to move towards a resource availability status of "no water available" and therefore new consumptive licenses are likely to be available from the Chalk subject to normal abstraction licensing determination criteria (EA, 2006).

Vol 26 Plate K.1 Groundwater – confined Chalk licensing



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

K.4.3 The CAMS policy also states that, "every application would be considered on an individual basis" (EA, 2006). A preliminary hydrogeological assessment, following guidance provided in the CAMS policy, has been completed for the proposed development in Vol 26 Table K.6.

Vol 26 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 26 Figure 13.4.4 (see separate volume of figures) for an EA observation borehole at the site shows the groundwater level to have a fluctuating trend since 2005.
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.	At the Beckton Sewage Treatment Works drive shaft site, the London Clay Formation is present at a sufficient thickness (7.5m) to establish a localised hydraulic barrier between the upper and lower aquifers and groundwater levels in the Chalk at the nearby EA observation borehole are on average 15m above the base of the London Clay Formation. At the Beckton Sewage Treatment Works reception shaft site, the London Clay Formation is absent; however groundwater levels in the Chalk at the nearby EA observation borehole are also on average 15m above 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.	The Lee Tunnel is the main large recent development in the vicinity of the Beckton Sewage Treatment Works shaft sites. Substantial localised dewatering of the lower aquifer has been licensed by the EA to enable construction of this development. There are no licensed groundwater abstractions from the lower aquifer within 1km of the Beckton Sewage Treatment Works shaft sites.
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	No known ARS in the vicinity.

No.	Question	Preliminary response
	additional resource to the scheme operator.	

K.4.4 The estimated average rate of dewatering needed at Beckton Sewage Treatment Works is less than 200m^3/d, which is below the abstraction licensing limit set by the EA of 0.2 Ml/d (200m^3/d). A detailed local assessment is unlikely to be required by the Agency.

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.

K.4.6 There are no licensed or known unlicensed groundwater abstractions from either the upper or lower aquifers within 1km of the Beckton Sewage Treatment Works shaft sites.

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 Beckton Sewage Treatment Works shaft sites are not within a modelled SPZ. The nearest modelled SPZ for a Chalk source lies approximately 1.2km to the north.

K.6 Environmental designations

K.6.1 There are no environmental designations relevant to groundwater such as SSSI, SAC and SNCIs within 1km of the Beckton Sewage Treatment Works site.

K.7 Groundwater quality and land quality assessment

K.7.1 Historical land use mapping at the Beckton Sewage Treatment Works shaft sites, reviewed as part of the land quality assessment, has identified two sites located within a 250m radius with potential contamination sources (Vol 26 Section 8). In addition, the area to the south of the Becton Sewage Treatment Works site has a long legacy of previous industrial usage including a substantial gas works. 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 EA monitors groundwater quality at number of points across London. The nearest EA monitoring location with brackish water lies approximately 2.4km to the south of the site (PGWU1591). The distance of this location

from the Beckton Sewage Treatment Works shaft sites makes it unreliable as predictor of water quality conditions around the site. However the site is known to lie within an area identified as having saline intrusion into the lower aquifer (BGS, 2004)[9].

K.7.3 Groundwater quality data recorded at boreholes, drilled for the Lee Tunnel, located on site or up to 140m from the Beckton Sewage Treatment Works site, has been used to represent site conditions.

K.7.4 The baseline groundwater quality assessment obtained from ground investigation boreholes BH01A-1, BH01B-4, BH01C-1, BH01F-1, BH01G-3, BH02B-1, BH02C, BH02E, BH02D-1 and BH3 (located within 140m of the Beckton Sewage Treatment Works site and shown in Vol 26 Figure 13.4.1, see separate volume of figures), show exceedances of the UK drinking water standards or relevant Environmental Quality Standards (EQS) pertaining to both brackish conditions (in the upper and lower aquifers). Dewatering activities from the Lee Tunnel project has resulted in a 50 to 100% increase in chloride, sulphate, sodium, other cations and electrical conductivity within the Chalk. The occurrence of brackish conditions here is to be expected due to the location of the site close by the tidal Thames but it does appear that dewatering has pulled in more saline water from the tidal Thames into the lower aquifer below the Beckton Sewage Treatment Works site.

K.7.5 The data also shows exceedances with respect to heavy metals, hydrocarbons and polycyclic aromatic hydrocarbons (PAH's) in the Alluvium at BH01A-1 (on site), BH02D-1 (on site) and BH3 (140m from site), with respect to PAH's in the River Terrace Deposits at BH01G-1 (on site) and with respect to PAH's in the Chalk at BH02C (on site) (for further detail, see the Lee Tunnel project[10]). PAH's may be formed during a range of human activities, including incomplete combustion of carbon-based fuels and other industrial processes[11]. In addition, PAH's are considered to be Priority Hazardous Substances under the Water Framework Directive[12].

