

## Wapping Wharf - UXO Desk Study & Risk Assessment

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## UXO DESK STUDY & RISK ASSESSMENT

### Wapping Wharf

#### EXECUTIVE SUMMARY

Zetica Ltd was commissioned by Arcadis to carry out an Unexploded Ordnance (UXO) Desk Study and Risk Assessment for 3No. adjoining areas totalling approximately 0.25 hectares (ha) centred on Cinnamon Street, Wapping, London Borough of Tower Hamlets ('the Site').

The aim of this report is to gain a fair and representative view of the UXO hazard for the Site and its immediate surrounding area in accordance with the Construction Industry Research and Information Association (CIRIA) C681 'Unexploded Ordnance (UXO), a Guide for the Construction Industry'.

No records have been found indicating that the Site was bombed and no other significant sources of UXO hazard have been identified on the Site.

Given this, it is considered that the Site has a low UXO hazard level, as shown in the following Figure, reproduced as Figure 6 in the main report.

**Figure** UXO hazard zone plan of the Site



Source: Client

Not to Scale

<b>Legend</b>	Very Low		Low		Moderate	
	High		Very High		Site boundary	

The main findings of the report are summarised below.

- No records of bombing or military activity on the Site during World War One (WWI) have been found.
- During World War Two (WWII) the main strategic targets in the vicinity of the Site included the London Docks, wharves and warehouses along the River Thames, major transport infrastructure and gas works.
- No records have been found indicating that the Site was bombed during WWII. The nearest recorded High Explosive (HE) bomb fell approximately 50m south of the Site. This caused some minor blast damage to buildings on the southern part of the Site.
- No post-WWII military activity is recorded on the Site.

The Table below, reproduced as Table 5 in the main report, provides a UXO risk assessment for potential work on the Site.

Further details on the methodology for the risk assessment are provided in Section 10.1 of the main report.

Table	UXO risk assessment for the Site							
Potential UXO Hazard	Anticipated Works	PE	PD	P = PE x PD	Likelihood	Severity	Risk Rating	UXO Risk
UXB	Shallow Excavations	1	1	1	1	5	5	Low
	Deep Excavations	1	1	1	1	5	5	Low
	Piling/Boreholes	1	1	1	1	4	4	Low
Other UXO	Shallow Excavations	1	1	1	1	4	4	Low
	Deep Excavations	1	1	1	1	4	4	Low
	Piling/Boreholes	1	1	1	1	3	3	Low
<b>PE (Probability of Encounter), PD (Probability of Detonation), P (Overall Probability)</b>								
<b>Shallow Excavations defined as &lt;1.0m below ground level (bgl).</b>								
<b>Risk Mitigation Recommendations</b>								
<p>To ensure that the UXO risk is reduced to As Low As Reasonably Practicable (ALARP) the following mitigation is advised:</p> <p>Where a low risk of UXO encounter is anticipated, industry good practice is to raise the awareness of those involved in excavations so that in the unlikely event that a suspect item is discovered, appropriate action is taken. This can be achieved through UXO awareness briefings to site staff.</p> <p>Clearance certification for borehole or pile locations is considered prudent only if a zero tolerance to risk is adopted. Zero tolerance is commonly adopted for sites that have safety critical infrastructure such as nuclear establishments and oil refineries.</p> <p>Table 6 in the main report gives recommended actions in relation to the potential UXO risk level and the anticipated Site activity.</p> <p>Further advice on the mitigation methods can be provided by Zetica on request.</p>								

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## UXO DESK STUDY & RISK ASSESSMENT

### Wapping Wharf

**Note:** To aid the reader of this report, Zetica has colour coded each paragraph. Paragraphs with black text on a white background are paragraphs that provide site-specific information or information specifically researched as part of this project.

Paragraphs in a dark green text with a green background are paragraphs containing background information or explanations which may appear as standard text in all similar reports.

## 1 INTRODUCTION

### 1.1 Project Outline

Zetica Ltd was commissioned by Arcadis to carry out an Unexploded Ordnance (UXO) Desk Study and Risk Assessment for 3No. adjoining areas totalling approximately 0.25 hectares (ha) centred on Cinnamon Street, Wapping, London Borough of Tower Hamlets ('the Site').

The aim of this report is to gain a fair and representative view of the UXO hazard for the Site and its immediate surrounding area in accordance with the Construction Industry Research and Information Association (CIRIA) C681 'Unexploded Ordnance (UXO), a Guide for the Construction Industry'. This hazard assessment includes:

This hazard assessment includes:

- Likelihood of ordnance being present.
- Type of ordnance (size, filling, fuze mechanisms).
- Quantity of ordnance.
- Potential for live ordnance (UXO).
- Probable location.
- Ordnance condition.

It should be noted that some military activity providing a source of UXO hazard may not be readily identifiable and therefore there cannot be any guarantee that all UXO hazards within the Site have been identified in this report.

### 1.2 Historical Information

With most locations, the potential presence of UXO as a result of enemy action, unauthorised disposal or unrecorded military activity can never be totally discounted.

Detailed records of military activity are rarely released into the public domain. Even when military information is made public there may be gaps in the records because files have been lost or destroyed.

Records for periods such as WWII are only as detailed and accurate as the resources and working conditions would allow at the time. Densely populated areas tend to have a greater number of records than rural areas. Such records may be inaccurate due to the confusion surrounding continuous air raids.



Press records can supplement local information, although this source of information must be treated with caution, as inaccuracies do exist, either inadvertently or intentionally in order to confuse enemy intelligence. Classified official records can sometimes be considered inaccurate for the same reason.

Recent research indicates that England alone had 17,434No. recorded defence sites, of which 12,464No. were classified as defensive anti-invasion sites. The precise locations of many of these sites are still to be identified, illustrating the scale of the problem when establishing potential risks from limited historical data.

### 1.3 Sources of Information

Zetica Ltd researched the military history of the Site and its surrounding area utilising a range of information sources. The main sources of information are detailed in the following sections and referenced at the end of this report.

#### 1.3.1 Zetica Ltd Defence Related Site Records

Zetica Ltd's in-house records were consulted, including reference books and archived materials from past work in the region. Relevant documents have been cited within the bibliography of this report.

#### 1.3.2 Zetica Ltd Bombing Density Records and Maps

Reference has been made to the Zetica Ltd bomb risk maps located on Zetica Ltd's website (<http://zeticauxo.com/downloads-and-resources/risk-maps/>).

#### 1.3.3 Ministry of Defence and Government Records

Various government departments and units within the Ministry of Defence (MoD) were approached for information of past and present military activity in the area. These included the Home Office records of abandoned bombs.

#### 1.3.4 Other Historical Records, Maps and Drawings

Numerous reference documents including historical maps, aerial photographs and drawings have been consulted from sources such as the National Archives, the US National Archives and Records Administration (NARA), the Imperial War Museum (IWM), Historic England and the Defence of Britain Project.

The British Geological Survey (BGS) was consulted for borehole information.

#### 1.3.5 Local Authority Records

Information has been obtained from Tower Hamlets London Borough Council.

#### 1.3.6 Local Record Offices and Libraries

The London Metropolitan Archives and Tower Hamlets Local History Library and Archives were consulted for information.

### 1.3.7 Local Historical and Other Groups

Local history groups and archaeological bodies were consulted, including the Greater London Historic Environment Record (HER).

### 1.4 Data Confidence Level

In general, there is a high level of confidence in the researched information sources used for this report. Any exceptions to this are specifically detailed in the text of this report.

## 2 THE SITE

### 2.1 Site Location

The Site is centred on Ordnance Survey National Grid Reference (OSNGR) TQ 350802. It is located on Cinnamon Street in Wapping, approximately 4.9km east of Central London.

The Site comprises disused warehouses and open hardstanding. A London Underground ventilation shaft is located on the southern part of the Site. The 3No. parts of the Site are separated by Cinnamon Street, Clegg Street and Clave Street.

The Site is bounded to the east, south and west by commercial and residential buildings, and to the north by vacant land.

Figure 1 is a Site location map and Plate 1 is a recent aerial photograph of the Site.

**Figure 1** Site location map



Source: City of London Corporation

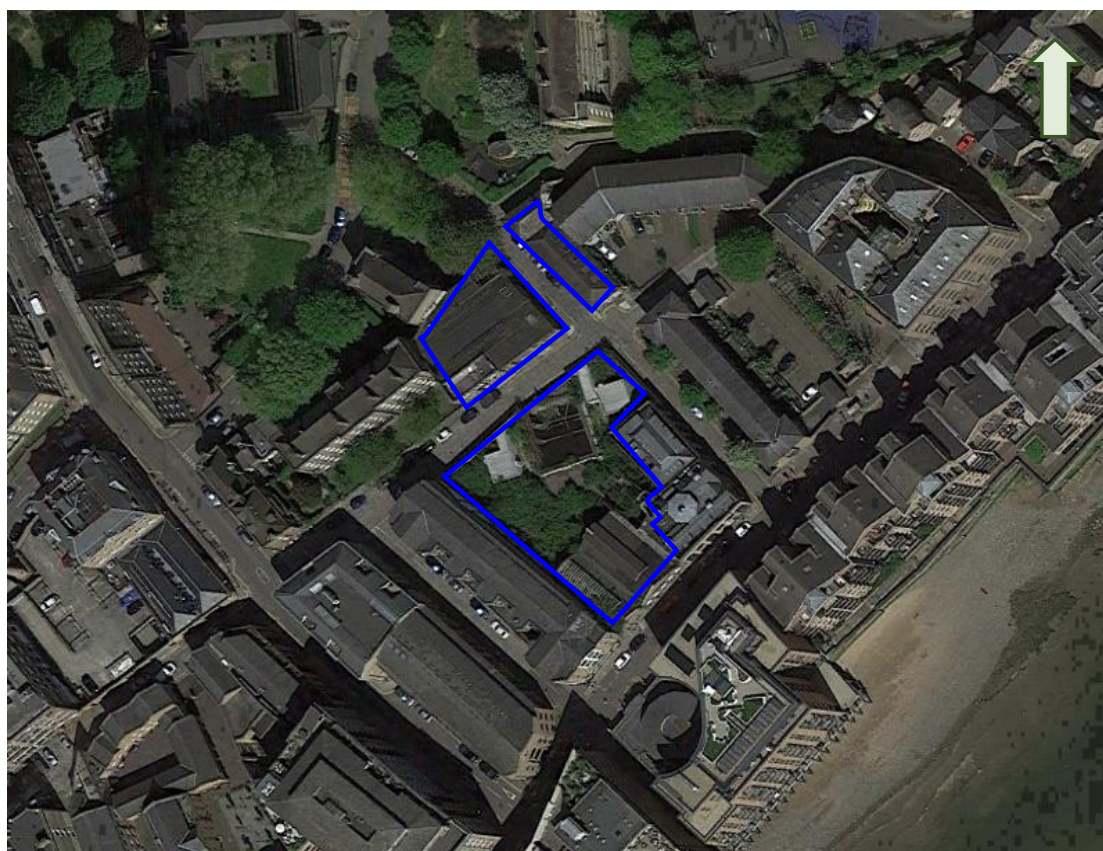
Not to Scale

#### Legend

Site boundary



**Plate 1** Recent aerial photograph of the Site



Source: Google Earth

Not to Scale

**Legend**

Site boundary



## 2.2 Proposed Works

It is understood that planned works on the Site include demolition of the existing buildings, intrusive ground investigations, excavations and possibly piling.

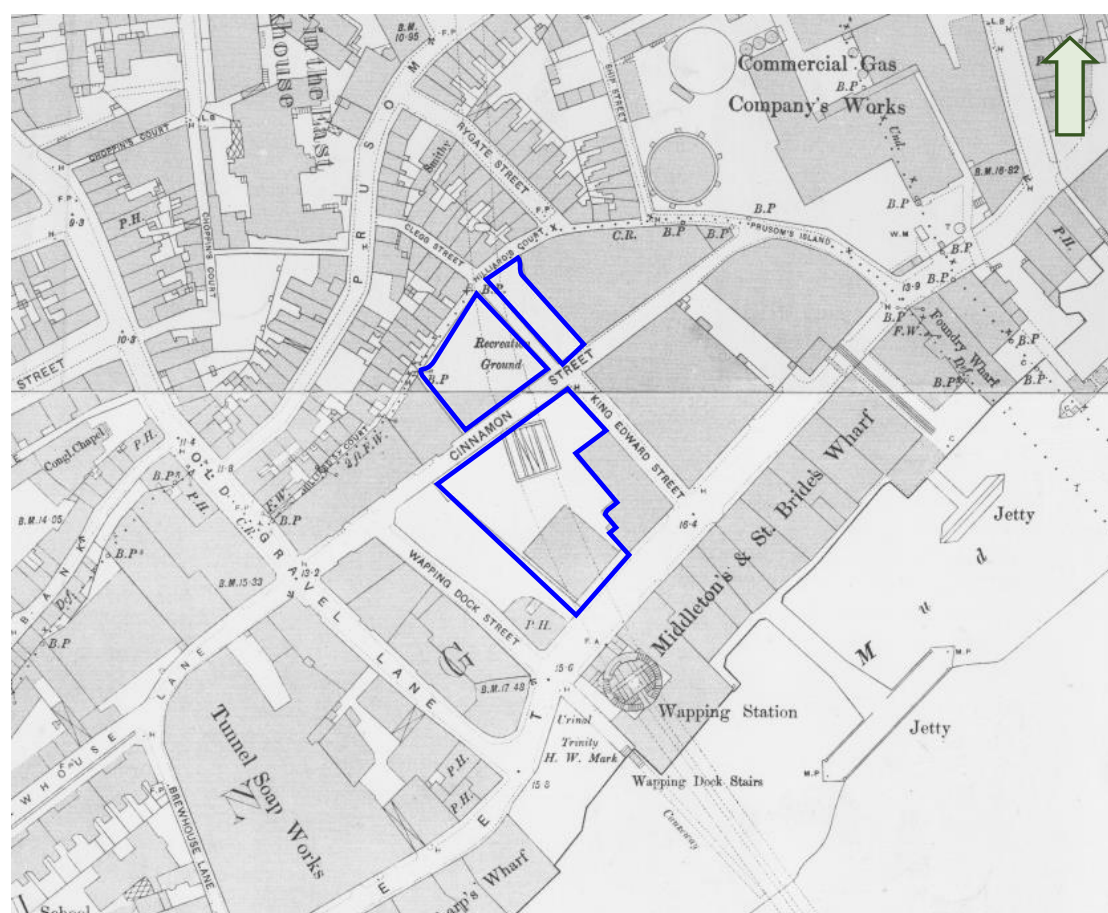
## 2.3 Site History

The historical map of 1896 (Figure 2) shows that at the end of the 19<sup>th</sup> century the southern part of the Site was occupied by a warehouse and open ground. A ventilation shaft for the London Underground was also located on the southern part of the Site, with the Underground line running beneath the Site.

The northern part of the Site comprised a recreation ground and open land.



**Figure 2** Historical map, 1896



Source: © Crown Copyright 2018. Reproduced by permission of Ordnance Survey

Not to Scale

**Legend**

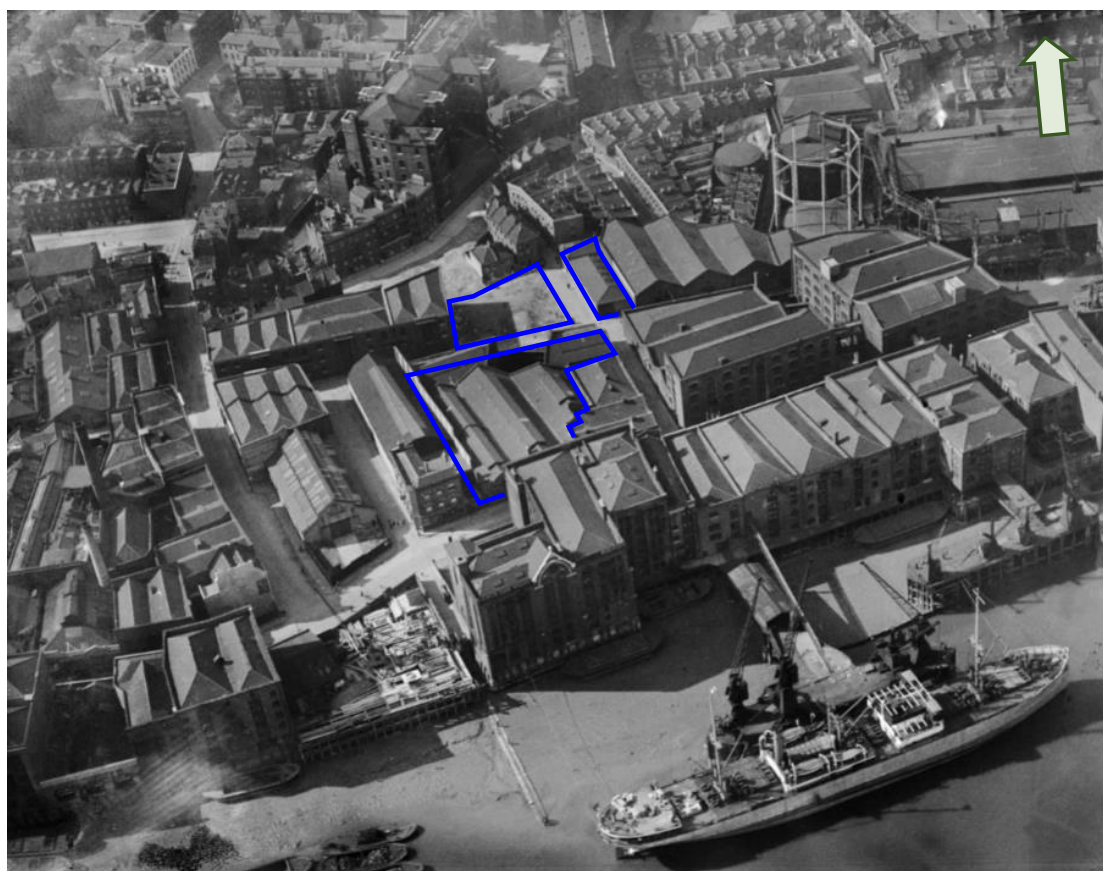
Site boundary ———

Minor development occurred on the Site in the early 20<sup>th</sup> century. Warehouses were established on the southern and north-eastern parts of the Site, as shown in Plate 2, an aerial photograph dating from April 1922.

The north-western part of the Site remained open ground.

Plate 2

Aerial photograph, April 1922



Source: Historic England

Not to Scale

**Legend**

Approximate Site boundary

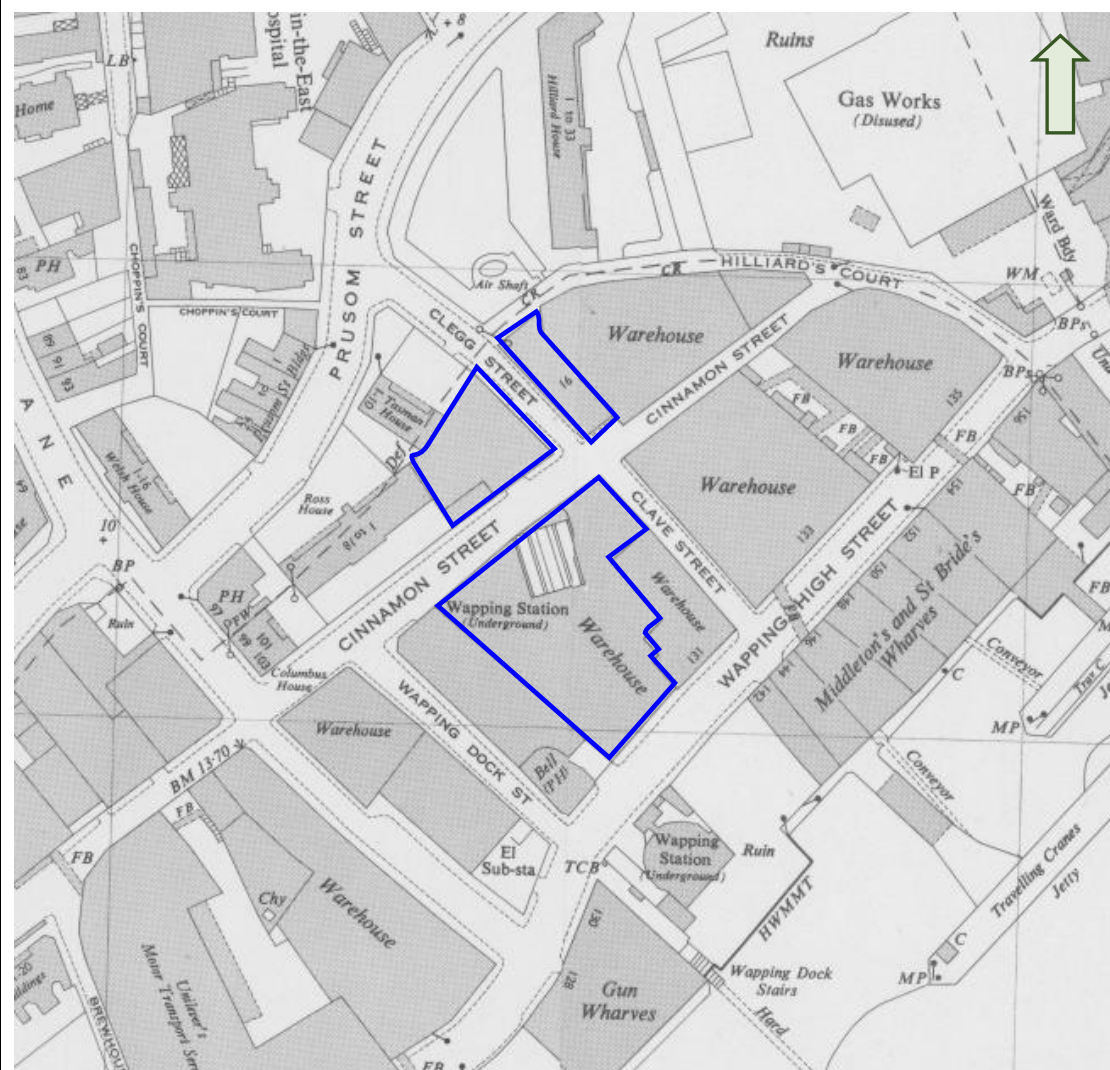


By the late 1930s, further warehouse buildings had been constructed across the remainder of the Site. During WWII, the Wapping area was heavily bombed and buildings in the vicinity of the Site were either severely damaged or demolished (see Section 3.3).

The historical map of 1949 (Figure 3) shows that the majority of the Site remained comprised of warehouses, with the ventilation shaft still present on the southern part of the Site.

Several ruins and areas cleared of buildings in the vicinity of the Site are indicative of WWII bomb damage.