K.7.6 The Lee Tunnel project monitoring has indicated a number of exceedances of screening 'alert levels' between July 2011 and July 2012 at Beckton Sewage Treatment Works[13]. The majority of exceedances which occurred were observed to peak in one or two rounds of sampling and have subsequently fallen below 'alert levels' in subsequent monitoring rounds. Following the detection of total petroleum hydrocarbons (TPH) in samples taken in September 2011 from discharge line for the dewatering of the Chalk. A follow-up investigation indicated that these detections were unrelated to construction of the Lee Tunnel project. Subsequently, four new monitoring boreholes were constructed along the southern and northern boundaries of the Beckton Sewage Treatment Works site and these have all detected TPH in the dissolved and free phase forms to be present in the Chalk aquifer. There have been no detections of TPH in any of the Lee Tunnel works at shallower depths.

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)[14] shows that the Lambeth Group, Thanet Sands and Chalk Formation in the area of the Beckton Sewage Treatment Works 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 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).

K.8.6 The Thames Tideway Tunnel project would prevent deterioration of the current and predicted status of groundwater and would adhere to the key actions identified in the RBMP to achieve good status by 2021 or 2027, as follows (EA, 2009):

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

b. Prevent input of nitrates to groundwater body.

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

d. Prevent and mitigate potential inflow of river water to groundwater due to dewatering/ abstraction by implementing working methods to protect surface and groundwater from impacts, including changes to flow, by producing site-specific water management plans and by monitoring where required.

e. Prevent direct discharges of pollutants to groundwater.

K.9 Data sources

K.9.1 A list of data used for the Beckton Sewage Treatment Works site assessment is given in Vol 26 Table K.7.

Vol 26 Table K.7 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 Tideway Tunnel project	Groundwater monitoring strategy	Draft strategy Feb 2012	
Individual licence holders	Letters sent out to 30 licence holders	December 2011 (last updated 15th October 2012)	
Lee Tunnel project – Mott MacDonald	Eastern Tunnel Alignment, Groundwater Monitoring,	25th October 2012	

Source	Data	Date received	Notes
	Construction Monitoring Round 10 Report and Annual Review 2011		
Lee Tunnel project – Mott MacDonald	Construction Groundwater Monitoring, Eastern Tunnel Alignment Round 22 and Abbey Mills Round 11, Summary Report and Annual Review to 20 July 2012	25th 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 Physical Properties of Minor Aquifers in England and Wales. Hydrogeology Group, Technical Report WD/00/04*, Environment Agency R&D Publication 68 (2000).

[3] 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

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

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

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

[7] Environment Agency. *The Roding, Beam and Ingrebourne Catchment Abstraction Management Strategy (CAMS). Final Strategy Document* (2006). Available at: http://publications.environment-agency.gov.uk/PDF/GETH1205BJYD-E-E.pdf

[8] 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

[9] British Geological Survey. Geology of London, 2004.

[10] Norwest Holst. *Report on Ground Investigation at Lee Tunnel, London, Volume 3* (2008).

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

[12] Directive of the European Parliament and of the Council on environmental quality standards in the field of water policy and amending Directive 2000/60/EC. Commission of the European Communities (2009). Available at: http://ec.europa.eu/environment/water/water-dangersub/pdf/com_2006_397_en.pdf?lang=_e

[13] Mott MacDonald, 2011, Eastern Tunnel Alignment Groundwater Monitoring Construction Monitoring Round 10 Report and Annual Review. London Tideway Tunnels, Lee Tunnel Project.
Mott MacDonald, 2012, Construction Groundwater Monitoring Eastern Tunnel Alignment Round 22 and Abbey Mills Round 11 Summary Report and Annual Review to 20 July 2012. London Tideway Tunnels, Lee Tunnel Project.

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

Thames Tideway Tunnel
Thames Water Utilities Limited

Application for Development Consent

Application Reference Number: WWO10001

Environmental Statement

Doc Ref: **6.2.26**

Volume 26: Beckton Sewage Treatment Works appendices

Appendix L: Water resources - surface water

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

Hard copy available in

Box **40** Folder **B**
January 2013

Thames Tideway Tunnel

Creating a cleaner, healthier River Thames

This page is intentionally blank

Thames Tideway Tunnel

Environmental Statement

Volume 26 Beckton Sewage Treatment Works 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: **6.2.26**

Volume 26: Beckton Sewage Treatment Works appendices

Appendix M: Water resources - flood risk

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

Hard copy available in

Box **40** Folder **B**
January 2013

Thames Tideway Tunnel

Creating a cleaner, healthier River Thames

This page is intentionally blank

Thames Tideway Tunnel

Environmental Statement

Volume 26 Beckton Sewage Treatment Works 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 Beckton Sewage Treatment Works is provided below.