**Figure 3** Historical map, 1949



Source: © Crown Copyright 2018. Reproduced by permission of Ordnance Survey

Not to Scale

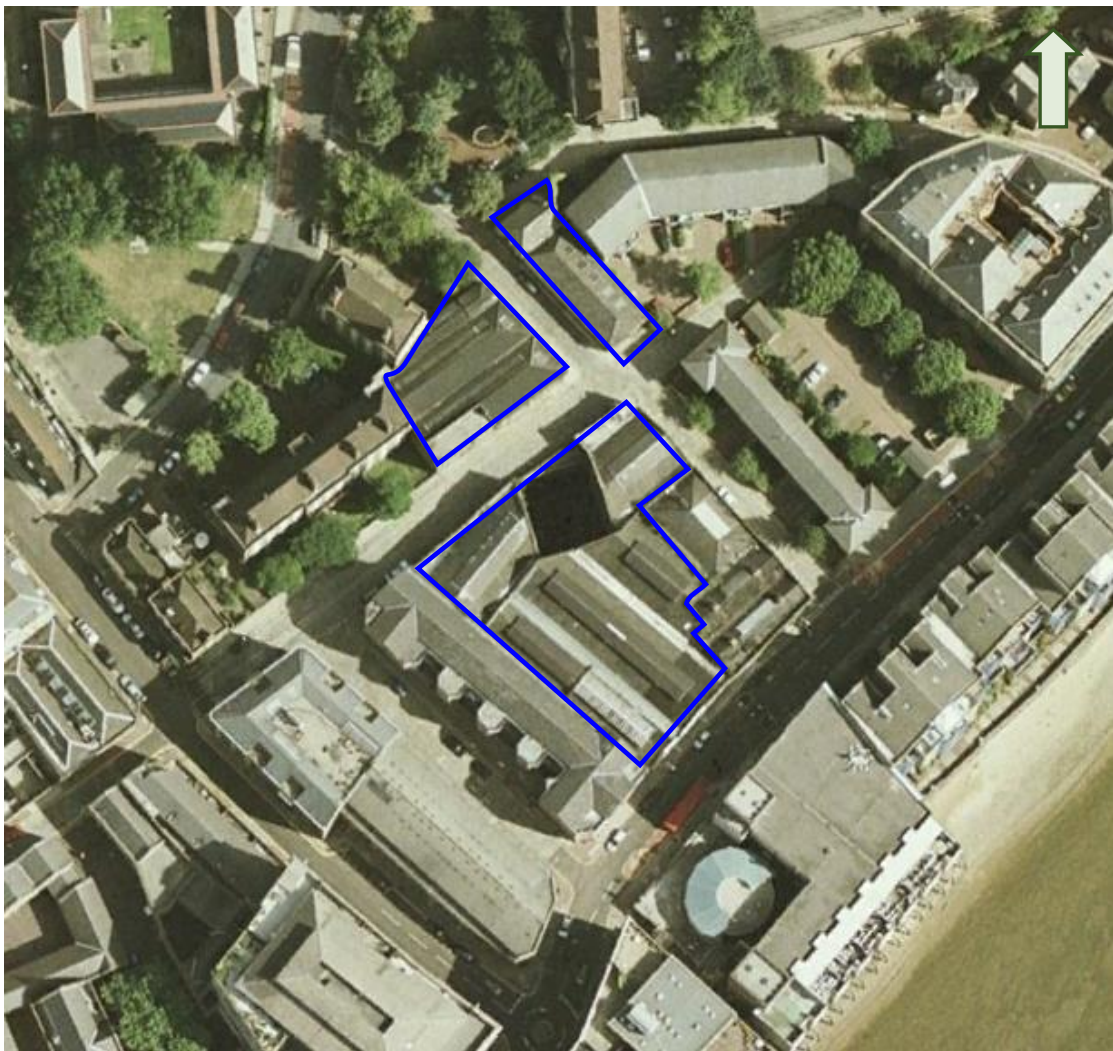
**Legend**

Site boundary ———

During the second half of the 20<sup>th</sup> century, there were no significant changes on the Site, which remained comprised of pre-WWII warehouses and a ventilation shaft for the London Underground.

This is shown in Plate 3, an aerial photograph dating from 1999. Residential units, constructed in the 1980s, were located adjacent to the eastern boundary of the Site.



<b>Plate 3</b>	Aerial photograph, 1999
	
<p>Source: Google Earth <span style="float: right;">Not to Scale</span></p>	
<b>Legend</b>	Site boundary <span style="color: blue;">—</span>
<p>In 2008, several of the warehouse buildings on the southern part of the Site were demolished, leaving only the Victoria-era warehouse standing. 2No. structures were established on either side of the London Underground ventilation shaft.</p> <p>Since then, no further development has occurred on the Site (see Plate 1).</p>	
<h2>2.4 Pre-WWI Military Activity</h2>	
<p>No records of any significant pre-WWI military activity on or in close proximity to the Site have been found.</p>	



## 2.5 WWI Military Activity

No records of any significant WWI military activity on or in close proximity to the Site have been found.

During WWI an estimated 9,000No. German bombs were dropped over Britain. It was the first time that strategic aerial bombing had been used.

No records have been found indicating that the Site was bombed during WWI. The nearest recorded incident is described below.

### 31<sup>st</sup> May 1915

1No. High Explosive (HE) bomb and 2No. Incendiary Bombs (IBs) fell on Pearl Street, within approximately 0.1km north of the Site, during the first Zeppelin raid over London.

In response to the air raids, Anti-Aircraft (AA) guns were established. These were potential sources of Unexploded AA (UXAA) shells which could land up to 13km from the firing point, although more typically fell within 10km during WWI.

Records indicate that the Site was within the range of at least 25No. static AA gun batteries during WWI. The nearest was located at the Tower of London (TQ 336805), approximately 1.3km west-northwest of the Site. This was armed with 2No. 3-inch (") guns.

WWI military activity is not considered to provide a source of UXO hazard to the Site.

## 2.6 WWII Military Activity

There were several major strategic targets in the vicinity of the Site, and the surrounding area recorded numerous air raids. Details for air raid incidents in the vicinity of the Site are provided in Section 3 and Appendix 1.

Numerous defensive and offensive military structures were built in the vicinity of the Site. These included lines of defence (Stop Lines), pillboxes, bombing decoys and AA guns. Further details are given in Section 4.

Other military establishments in the vicinity of the Site are described in Sections 5 to 7.

## 2.7 Post-WWII Military Activity

No records of any significant post-WWII military activity on or in close proximity to the Site have been found.

### 3 WWII BOMBING

Bombing raids began in the summer of 1940 and continued until the end of WWII. Bombing densities generally increased towards major cities or strategic targets such as docks, industrial premises, power stations and airfields.

The German bombing campaign saw the extensive use of both High Explosive (HE) bombs and Incendiary Bombs (IBs). The most common HE bombs were the 50kg and 250kg bombs, although 500kg were also used to a lesser extent. More rarely 1,000kg, 1,400kg and 1,800kg bombs were dropped.

The HE bombs tended to contain about half of their weight in explosives and were fitted with one or sometimes two fuzes. Not all HE bombs were intended to explode on impact. Some contained timing mechanisms where detonation could occur more than 70 hours after impact.

Incendiary devices ranged from small 1kg thermite filled, magnesium bodied bombs to a 250kg 'Oil Bomb' (OB) and a 500kg 'C300' IB. In some cases the IBs were fitted with a bursting charge. This exploded after the bomb had been alight for a few minutes causing burning debris to be scattered over a greater area. The C300 bombs were similar in appearance to 500kg HE bombs, although their design was sufficiently different to warrant a specially trained unit of the Royal Engineers to deal with their disposal.

Anti-Personnel (AP) bombs and Parachute Mines (PMs) were also deployed. 2No. types of anti-personnel bombs were in common use, the 2kg and the 12kg bomb. The 2kg bomb could inflict injury across an area up to 150m away from the impact, within 25m of this, death or fatal injury could occur.

PMs (which were up to 4m in length) could be detonated either magnetically or by noise/vibration. Anti-shipping parachute mines were commonly dropped over navigable rivers, dockland areas and coastlines. The Royal Navy was responsible for ensuring that the bombs were made safe. Removal and disposal was still the responsibility of the Bomb Disposal Unit of the Royal Engineers.

WWII bomb targeting was inaccurate, especially in the first year of the war. A typical bomb load of 50kg HE bombs mixed with IBs which was aimed at a specific location might not just miss the intended target but fall some considerable distance away.

It is understood that the local Civil Defence authorities in urban areas had a comprehensive system for reporting bomb incidents and dealing with any UXO. In more rural areas, fewer bombing raids occurred. It is known that ARP records under-represent the number and frequency of bombs falling in rural and coastal areas.

Bombs were either released over targets or as part of 'tip and run' raids where bomber crews would drop their bombs to avoid Anti-Aircraft fire or Allied fighter aircraft on the route to and from other strategic targets. Bombs dropped as a result of poor targeting or 'tip and run' raids on rural, river, marsh or coastal areas were often unrecorded or entered as 'fell in open country', 'fell in the sea' or 'fell in the river' and left little evidence of the fall.

#### 3.1 Bombing in London

From prior to the declaration of war in 1939, Britain was subject to reconnaissance flights by the Luftwaffe which was building up a photographic record of potential targets. London was a principal target of Luftwaffe bombing during the Blitz.

The first air raid of the Blitz on London took place on 7<sup>th</sup> September 1940 when a large German force bombed the docks and surrounding areas.

The aim was to paralyse the commercial life of the capital by bombing the docks, warehouses, wharves, railway lines, factories and power stations of the East End. The Port of London was the most heavily bombed civilian target in the UK.

From mid-September until the end of that year, London was raided on all but 3 No. nights. The raids continued through the early months of 1941 becoming less frequent, although often more intense. Heavier bombs, including PMs and OBs, were now used and major incendiary raids on the 29<sup>th</sup> December 1940 and the 10<sup>th</sup> May 1941 caused widespread fire damage across the city.

From July 1941 the bombing campaign against London entered a period of relative inactivity. Raids still took place but tended to be relatively minor in severity. Manned bomber raids returned to London in the first four months of 1944 and, after a brief respite, were followed by the start of the V1 (Pilotless Aircraft) offensive against the capital in June 1944.

These weapons arrived at any time of day and caused massive blast damage (although little fire damage). The V1 offensive on London was all but over by September 1944, although some V1s continued to fall on the capital until March 1945.

In September 1944 the V2 (Long Range Rocket) offensive on London began. Falling from a height of some 50 miles (80km) above the city, these ballistic missiles caused larger craters and greater damage to underground utilities than the V1s, but their surface blast effect was generally less.

The area surrounding Wapping and the London Docks was bombed frequently between September 1940 and July 1941. Most of the air raids in the area were of a high intensity, including the use of 'mixed loads' of HE bombs and IBs.

## 3.2 Strategic Targets

The presence of strategic targets significantly increased the likelihood of bombing within the local area. Airfields, docks, industrial facilities, transport infrastructure and anti-invasion defences were all targeted by Luftwaffe bombers. The inherent bombing inaccuracies at the time meant that areas surrounding the targets were often subjected to bombing.

The main strategic targets in the vicinity of the Site are described below.

### 3.2.1 London Docks and River Thames

The wharves and warehouses along the River Thames were strategically important targets for the Luftwaffe, and the Port of London was the most heavily bombed civilian target in the UK.

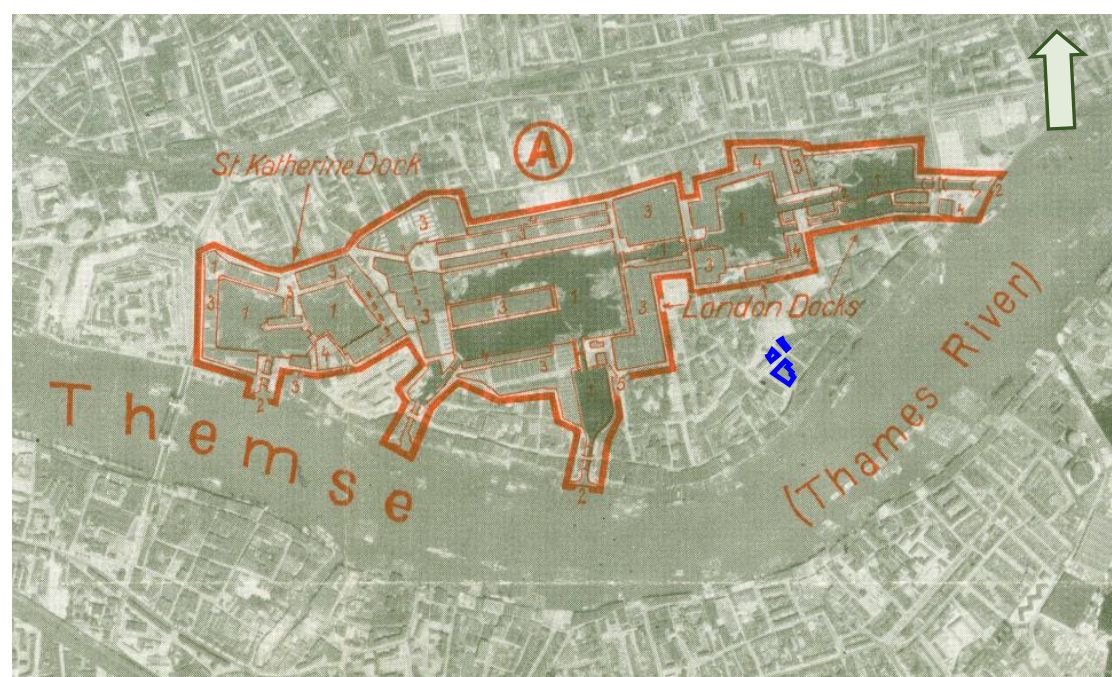
Commercial wharves and dockyards lined the banks of the River Thames. The nearest were Middleton's and St Bride's Wharves, located approximately 30m east of the Site.

London Docks, located between approximately 0.4km west and 0.6km northeast of the Site, comprised of Wapping Basin, Hermitage Basin, Western Dock, Eastern Dock and the Shadwell Basins. They were connected by locks and sluice gates which controlled access to and from the River Thames.

St Katharine's Dock was located approximately 0.8km west of the Site. Numerous warehouses were situated in close proximity to these wharves and docks, covering an extensive area which encompassed the Site.

Plate 4 is a Luftwaffe target photograph of St Katharine's Dock and the London Docks, dated the 4<sup>th</sup> June 1939. The identified targets are listed in Table 1.

**Plate 4** Luftwaffe target photograph of St Katharine's and London Docks, 4<sup>th</sup> June 1939



Source: NARA

Not to Scale

<b>Legend</b>	Site boundary —
---------------	-----------------

**Table 1** Luftwaffe targets in the vicinity of the Site

Target No.	Target
1	Harbour basin
2	Sluice gates
3	Warehouses and large military storage depots
4	Warehouses and loading berths
5	Administration buildings

Surrey Commercial Docks were located approximately 0.8km east of the Site.

The West India Docks were located approximately 2.1km east of the Site.

The Millwall Docks were located approximately 2.5km east-southeast of the Site.

### 3.2.2 Public Utilities

Public utilities were frequently targeted to disrupt power supplies to local industries.

The South Metropolitan Gas Works was located approximately 0.5km southeast of the Site.

### 3.2.3 Transport Infrastructure

Transport infrastructure was frequently targeted by the Luftwaffe to disrupt logistical supply lines.

The London & Blackwall line ran approximately 0.7km north of the Site.

Shadwell Station was located approximately 0.7km north of the Site.

Leman Street Station was located approximately 1km northwest of the Site.

### 3.3 Bombing Density and Incidents

Table 2 gives details of the overall bombing statistics recorded for the local authority districts of the Site and surrounding districts. These were categorised as Rural Districts (RD), Urban Districts (UD), Municipal or Metropolitan Boroughs (MB) and County Boroughs (CB).

WWII bomb density levels are defined below:

<5 bombs per 405ha is a Very Low regional bombing density.

5-15 bombs per 405ha is a Low regional bombing density.

15-50 bombs per 405ha is a Moderate regional bombing density.

50-250 bombs per 405ha is a High regional bombing density.

>250 per 405ha is a Very High regional bombing density.

The Site was located in Stepney Metropolitan Borough (MB).

**Table 2** Bombing statistics

Area	Bombs Recorded				
	High Explosive	Parachute Mines	Other	Total	Bombs per 405ha (1,000 acres)
<b>Stepney MB</b>	<b>1,212</b>	<b>9</b>	<b>15</b>	<b>1,236</b>	<b>699.9</b>
City of London MB	393	9	13	415	613.0
Bermondsey MB	809	11	29	849	564.9
Bethnal Green MB	281	9	8	298	392.1
Poplar MB	755	20	11	786	337.2

Note that Table 2 excludes the figures for V1s (Pilotless Aircraft, also known as 'Doodlebugs'), V2s (Long Range Rockets) and IBs. Discrepancies between this list and other records, such as bomb clearance records, demonstrate that this data is likely to under-represent actual bombing.

The nearest recorded incidents to the Site are described in the Section below. Appendix 1 provides details of further air raid incidents in the vicinity of the Site.

#### 8<sup>th</sup> September 1940

1No. HE bomb and IBs (number unspecified) fell on Wapping High Street, within approximately 0.2km of the Site.

#### 11<sup>th</sup> September 1940

1No. HE bomb fell on Gun Wharf, approximately 50m south of the Site.

#### 7<sup>th</sup> October 1940

1No. HE bomb fell on factory buildings in Brewhouse Lane, within approximately 0.1km west-southwest of the Site.

**10<sup>th</sup> October 1940**

1No. HE bomb fell on Brewhouse Lane School, approximately 0.2km west-southwest of the Site.

**11<sup>th</sup> October 1940**

1No. HE bomb fell on a garage in Brewhouse Lane, approximately 0.1km west-southwest of the Site.

1No. HE bomb and IBs (number unspecified) fell on Brewhouse Lane, within approximately 0.2km west of the Site.

**8<sup>th</sup> December 1940**

IBs (number unspecified) fell on Wapping Dock Street, adjacent to the western boundary of the Site.

**9<sup>th</sup> December 1940**

IBs (number unspecified) fell on a warehouse at the end of Wapping Dock Street, adjacent to the southern boundary of the Site.

IBs (number unspecified) fell on a soap works on Brewhouse Lane, approximately 0.1km southwest of the Site.

1No. HE bomb fell on the Thames Police Station, approximately 0.2km southwest of the Site. This was recorded as UXB and removed.

1No. HE bomb and IBs (number unspecified) fell on Brewhouse Lane, within approximately 0.2km west of the Site.

**29<sup>th</sup> December 1940**

IBs (number unspecified) fell on Middleton's and St Bride's Wharf, adjacent to the southern boundary of the Site.

1No. HE bomb and IBs (number unspecified) fell on Cinnamon Street, within approximately 0.1km of the Site.

IBs (number unspecified) fell on a soap works on Brewhouse Lane, approximately 0.1km southwest of the Site.

**8<sup>th</sup> March 1941**

1No. 50kg HE bomb fell on the junction of Green Bank and Wapping Lane, approximately 70m west of the Site.

1No. 50kg HE bomb fell on an office building opposite St John's Wharf, approximately 0.2km west-southwest of the Site.

1No. 50kg HE bomb fell on a boatyard next to Wapping Police Station, approximately 0.2km west-southwest of the Site.

**19<sup>th</sup> March 1941**

1No. 250kg HE bomb fell on Metropolitan Wharf, approximately 0.2km east-northeast of the Site.

**16<sup>th</sup> April 1941**

1No. HE bomb and IBs (number unspecified) fell on Wapping Wall, within approximately 0.2km northeast of the Site.



### 10<sup>th</sup> May 1941

1No. 500kg HE bomb fell on the Old Tower Buildings on Brewhouse Lane, approximately 0.1km west of the Site.

1No. 500kg HE bomb fell on a public shelter on Watts Street, approximately 0.2km west-northwest of the Site.

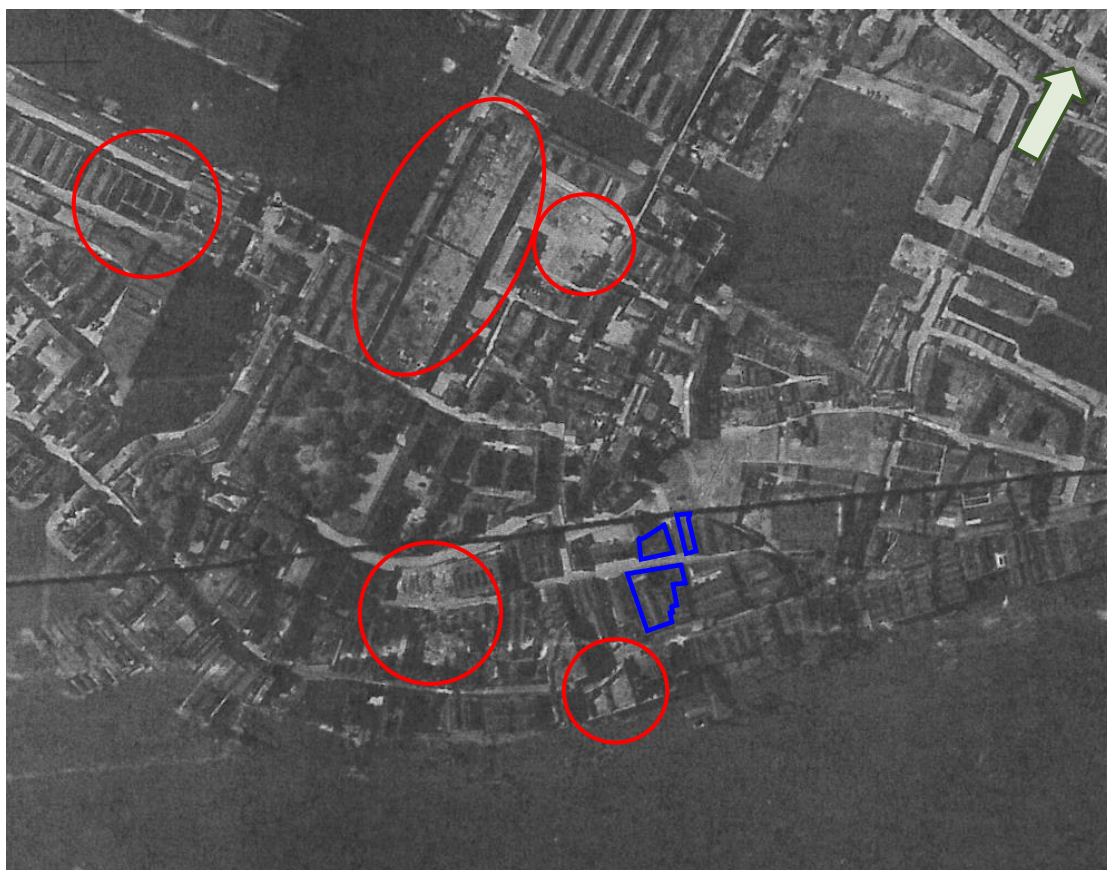
1No. 500kg HE bomb fell on Chancellor House, Brewhouse Lane, approximately 0.2km west of the Site.

1No. 500kg HE bomb fell on the junction of Old Gravel Lane and Raine Street, approximately 0.2km north-northwest of the Site.

Plate 5 is an aerial photograph dated the 18<sup>th</sup> June 1941. No bomb damage has been identified on the Site.

Possible bomb damage, characterised by demolished and ruined buildings, has been identified in the vicinity of the Site.

**Plate 5** Aerial photograph, 18<sup>th</sup> June 1941



Source: Historic England

Not to Scale

#### Legend

Site boundary —

Possible bomb damage ○

### 29<sup>th</sup> January 1944

IBs (number unspecified) fell on the former Wapping Gas Works, approximately 40m northeast of the Site.

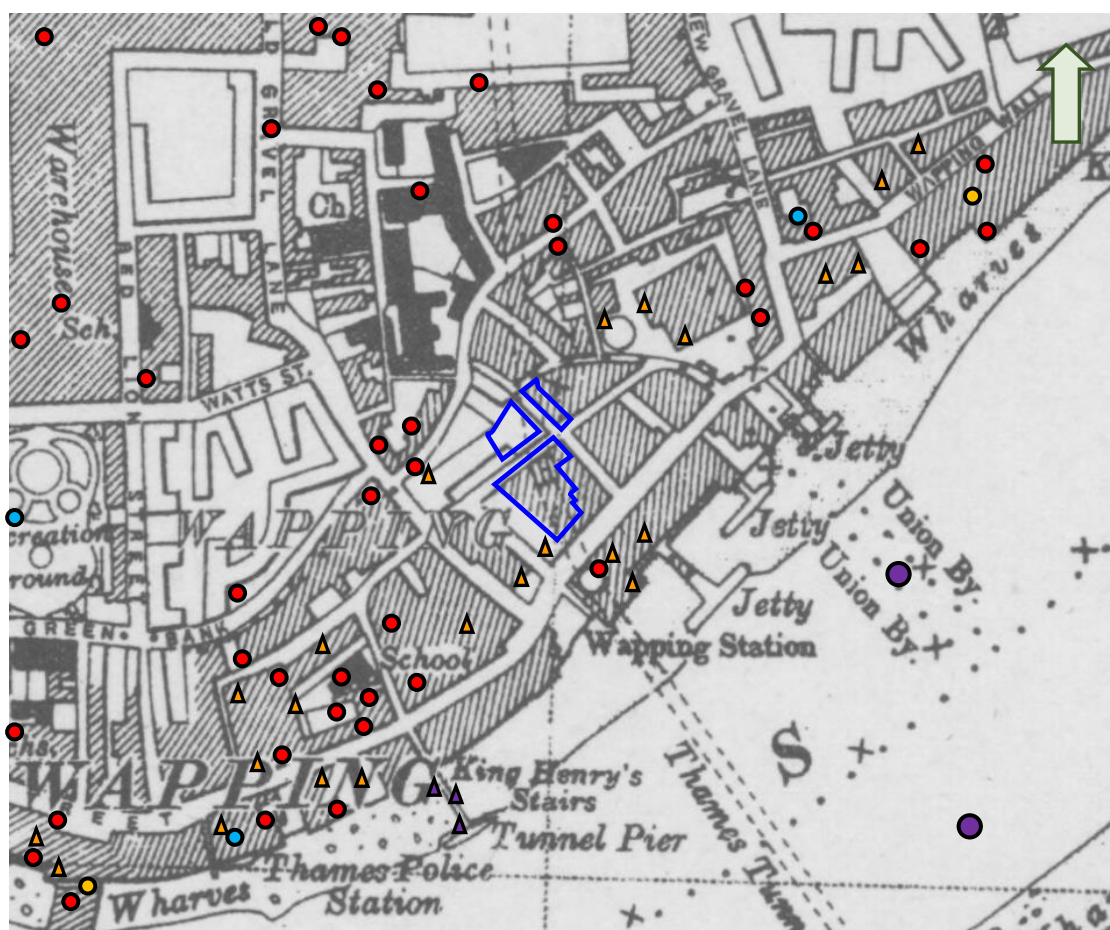
3No. Phosphorous IBs (PhIB) fell on Wapping Pier, approximately 0.2km southwest of the Site.