Local policy

Strategic Flood Risk Assessment

M.1.4 The Beckton Sewage Treatment Works site lies within the London Borough (LB) of Newham. The LB of Newham produced a Level 1 and Level 2 Strategic Flood Risk Assessment (SFRA) (Capita Symonds, 2010)[2]. These outline the main flood sources to the borough.

M.1.5 The Newham SFRAs confirm that there is no actual risk of tidal flooding in the 0.5% AEP return period event. The risk of fluvial flooding is considered low to moderate in the 1% AEP event. As the River Roding approaches the River Thames the 1% AEP event generally remains within bank.

M.1.6 According to the SFRAs:

a. The site lies in the Environment Agency (EA) Flood Zone 3, the site is also partially within Flood Zone 1.

b. The surrounding area is bordered by man-made raised defences.

c. The site is defended against inundation from the River Thames during the 0.1% AEP; however there remains a residual risk of flooding from overtopping or a breach in the defences. The proximity of the site to the flood defences means there is potential for deep, fast flowing water in the event of a nearby breach.

d. There is a medium/high risk of groundwater flooding.

e. There are no recorded surface water flooding incidents within the vicinity in the last 10 years.

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 Council, in partnership with the Greater London Authority (GLA), Thames Water and the EA has produced a Surface Water Management

Plan (SWMP) (Capita Symonds and Scott Wilson, 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[i]

b. Flow paths through the site have been identified for the 1% AEP + 30% climate change rainfall event

c. There are 1-5 recorded sewer flooding incidents in the postcode area IG 110.

Regional policy

Thames Estuary 2100

M.1.10 Beckton Sewage Treatment Works site lies within the Royal Docks Policy Unit which has been assigned flood risk management policy 'P4' within the Thames Estuary 2100 (TE2100) Plan meaning that further action will be taken to sustain the current scale of flood risk into the future.

M.1.11 The TE2100 Plan identifies the local sources of flood risk (relative to the Beckton STW site) as including:

a. tidal flooding from the River Thames and River Roding/Barking Creek

b. surface water (heavy rainfall) and urban drainage sources.

M.1.12 Flood Defence systems currently managing flooding from these sources include:

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

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

c. flood forecasting and warning.

M.1.13 The TE2100 Plan seeks to promote, where possible, defence improvements that ensure views are maintained and impacts to river access/views are minimised, and to improve the appearance of the river frontage and provide environmental enhancement and amenity opportunities by using opportunities provided by future development to modify the layout of flood defences. Where defence raising in the future to manage the consequences of climate change is not possible,, secondary defences and floodplain management should be introduced. In the Plan there is also the vision to increase flood risk awareness within the area.

Thames Region Catchment Flood Management Plan

M.1.14 The Thames Region Catchment Flood Management Plan (CFMP) (EA, 2007)[4] covers fluvial and non-tidal sections of the River Thames, ie, the River Thames upstream of Teddington weir and tributaries of the River Thames (eg, River Roding).

[i] Are susceptible to surface water flooding.

M.1.15 The Thames Region CFMP advocates the reduction in flood risk through the design and layout of developments within the floodplain; redevelopment should be compatible with its location within the floodplain (ie, flood resilience measures should be incorporated). This should be achieved through re-creating more natural river systems and giving space for flood water, aiming for a balance between attenuation and conveyance.

London Regional Flood Risk Appraisal

M.1.16 For the reach between the Thames Barrier and Tilbury Docks (Regeneration Reach) the London Regional Flood Risk Appraisal (RFRA) (GLA, 2009)[5] encourages development to be designed in such a way as to take opportunities to reduce flood risk and include resilience.

M.1.17 Large areas of currently undeveloped land could be used as strategic flood storage areas, to store storm surge flood water.

M.1.18 There is particular concern surrounding confluences of tributaries into the River Thames and the interactions between tidal and fluvial flows in the future due to climate change.

M.1.19 The RFRA indicates that SuDS should be included within developments to reduce surface water discharge.

References

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

[2] Capita Symonds. *London Borough of Newham Strategic Flood Risk Assessment Final Report*. (May 2010).

[3] Capita Symonds and Scott Wilson. *London Borough of Newham Surface Water Management Plan Final Report*. (Aug 2011).

[4] Environment Agency. *Thames Region Catchment Flood Management Plan Summary Documen*t. (Jan 2007)

[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: **6.2.26**

Volume 26: Beckton Sewage Treatment Works appendices

Appendix N: Development schedule

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

Hard copy available in

Box **40** Folder **B**
January 2013

Thames Tideway Tunnel

Creating a cleaner, healthier River Thames

This page is intentionally blank

Thames Tideway Tunnel

Environmental Statement

Volume 26 Beckton Sewage Treatment Works 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 26 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 26 Table N.1 Development schedule for Beckton Sewage Treatment Works

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)	2023 (Year 1 of operation)		
Beckton STW – Sludge Digestion	On site	10/01713/LTGDC	Thames Water	Beckton sewage treatment works enhanced sewage sludge digestion facility including relocation of existing workshop building	A	100% complete & operational	100% complete & operational	100% complete & operational	Thames Water	Base case (all years)
The Lee Tunnel & Beckton STW Extension / Upgrade Works	On site	08/01159/LTGDC (and subsequent amendments and approval of details applications)	Thames Water	The Lee Tunnel and Beckton STW extension scheme incorporating the following elements at Abbey Mills PS: works to enable the interception of combined sewer overflows and transfer into the Lee Tunnel including shafts, transfer tunnels, connecting culverts, connection chambers and associated odour control units. Part of the Thames Tideway Quality Improvements Schemes aimed to improve water quality in the Tideway. £190m upgrade scheme that will enable the site to treat 60% more sewage than it does now and allow for a 10% increase in population until 2021.	A	100% complete & operational	100% complete & operational	100% complete & operational	Thames Water 2014 completion date for upgrade works.	Base case (all years)
Gallions Reach Shopping Park (unimplemented part)	100m south (closest part of dev)	P/97/0476 and 05/1030		The first phase of development (Phase I) provided for 27,762 sqm of retail floorspace including a 14,235 sqm anchor food store. Detailed approval for the Phase I development was secured in June 2000 (Ref: P/97/0476) and is now largely complete in the form of the Gallions Reach Shopping Park. Planning permission for 8,836 sqm of leisure floorspace within the Shopping Park remains extant, but not implemented. In the alternative, planning permission (Ref: 05/1030) for 7,484 sqm of retail floorspace within this part of the shopping park was granted on 25 June 2006 and remains extant.	B	100% complete & operational	100% complete & operational	100% complete & operational	Planning application documents. Can be assumed that development will have been implemented by Year 1 of construction.	Base case (all years)
Beckton Waterfront Masterplan (British Gas Land, Winsor	150m south (closest part of dev)	08/00017/LTGDC	National Grid Property Holdings Ltd	Comprehensive mixed use redevelopment including up to 1,500 dwellings (Class C3 apartments and townhouses and sui-generis live-work units); up to 25,000sq.m of employment	B	Area 1 (Linear Park), eastern half of Area 2 (Riverside Park), Area 3 (Mixed Use	Area 1 (Linear Park), eastern half of Area 2 (Riverside Park), Area 3 (Mixed Use Area	100% complete and operational		**2016:** No base case Cumulative = Areas

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)	2023 (Year 1 of operation)		
Terrace, Beckton)				floor space (Class B1 and B8); up to 9,500sq.m of hotel accommodation (Class C1); a nursing home of up to 4,000sq.m (Class C2); up to 1,200sq.m of retail and community service floor space (Class A1, A2, A3 and D1); and approximately 8.5 hectares of publicly accessible open space and strategic landscaping.		Area East), Area 4 (Mixed Use Area West), Area 8 (Tower) and Area 9 (Northern Riverside Residential Area) under construction.	East), Area 4 (Mixed Use Area West), Area 8 (Tower) and Area 9 (Northern Riverside Residential Area) complete and operational. Western half of Area 2 (Riverside Park), Area 5 (Townhouse Area), Area 6 (Sports Area & Amenity Parkland), Area 7 (Southern Employment Area) & Area 10 (Southern Riverside Residential Area) under construction.		Permission expires August 2014. Therefore assume work commences in 2013/14. Application documentation phasing information used as basis of assumptions.	1, part of 2, 3, 4, 8 & 9 **2017:** Base case: Areas 1, eastern half of 2, 3, 4, 8 & 9 Cumulative = Western half of Area 2 and Areas 5, 6, 7 & 10 **2023:** Base case = all Areas. No cumulative
Land at Jenkins Lane, north of A13	Approx 750m north	10/01159/LTGDC	London Thames Gateway Development Corporation	Development of no more than 15,000 sqm of floor space comprising Use Class B2/B8 accommodation with ancillary offices (Use Class B1) and a car showroom sui generis), with associated vehicle parking, access and works in a landscaped setting.	B	80% complete & operational 20% under construction	100% complete & operational	100% complete & operational	Environmental Statement indicates a three year construction period. Assuming construction begins in 2013, development will be complete by 2016. No details available on phasing across development so EIA topics to assume worst-case with regard to which parts of the development remain under construction in 2016.	**2016:** Base case = 80% Cumulative = 20% **2017 & 2023**: Base case No cumulative

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-060226