It should be noted that during WWII, many UXB were mapped and subsequently removed as and when conditions and demands on Bomb Disposal teams allowed. Their removal was not always accurately recorded and sometimes records were later destroyed. In practice, most UXB were probably removed and only a much smaller number were actually registered as officially abandoned bombs.

Figure 4 is a map showing the approximate locations of bomb impacts in the immediate vicinity of the Site. IBs shown are indicative of larger numbers of similar devices that fell within the given area. The map has been compiled from a number of different sources, including air raid incident reports, bomb census maps and historical aerial photographs.

Note that air raid incident reports did not always record precise locations, often only indicating on which street or area a bomb fell.

**Figure 4** Compiled bomb impact map for the vicinity of the Site



Source: © Crown Copyright 2018. Reproduced by permission of Ordnance Survey

Not to Scale

Legend	Site boundary	—	HE bomb	●	UXB	●	OB	●	IBs	▲	PhIB	▲
	V1	●										



Figure 5 is an extract from the London Bomb Damage Map compiled at the end of WWII, on which the colouring denotes the severity of damage to buildings. Black indicates total destruction, purple indicates damage beyond repair, red indicates serious damage (doubtful if repairable), pink indicates serious damage (repairable at cost), orange indicates moderate blast damage and yellow indicates minor blast damage.

The map shows that no significant bomb damage was recorded on the Site. Buildings on the southern part of the Site sustained minor blast damage, likely the result of nearby HE bomb impacts.

**Figure 5** Extract from the London Bomb Damage Map



Source: London Topographical Society

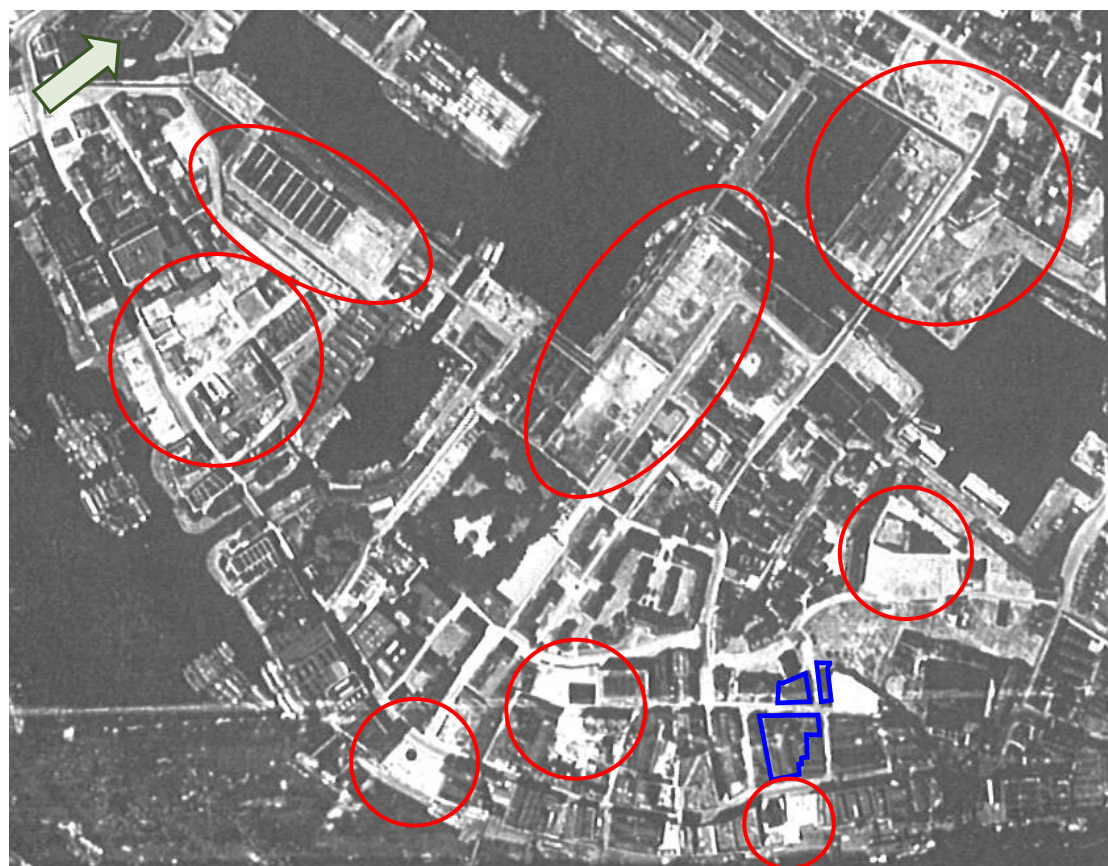
Not to Scale

**Legend** Site boundary —

Plate 6 is an aerial photograph dated the 7<sup>th</sup> August 1944. No bomb damage has been identified on the Site.

Possible bomb damage has been identified in the vicinity of the Site, largely corroborating the bomb damage map above.

**Plate 6** Aerial photograph, 7<sup>th</sup> August 1944



Source: Historic England

Not to Scale

**Legend**

Site boundary



Possible bomb damage



Plate 7 is an aerial photograph dated the 18<sup>th</sup> February 1949. No residual bomb damage has been identified on the Site, which appears to remain occupied by the same warehouses that were present pre-WWII.

Possible residual bomb damage has been identified to the southeast and southwest of the Site.

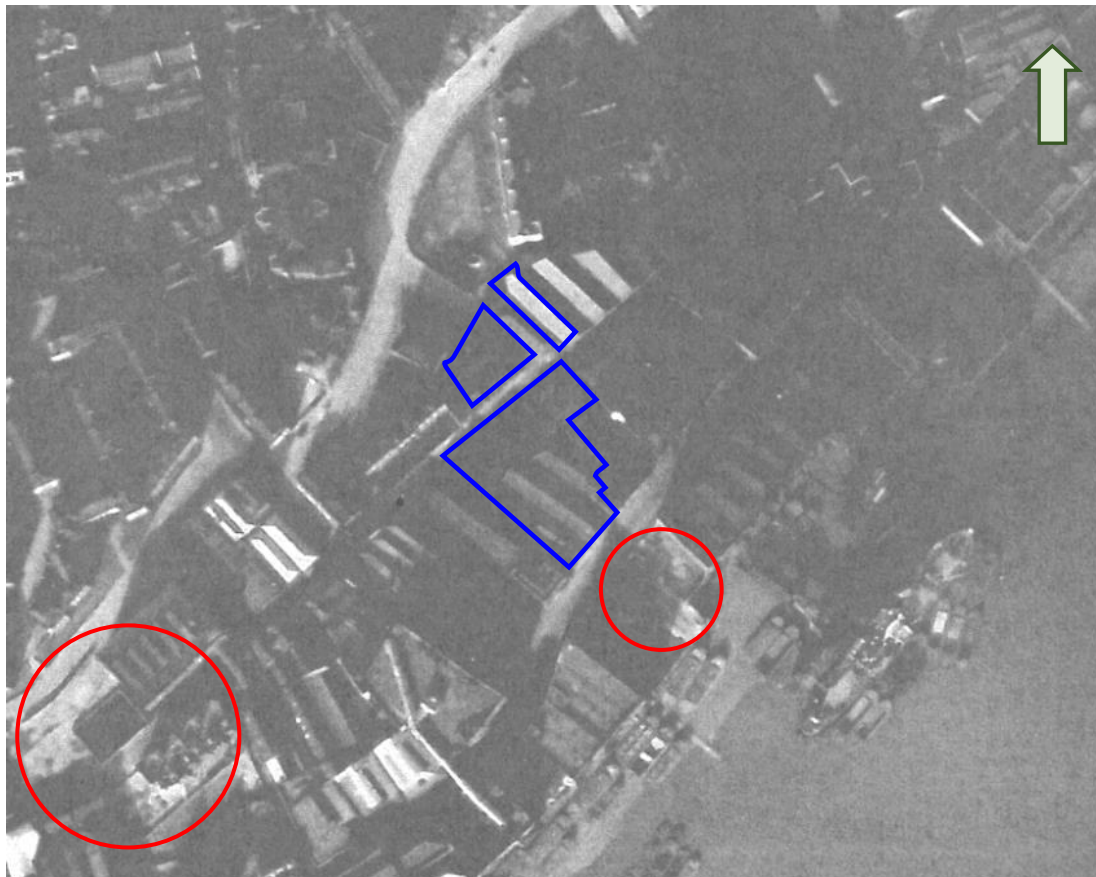
Plate 7	Aerial photograph, 18 <sup>th</sup> February 1949	
		
Source: Historic England		Not to Scale
Legend	Site boundary —	Possible bomb damage ○
<b>Potential UXO Hazard</b>		
<p>No records have been found indicating that the Site was bombed and no significant bomb damage has been identified on the Site on historical aerial photographs.</p> <p>The London Bomb Damage Map indicates that buildings on the Site sustained only minor blast damage, which is considered unlikely to have masked the impact of a UXB.</p> <p>WWII bombing is not considered to provide a source of UXO hazard to the Site.</p>		
<b>3.4 Geology and Bomb Penetration Depths</b>		
<p>It is important to consider the geological materials present on the Site at the time that a bomb was dropped in order to establish its maximum penetration depth. British Geological Survey (BGS) 1:50,000 Sheet 270, South London (Solid and Drift) and BGS borehole records were consulted.</p> <p>During WWII the geology of the Site comprised Made Ground over alluvium deposits, overlying the Lambeth Group.</p>		



Table 3 provides an estimate of average maximum bomb penetration depths for the Site assuming WWII ground conditions of approximately 3.5m of Made Ground (modelled as gravel) over 1m of soft clay and 4m of gravel, overlying more than 20m of weak rock.

Table 3	Estimated average maximum bomb penetration depths	
Estimated average bomb penetration depths for anticipated geology		
Bomb Weight	50kg	2.5m
	500kg	7.5m

The estimated bomb penetration depths given in Table 3 are from the WWII ground level and are based on the following assumptions:

- a) High level release of the bomb resulting in an impact velocity of 260m/s (>5,000m altitude).
- b) A strike angle of 10 to 15 degrees to the vertical.
- c) That the bomb is stable, both in flight and on penetration.
- d) That no retarding units are fitted to the bomb.
- e) That the soil type is homogenous.

A high altitude release of a bomb will result in ground entry at between 10° and 15° to the vertical with the bomb travelling on this trajectory until momentum is nearly lost. The bomb will then turn abruptly to the horizontal before coming to rest. The distance between the centre of the entry hole and the centre of the bomb at rest is known as the 'offset'. A marked lateral movement from the original line of entry is common.

Low-level attacks may have an impact angle of 45° or more, which will frequently lead to a much greater amount of offset movement during soil penetration.

In low level attacks over deep water bodies, the offset distances from the point of entry at the water surface may be considerably enhanced due to hydrodynamic effects before the bomb penetrates or settles on the sea bed. Shallow water has little effect on bomb penetration depths during high level attacks.

## 4 WWII DEFENCES

### 4.1 Bombing Decoys

In order to draw enemy aircraft away from towns and other strategically important targets, a series of decoys were developed between 1940 and 1941.

They were estimated to have drawn at least 5% of the total weight of bombs away from their intended targets. Approximately 792No. static decoy sites were built at 593No. locations in England. In addition, numerous temporary and mobile decoys were deployed.

Several different types of decoy were devised:

- Night time dummy airfields (Q sites).
- Daytime dummy airfields (K sites).
- Diversionary fires to simulate successful bombing raids on airfields (QF sites), petroleum depots (P sites) and major towns and cities (Starfish or SF sites).
- Simulated urban lighting (QL sites).
- Dummy Heavy Anti-Aircraft (HAA) batteries, factories and buildings (C series).
- Mobile decoys representing 'hards' for troop embarkation (MQLs), tanks and other vehicles.

Machine gun emplacements and Light Anti-Aircraft (LAA) guns were used to prevent possible enemy landings at decoy airfields.

By their nature, decoy sites provide a potential risk from Unexploded Bombs (UXB), both within the decoy site boundary and in the surrounding areas.

The nearest recorded bombing decoy was located in Richmond Park (TQ 204730), approximately 16.2km west-southwest of the Site.

Bombing decoys are not considered to provide a source of UXO hazard to the Site.

### 4.2 Anti-Aircraft Defences

Anti-Aircraft (AA) gun batteries were targeted by the Luftwaffe. They were also a source of Unexploded AA (UXAA) shells which could land up to 27km from the firing point during WWII, although more typically fell within 15km. These could be distributed over a wide area.

AA batteries present a potential source of UXO hazard as a result of the storage, use and disposal of ordnance associated with the armaments used. They may have a risk from small caches of ammunition buried locally to them. 3No. types of AA batteries existed:

- Heavy Anti-Aircraft (HAA) batteries of large guns designed to engage high flying bomber aircraft. These tended to be relatively permanent gun emplacements.
- Light Anti-Aircraft (LAA) weaponry, designed to counter low flying aircraft. These were often mobile and were moved periodically to new locations around strategic targets such as airfields.
- Rocket batteries (ZAA) firing 3" or 3.7" AA rockets with a maximum altitude of 5,800m and a ground range of 9km were also relatively permanent emplacements.

Many AA batteries were associated with searchlights and consequently 'visible' at night, providing clear targets to the Luftwaffe bombers and a potential for UXB.

During WWII the Site was within the range of guns deployed in the London Gun Defended Area (GDA).

Table 4 is a list of recorded HAA gun batteries and ZAA rocket batteries within 10km of the Site.

<b>Table 4</b>		WWII HAA and ZAA batteries within 10km of the Site		
<b>Grid Reference</b>	<b>Serial No.</b>	<b>Location</b>	<b>Armament</b>	<b>Approximate Distance and Direction from Site</b>
TQ 350794	ZE12	Southwark Park	Unknown	0.8km S
TQ 354788	21Z	Southward Park	64No. UP projectors	1.2km S
TQ 353789	ZE13	Southwark Park	Unknown	1.2km S
TQ 356819	ZE19	Walthamstow	Unknown	1.7km NNE
TQ 382788	ZE8	Isle of Dogs	4No. 4.5" guns	3.5km ESE
TQ 366842	-	Victoria Park	Unknown	4.2km NNE
TQ 365842	19Z	Victoria Park	Unknown	4.5km NNE
TQ 346753	ZS25	Peckham Rye	Unknown	4.9km SSW
TQ 395827	25Z	West ham	Unknown	5.1km NE
TQ 373754	ZS11	Brockley	4No. 4.5" guns	5.3km SSE
TQ 375853	ZE21	Hackney Marshes	4No. 4.5" guns	5.7km NNE
TQ 395768	4Z	Blackheath Common	64No. UP projectors	5.7km SE
TQ 374859	ZE21	Hackney Marshes	4No. 4.5" guns	6.1km NNE
TQ 326865	ZE22	Clissold Park	Unknown	6.7km NNW
TQ 417815	ZE16	Beckton	3.7" guns	6.9km ENE
TQ 284775	9Z	Battersea Park	64No. UP projectors	7.0km WSW
TQ 280805	8Z	Hyde Park	64No. UP projectors	7.1km W
TQ 278806	ZW5	Hyde Park	4No. 4.5" guns	7.2km W
TQ 341729	18Z	Dulwich	Unknown	7.2km SSW
TQ 341727	SZ14	Dulwich	4No. 4.5" guns	7.6km SSW
TQ 289751	ZS16	Clapham Common	4No. 4.5" guns	7.8km SW
TQ 427773	ZS8	Woolwich Common	4No. 4.5" guns	8.1km ESE
TQ 409864	20Z	Wanstead Flats	64No. UP projectors	8.5km NE
TQ 411865	ZE9	Wanstead	4No. 3.7" guns	8.7km NE
TQ 277864	16Z	Hampstead Heath	64No. UP projectors	9.8km NW

It should be noted that the lack of official records of HAA batteries or armaments cannot be taken to imply their absence because many units were mobile and were moved around as operational requirements dictated.

The nearest recorded WWII AA shell incidents to the Site are described below.

#### 5<sup>th</sup> January 1944

1No. AA shell fell on St John's Wharf, approximately 0.2km southwest of the Site.

#### 13<sup>th</sup> February 1944

1No. AA shell fell on Willoughby House, approximately 0.3km west-southwest of the Site.

Given the number of gun batteries in the surrounding area, the potential for a UXAA shell to have fallen unnoticed on the Site, whilst unlikely, cannot be totally discounted.

#### 4.3 Barrage Balloons and Anti-Landing Obstacles

Balloon barrages were flown in many British towns and cities to protect against air raids. Their presence deterred low flying aircraft, making it more difficult for bombs to reach their intended targets. Barrage balloon sites can be a source of UXO as they were targeted by the Luftwaffe. They also often had a small explosive charge fitted with tilt fuzes attached approximately 50m from each end of the balloon cables and designed to detonate if the cables were hit by an aircraft.

Measures were also taken to prevent enemy aircraft landing in the event of invasion. Obstructions were constructed around airfields and on other open sites deemed fit for use as landing grounds. Solid obstructions (such as concrete blocks), posts or stakes, felled trees, haystacks, scaffolding with wire and trenching were the main measures used.

No records of any barrage balloons or anti-landing obstacles on or in close proximity to the Site have been found.

#### 4.4 Anti-Invasion Defences

Defence structures are a potential source of UXB as they were especially targeted by low flying enemy aircraft, particularly during 'tip and run' raids which were common in industrialised regions. These defences may also be associated with small caches of UXO in the form of small arms, used by the troops manning the emplacement.

The rapid advance of German Troops into France, Holland and Belgium after the start of WWII prompted the War Office to review the vulnerability of the UK to invasion and a decision was taken to begin work on a national plan of anti-invasion defences. Static defences were built to interrupt and delay the progress of any invading force.

Coastal defences were strengthened (the 'Coastal Crust'). These defences included barbed wire entanglements and minefields, which were often combined to give defence in depth.

Inland, lines of defence structures were constructed along 'Stop Lines' in order to impede enemy progress for long enough to allow mobile defending forces to counter-attack.

Stop Lines included the fortification of key 'centres of resistance', such as river crossings and important road or rail junctions that could seriously hamper the enemy's advance across country. Bridges were mined for demolition and tank traps installed.

Stop Lines were further integrated into a network of fortified nodal points and 'Anti-Tank (AT) Islands'.

No records of any anti-invasion defences on or in close proximity to the Site have been found.

#### 4.5 Pillboxes, Mortar and Gun Emplacements

Defences also included spigot mortar positions and gun emplacements.

Spigot mortars, also known as Blacker Bombards, were used primarily in an anti-tank role at road blocks or to defend airfields. Typically they fired a 20 pound (lb) HE mortar bomb. The fixed positions, in weapons pits with ammunition lockers, were frequently positioned near pillboxes.

Spigot mortar positions could be either fixed or mobile.

No records of any gun emplacements on or in close proximity to the Site have been found.

Pillboxes provide a potential UXO hazard both from the storage, use and disposal of ordnance associated with them and from UXB because they were targeted by enemy aircraft.

Pillboxes were common along Stop Lines, perimeters of airfields, potential land invasion sites and around important civil sites. Several different designs existed including Seagull Trenches (semi-buried structures), Alan Williams and Tett Turrets (small prefabricated pillboxes). Fortified sites, buildings or loop-holed walls also functioned as pillboxes.

No records of any pillboxes on or in close proximity to the Site have been found.

The nearest recorded pillbox was located on the north side of Tower Bridge (TQ 336804), approximately 1.3km west of the Site.

Pillboxes and gun emplacements are not considered to provide a source of UXO hazard to the Site.

#### 4.6 Home Guard and Auxiliary Units

Local Defence Volunteers (LDV) units, later known as the Home Guard, were located in all cities, towns and large villages. Anti-invasion defences were to be defended by the Home Guard and regular Army troops for as long as possible in the event of an invasion. The troops were issued with 'No Withdrawal' orders.

Important elements of the ordnance supply for the use of the Home Guard included substantial supplies of Mills bombs (fragmentation grenades) and Self Igniting Phosphorus (SIP) grenades as well as machine gun and small arms ammunition.

Records of Home Guard activities and related sites are rarely preserved. Storage and disposal of munitions by the Home Guard was poorly documented and surplus supplies were either buried or dumped in lakes and ponds.

Given the irregular nature of this activity, the possibility of items of UXO being discovered at any locations occupied or used for training by the Home Guard can never be totally discounted.

In addition to the regular Home Guard, Auxiliary Units existed which were made up of guerrilla troops trained in sabotage and assassination in case of invasion. Sites used by these Units were Top Secret and many locations are still unknown.

No Home Guard or Auxiliary Unit activity has been identified on or in close proximity to the Site.

#### 4.7 Minefields and Mined Locations

Minefields were laid along the coast, in estuaries and along the banks of major rivers to deter infantry invasion. Strategic points such as bridges and gaps in cliffs were mined to impede enemy advance. Most of the mined locations in the UK have been cleared and the risk of finding UXO in these areas is considered to be low.

No records of any minefields or mined locations on or in close proximity to the Site have been found.



## 5 MILITARY AIRFIELDS

Military airfields offer the potential for significant UXO hazards due to the use, storage and disposal of ordnance and as a result of enemy bombing during WWI and WWII.

Airfields active during WWII were targeted by the Luftwaffe, providing a potential source of UXB on the airfield.

As bombing accuracy was so poor during WWII, it is likely to find UXB in the surrounding areas. Aircraft crashes are also associated with operational airfields.

No records have been found indicating that any military airfields were located within 10km of the Site.

The nearest recorded military airfield during WWII was Royal Air Force (RAF) Fairlop (TQ 450901), approximately 14.4km northeast of the Site. This had been used as a Royal Naval Air Service (RNAS) base during WWI and at the beginning of WWII served as a Fighter Command satellite airfield for RAF Hornchurch. The airfield closed after WWII.

Military airfields are not considered to provide a source of UXO hazard to the Site.

### 5.1 Aircraft Crashes

Aircraft crash sites are a known UXO hazard. The MoD advises that if crashed aircraft are found, the safest policy is to leave them alone where possible. Unless disturbed there is no statutory requirement for the MoD to clear such sites.

No records of any military aircraft crashes on or in close proximity to the Site have been found.

## 6 EXPLOSIVES AND MUNITIONS ESTABLISHMENTS AND DEPOTS

Explosives and munitions manufacturing or storage sites offer a particularly high risk from both explosive substances and UXO. Standard procedures of explosive/ordnance disposal through burial or burning means that explosive and UXO hazards will be present in some areas of such establishments.

In addition, UXB hazards may be present as a result of enemy bombing during WWI and WWII.

### 6.1 Explosives and Ordnance Factories

No records of any explosives or ordnance factories on or in close proximity to the Site have been found.

During WWI, National Filling Factory (NFF) No. 8 Southwark was located approximately 2.8km west of the Site. It produced No. 100-103 type fuzes.

Explosives and ordnance factories are not considered to provide a source of UXO hazard to the Site.

### 6.2 Munitions Stores

Local ammunition caches would have been present near to defended road blocks, pillboxes, HAA and LAA sites. Most of those associated with the anti-invasion sites are understood to have been cleared.

No records of any official munitions stores on or in close proximity to the Site have been found.

### 6.3 Informal Munitions Depots

Informal munitions depots, often made by requisitioning roadside lay-bys or parks. Other informal munitions depots were commonly located in areas of woodland or on train wagons along sidings in marshalling yards.

No records of any informal munitions depots on or in close proximity to the Site have been found.

### 6.4 Munitions Disposal Areas and Bomb Cemeteries

Munitions disposal areas were often made by requisitioning open areas of land, usually away from habitation. Marshland, beaches or sand dunes were frequently used for this purpose. Disposal of munitions was carried out in many different ways, ranging from destruction to burial. Full records were not necessarily maintained for these locations, and so they can potentially be a source of UXO.

No records of any munitions disposal areas or bomb cemeteries on or in close proximity to the Site have been found.

During WWII, the nearest official bomb cemetery was located on land at Marshgate Bridge, approximately 4.5km northeast of the Site.

Munitions disposal areas and bomb cemeteries are not considered to provide a source of UXO hazard to the Site.

## 7 FIRING RANGES AND MILITARY TRAINING AREAS

By their nature, firing ranges and military training areas represent a potential source of UXO due to associated training activities. The training will involve both practice and live munitions and will offer a significant risk from a very wide range of potential UXO.

### 7.1 Small Arms Ranges

Small arms ranges (such as rifle ranges) and close combat ranges (such as mortar and grenade ranges) are likely to provide a significant source of UXO. It should be noted that even on small arms ranges, larger munitions such as mortars or grenades cannot be discounted.

No records of any small arms ranges on or in close proximity to the Site have been found.

### 7.2 Artillery Ranges

Artillery ranges will have utilised a wide range of munitions, predominantly shells, although close combat munitions such as mortars, or larger munitions such as bombs, cannot be discounted.

No records of any artillery ranges on or in close proximity to the Site have been found.

### 7.3 Bombing Ranges

Bombing ranges will have primarily used bombs, although other munitions such as shells and close combat munitions such as mortars cannot be totally discounted.

No records of any bombing ranges on or in close proximity to the Site have been found.

### 7.4 Training Areas

Training areas will have primarily used blank ammunition or practice shells in 'dry' areas, although live munitions such as shells and close combat munitions such as mortars cannot be discounted in any training area.

No records of any military training areas on or in close proximity to the Site have been found.

## 8 EXPLOSIVE ORDNANCE CLEARANCE ACTIVITIES

Official UK bombing statistics have been compiled from both British and German sources. There were differences in the way the figures were originally reported and collated which has led to discrepancies in the summary data.

Based on data from 1939 to 1945, War Office statistics indicate that 200,195No. HE bombs exploded within Great Britain. Additionally, 25,195No. HE bombs (representing 11%) were recorded as UXBs. However, records from the Royal Engineers who were responsible for bomb disposal at the time indicate that as of 27<sup>th</sup> February 1946 upwards of 45,000No. UXBs were disposed of.

On average 8.5% UXBs later self-exploded. In some cases the bombs had delayed action fuzes or were never intended to explode, their purpose being to cause inconvenience and fear.

Given the discrepancy in records and the fact that UXBs are still being found unexpectedly, it is clear that the original figures are understated and provide only an approximation of the number of potential UXBs in the UK.

War Office statistics also show that between October 1940 and May 1941 most of the UXBs (93%) were either 50kg or 250kg. It should be noted that details of the recovery and the size of the UXB were not always accurately reported.

The larger WWII UXBs are often difficult to recover due to both penetration depths and the presence of two or more fuzes, combined with more sensitive fillings of explosive mixtures including Amatol and Trialen.

### 8.1 Abandoned Bombs

No records of any officially abandoned bombs on the Site have been found.

### 8.2 EOC Tasks

Zetica Ltd holds the following records of post-WWII EOC tasks being undertaken in the vicinity of the Site.

#### 23<sup>rd</sup> January 1949

1No. UXB was removed from 3 Brunton Cottages, Brunton Place, approximately 1.5km northeast of the Site.

#### 8<sup>th</sup> March 1951

1No. 250kg UXB and 2No. Type 25 Fuzes were removed from a building site on Prescott Street, approximately 1.2km northwest of the Site.

#### 12<sup>th</sup> March 1965

1No. UXB was removed from Tower Hill underground station, approximately 1.4km west-northwest of the Site.

The MoD has provided no additional information on official EOC tasks on the Site.

9 UXO HAZARD ASSESSMENT			
9.1 UXO Hazard Level			
The definitions for the levels of UXO hazard are provided below.			
Definitions of UXO Hazard Level for a Site			
Hazard Level	Definition		
Very Low	There is positive evidence that UXO is not present, e.g. through physical constraints or removal.		
Low	There is no positive evidence that UXO is present, but its occurrence cannot be totally discounted.		
Moderate	There is positive evidence that ordnance was present and that other uncharted ordnance may be present as UXO.		
High	There is positive evidence that UXO is present.		
Very High	As high, but requires immediate or special attention due to the potential hazard.		
No records have been found indicating that the Site was bombed and no other significant sources of UXO hazard have been identified on the Site.			
Given this, it is considered that the Site has a low UXO hazard level, as shown in Figure 6.			
Figure 6	UXO hazard zone plan of the Site		
Legend	Very Low	Low	Moderate
	High	Very High	Site boundary

## 10 UXO RISK ASSESSMENT

### 10.1 UXO Risk Level

A UXO risk assessment has been undertaken for the proposed works, taking into consideration the identified UXO hazard.

Firstly, the probability of encountering UXO (PE) has been considered and rated for the different construction techniques, as detailed below.

Probability of Encounter (PE)	Rating
Frequent, highly likely, almost certain.	5
Probable, more likely to happen than not.	4
Occasional, increased chance or probability.	3
Remote, unlikely to happen but could.	2
Improbable, highly unlikely.	1
Impossible	0

Secondly, the probability of detonating a UXO (PD) has been considered and rated for the different construction techniques, as detailed below.

Probability of Detonation (PD)	Rating
Frequent, highly likely, almost certain.	5
Probable, more likely to happen than not.	4
Occasional, increased chance or probability.	3
Remote, unlikely to happen but could.	2
Improbable, highly unlikely.	1
Impossible	0

Next, the probability of encountering and detonating the UXO (PE x PD) have been used to generate an overall likelihood rating (P).

P = PE x PD	LIKELIHOOD of Encounter and Detonation	Rating
21 to 25	Frequent, highly likely, almost certain.	5
16 to 20	Probable, more likely to happen than not.	4
6 to 15	Occasional, increased chance or probability.	3
2 to 5	Remote, unlikely to happen but could.	2
1	Improbable, highly unlikely.	1
0	Impossible	0

**P ranges from 25, a certainty of UXO being encountered and detonated on the Site by engineering activity, to 0, a certainty that UXO does not occur on the Site and will not be detonated by engineering activity.**

The likelihood of encountering and detonating UXO during site works is multiplied by the severity of such an event occurring ( $P \times S$ ), in order to provide a risk level using the following matrix.

Severity (S)	Rating
Multiple fatalities	5
Major injury, long term health issues, single fatality.	4
Minor injury, short term health issues, no fatalities.	3
First aid case but no lost time or ill health.	2
Minor injuries, no first aid.	1
No injuries.	0

UXO Risk Matrix							
LIKELIHOOD (P)	SEVERITY (S)						
		5	4	3	2	1	0
	5	25	20	15	10	5	0
	4	20	16	12	8	4	0
	3	15	12	9	6	3	0
	2	10	8	6	4	2	0
	1	5	4	3	2	1	0
	0	0	0	0	0	0	0

The final risk assessment for the Site is given in Table 5.

Table 5	UXO risk assessment for the Site							
Potential UXO Hazard	Anticipated Works	PE	PD	P = PE x PD	Likelihood	Severity	Risk Rating	UXO Risk
UXB	Shallow Excavations	1	1	1	1	5	5	Low
	Deep Excavations	1	1	1	1	5	5	Low
	Piling/Boreholes	1	1	1	1	4	4	Low
Other UXO	Shallow Excavations	1	1	1	1	4	4	Low
	Deep Excavations	1	1	1	1	4	4	Low
	Piling/Boreholes	1	1	1	1	3	3	Low
PE (Probability of Encounter), PD (Probability of Detonation), P (Overall Probability)								
Shallow Excavations defined as <1.0m below ground level (bgl).								

UXO Risk	Matrix Rating	Definition
Very Low	0-1	Little action is required by the client provided that suitable records and procedures are in place to ensure appropriate action is undertaken should the UXO risk level change.
Low	2-5	Tolerable to the client as engineering activity need not alter if UXO related procedures and controls are strictly adhered to.
Moderate	6-15	May be tolerable for the client, but it is prudent to reduce the risk where cost effective and reasonably practicable.
High	16-20	Tolerable to the client only where further risk reduction is impracticable or disproportionate to the risk involved. Essential that all practicable measures are taken to reduce the level of risk.
Very High	21-25	Unacceptable to the client except in extraordinary circumstances. Imperative that all control measures are taken.

## 10.2 Risk Mitigation Recommendations

To ensure that the UXO risk is reduced to As Low As Reasonably Practicable (ALARP) the following mitigation is advised:

Where a low risk of UXO encounter is anticipated, industry good practice is to raise the awareness of those involved in excavations so that in the unlikely event that a suspect item is discovered, appropriate action is taken. This can be achieved through UXO awareness briefings to site staff.

Clearance certification for borehole or pile locations is considered prudent only if a zero tolerance to risk is adopted. Zero tolerance is commonly adopted for sites that have safety critical infrastructure such as nuclear establishments and oil refineries.

Table 6 below gives recommended actions in relation to the potential UXO risk level and the anticipated Site activity.

Further advice on the mitigation methods can be provided by Zetica on request.



Table 6		Risk mitigation for assumed Site activities			
Risk Level	Typical Future Activity on the Site				
	None	Shallow Excavations (<1.0m)	Deep Excavations (>1.0m)	Boreholes or Pile Construction	
Very low	Ensure suitable records and procedures are in place to highlight the risk should future development be planned.	Ensure site staff, are informed as part of the site safety induction that the potential presence of UXO cannot be discounted.  Appropriate action is required to be detailed within site procedures.	Ensure site staff, are informed as part of the site safety induction that the potential presence of UXO cannot be discounted.  Appropriate action is required to be detailed within site procedures.	Ensure site staff, are informed as part of the site safety induction that the potential presence of UXO cannot be discounted.  Appropriate action is required to be detailed within site procedures.	
Low	As very low.	As very low.  + It is considered prudent to include some UXO awareness training in site inductions.	As very low.  + It is considered prudent to include some UXO awareness training in site inductions.	As very low.  +Clearance certification for borehole or pile locations would be considered prudent only if a zero tolerance to risk is adopted.  Zero tolerance is commonly adopted for sites that have safety critical infrastructure such as nuclear establishments and oil refineries.	
Moderate	As very low.	As low.  +Non-intrusive investigation methods considered prudent where practical.  +Alternatively, EOC Engineer supervision is considered prudent.	As low.  +Non-intrusive investigation methods considered prudent where practical.  +Alternatively, EOC Engineer supervision is considered prudent.	As low.  +Clearance certification for borehole or pile locations is considered essential.	
High	As very low.	As moderate.  +Non-intrusive investigation methods considered essential where practical.  + Alternatively, EOC Engineer supervision is considered essential.	As moderate.  +Non-intrusive investigation methods considered essential where practical.  + Alternatively, EOC Engineer supervision is considered essential.	As moderate.	
Very High	Requires immediate or special attention.	Requires immediate or special attention.	Requires immediate or special attention.	Requires immediate or special attention.	
The above table is for guidance only.					

## APPENDICES

### Appendix 1 WWII Bombing Incident List

#### 8<sup>th</sup> September 1940

1No. HE bomb and IBs (number unspecified) fell on Wapping High Street, within approximately 0.2km of the Site.

#### 10<sup>th</sup> September 1940

1No. HE bomb fell on Tench Street, approximately 0.3km west of the Site. This was recorded as UXB and removed.

1No. HE bomb fell on the bridge between Western Dock and Eastern Dock, on Wapping Lane, approximately 0.3km north-northwest of the Site.

#### 11<sup>th</sup> September 1940

1No. HE bomb fell on Gun Wharf, approximately 50m south of the Site.

#### 6<sup>th</sup> October 1940

1No. OB fell on Aberdeen Wharf, approximately 0.3km southwest of the Site.

#### 7<sup>th</sup> October 1940

1No. HE bomb fell on factory buildings in Brewhouse Lane, within approximately 0.1km west-southwest of the Site.

#### 9<sup>th</sup> October 1940

1No. HE bomb and IBs (number unspecified) fell on the London Docks, within approximately 0.4km of the Site.

#### 10<sup>th</sup> October 1940

1No. HE bomb fell on Brewhouse Lane School, approximately 0.2km west-southwest of the Site.

#### 11<sup>th</sup> October 1940

1No. HE bomb fell on a garage in Brewhouse Lane, approximately 0.1km west-southwest of the Site.

1No. HE bomb and IBs (number unspecified) fell on Brewhouse Lane, within approximately 0.2km west of the Site.

1No. HE bomb and IBs (number unspecified) fell on Eagle Wharf, approximately 0.3km west-southwest of the Site.

#### 9<sup>th</sup> October 1940

1No. HE bomb and IBs (number unspecified) fell on the London Docks, within approximately 0.4km of the Site.

#### 7<sup>th</sup> November 1940

1No. HE bomb fell on Old Aberdeen Wharf, approximately 0.3km southwest of the Site.

#### 8<sup>th</sup> December 1940

IBs (number unspecified) fell on Wapping Dock Street, adjacent to the western boundary of the Site.

#### **9<sup>th</sup> December 1940**

IBs (number unspecified) fell on a warehouse at the end of Wapping Dock Street, adjacent to the southern boundary of the Site.

IBs (number unspecified) fell on Gun Wharf, approximately 50m south of the Site.

IBs (number unspecified) fell on a soap works on Brewhouse Lane, approximately 0.1km southwest of the Site.

1No. HE bomb fell on the Thames Police Station, approximately 0.2km southwest of the Site. This was recorded as UXB and removed.

1No. HE bomb and IBs (number unspecified) fell on Brewhouse Lane, within approximately 0.2km west of the Site.

#### **15<sup>th</sup> December 1940**

5No. HE bombs fell on Garnet Street, in the vicinity of the London Dock drawbridge, approximately 0.3km north-northeast of the Site.

#### **29<sup>th</sup> December 1940**

IBs (number unspecified) fell on Middleton's and St Bride's Wharf, adjacent to the southern boundary of the Site.

1No. HE bomb and IBs (number unspecified) fell on Cinnamon Street, within approximately 0.1km of the Site.

IBs (number unspecified) fell on a soap works on Brewhouse Lane, approximately 0.1km southwest of the Site.

IBs (number unspecified) fell on Orient Wharf, approximately 0.4km west-southwest of the Site.

#### **11<sup>th</sup> January 1941**

IBs (number unspecified) fell on the London Docks, within approximately 0.4km of the Site.

#### **8<sup>th</sup> March 1941**

1No. 50kg HE bomb fell on the junction of Green Bank and Wapping Lane, approximately 70m west of the Site.

1No. 50kg HE bomb fell on an office building opposite St John's Wharf, approximately 0.2km west-southwest of the Site.

1No. 50kg HE bomb fell on a boatyard next to Wapping Police Station, approximately 0.2km west-southwest of the Site.

1No. 50kg HE bomb fell on Morocco Wharf, approximately 0.3km west-southwest of the Site.

1No. 50kg HE bomb fell on Wapping High Street, in front of Orient Wharf, approximately 0.4km west-southwest of the Site.

#### **19<sup>th</sup> March 1941**

1No. 250kg HE bomb fell on Metropolitan Wharf, approximately 0.2km east-northeast of the Site.

1No. 50kg HE bomb fell on the playground of St John's School, approximately 0.3km west-southwest of the Site.

1No. 250kg HE bomb fell on Orient Wharf, approximately 0.3km west-southwest of the Site.

**16<sup>th</sup> April 1941**

1No. HE bomb and IBs (number unspecified) fell on Wapping Wall, within approximately 0.2km northeast of the Site.

**10<sup>th</sup> May 1941**

1No. 500kg HE bomb fell on the Old Tower Buildings on Brewhouse Lane, approximately 0.1km west of the Site.

1No. 500kg HE bomb fell on a public shelter on Watts Street, approximately 0.2km west-northwest of the Site.

1No. 500kg HE bomb fell on Chancellor House, Brewhouse Lane, approximately 0.2km west of the Site.

1No. 500kg HE bomb fell on the junction of Old Gravel Lane and Raine Street, approximately 0.2km north-northwest of the Site.

2No. 500kg HE bombs and 1No. OB fell on Metropolitan Wharf, approximately 0.3km east-northeast of the Site.

**22<sup>nd</sup> July 1942**

1No. HE bomb fell on Peter Hill Walk, approximately 0.5km south of the Site. This was recorded as UXB and removed.

**29<sup>th</sup> January 1944**

IBs (number unspecified) fell on the former Wapping Gas Works, approximately 40m northeast of the Site.

3No. PhIBs fell on Wapping Pier, approximately 0.2km southwest of the Site.

## Appendix 2 UXO Hazard and Ordnance Types

When assessing the risk from UXO including UXB, it is important to be aware of ordnance type and function. The following Section briefly describes the more common types of UXO. More data on these can be found at <http://zeticauxo.com/downloads-and-resources/ordnance-data-sheets/>.

### A2.1 Small Arms Ammunition

Small Arms Ammunition (SAA) is one of the more recognisable categories of ordnance which is primarily designed for anti-personnel use. SAA include items such as bullets, generally up to a calibre (diameter) of 20mm.

Larger calibre small arms munitions can contain fuze mechanisms and high explosives or pyrotechnic fillings and may have been used for anti-aircraft or anti-vehicle purposes.

Generally small arms ordnance has a relatively low risk as UXO, although the larger calibre categories may have the same detonation risk as larger high explosive ordnance. SAA is often associated with discarded ammunition boxes around firing practice ranges. The Plate below illustrates some common SAA.

#### Plate

Photograph of typical WWII small arms ammunition



Source: Google Images



## A2.2 Hand Grenades

Hand grenades can be filled with explosives or chemicals and have 3No. main parts, a body, a fuze with a pull ring and a safety-clip assembly. Fragmentation grenades are the most common and have a metal or plastic body filled with an explosive. Most use a burning delay fuze that functions for 3 to 5 seconds after the safety lever is released. Some, such as smoke grenades, are activated instantly when the lever is released.

The Plate below illustrates the typical character and condition of the most commonly found No. 36 hand grenades (Mills Bombs).

<b>Plate</b>	Photographs of a typical and an excavated WWII No. 36 hand grenade
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Source: IWM



Source: Zetica Ltd

## A2.3 Projected Grenades




Projected grenades are among the most commonly found UXO items, particularly the 40mm type. These contain high explosives and use a variety of fuzes, including some of the most sensitive internal impact-fuzing systems. They are extremely dangerous and can explode if moved or handled.

## A2.4 Mortars

A mortar is a short tube designed to fire a projectile at a steep angle. Mortars can range from approximately 50mm to 280mm in diameter and can be filled with explosives, toxic chemicals, white phosphorous or illumination flares. They generally have a thinner metal casing than projectiles, but use the same types of fuzing and stabilisation.

During WWII there are records that the target areas of RAF practice bombing ranges were occasionally used for mortar training.

The Plate below shows typical 2-inch (left) and 3-inch (right) mortar bombs.

Plate	Photographs of WWII 2-inch and 3-inch mortars
<div data-bbox="252 344 778 952">  </div> <div data-bbox="821 344 1348 952">  </div>	
A2.5 Shells	
<p>Shells are a projectile containing an explosive charge designed to burst the casing that can contain High Explosives, pyrotechnic compounds or other chemicals.</p> <p>Shells can be found in a range of sizes, from &lt;20mm to several times this size. The most likely shells to be found on the Site are Small Arms Ammunition (SAA) or UXAA shells that have fallen back to the ground unexploded.</p> <p>Most commonly used anti-aircraft shells were 2" and 3.7" HE shells.</p> <p>If fired and found as UXO, shells can offer a particular hazard from accidental detonation as they can have sensitive fuze mechanisms. A fuze is a device which incorporates mechanical, electrical, chemical or hydrostatic components to initiate a train of fire or detonation.</p> <p>The Plate below is a photograph of a 3.7" UXAA shell found in Camberwell, London.</p>	
Plate	Photograph of a recently excavated 3.7" AA shell
<div data-bbox="252 1541 1348 1921">  </div>	

## A2.6 Incendiary Bombs

Incendiary Bombs (IBs) ranged from small 1kg thermite filled, magnesium bodied bombs to a 250kg 'Oil Bomb' (OB) and a 500kg 'C300' IB. By far the most common air dropped devices across the UK during WWII were small 1kg to 2kg IBs.

In some cases the IBs were fitted with a very small High Explosive (HE) bursting charge. This exploded after the bomb had been alight for a few minutes causing burning debris to be scattered over a greater area. The C300 bombs were similar in appearance to 500kg HE bombs.

The small amount of HE, if any, and the almost negligible potential for IBs to remain active after more than 65 years in the ground means that these items have very little prospect of causing damage. In the majority of cases if IBs are found in the ground, the incendiary materials have deteriorated to such an extent that they are considered to provide a low UXO hazard level.

However, since magnesium and phosphorus were common components in IBs, some localised chemical contamination may occur where the contents have leached out of the IB into the surrounding soil.

The Plate below shows a 1kg IB and a variety of fragmentary remains of IBs recovered by the Civil Defence during WWII.

**Plate** Photographs of a 1kg IB and IB fragments



Source: IWM



Source: Swansea Museum

## A2.7 German High Explosive Bombs

Probably the most common and certainly most publicised UXOs to be found in the UK are bombs. Air dropped bombs, as a result of WWII enemy action, are found on a relatively frequent basis as UXO. They tend to be highly publicised (at least on a local basis) due to the common disruption where an evacuation of the potentially affected area is put in place.

The amount of High Explosive and the potential for a fuze to still be activated means that these devices have the prospect of causing some of the most widespread damage. WWII bombs were particularly sophisticated for their time, with anti-tamper fuzes.

Many German bombs were designed to not explode on impact and instead to cause disruption as a UXB. Some fuzes were set with a delay time of over 70 hours. During this time, an anti-tamper fuze could also be activated to detonate should it be disturbed.

The most commonly used bombs during WWII were the 50kg and 250kg sized general purpose bombs. Less frequently, the 500kg bomb was also used. Larger bombs were used, but so infrequently that any assessment of hazard is more typically based on bombs ranging up to 500kg only.

It should be noted that the June 2008 find of a 1000kg bomb in London, does demonstrate that larger bombs can be found and any risk mitigation measures should consider this.

The Plate below shows the variety of UXB recovered by the Civil Defence during WWII.

**Plate** Photograph of a variety of UXB recovered by the Civil Defence during WWII



Source: IWM

## A2.8 Detonators, Gains and Fuzes

Bomb components such as detonators, gains and fuzes were stored at operational airfields during WWII and typically contained some type of explosive charge to initiate the detonation of a munition.

A wide variety of these components were used and examples of some common fuzes are shown in the Plate below.



Plate	Photographs showing examples of WWII fuzes
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Source: Zetica Ltd



## A2.9 Land Mines

Wartime activities provide numerous sources of UXO within the land environment. Whilst efforts have been made to clear the known British minefields, it was common for mines to become lost for a variety of reasons and so not recovered. Additionally, such munitions might have been disposed of on an unofficial basis and so no records were kept.

Most of the mined beaches and other land areas in the UK have been cleared by the MoD. Occasionally, wave action or activities such as bombing caused mines to become displaced and these were missed as part of any past clearance activities.

The Plate below is a photograph of a typical WWII land mine used on the land area, beaches and cliffs around Britain. The example on the right was found at Gatwick Airport, formerly RAF Gatwick.

Plate	Photographs of original and recently excavated WWII land mines
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Source: IWM



Source: Zetica Ltd



## A2.10 Home Guard Weapons

Initially, the Home Guard's armoury was largely second-hand and much of it was of WWI vintage. Personal weapons (such as shotguns) and home-made devices were also employed.

By the end of WWII, some units were well equipped with a wide variety of small arms and munitions.

These included .32, .38 and .455 revolvers, .303 P14, .300 P17 and .303 Canadian Ross rifles, anti-tank rifles and a variety of Sub- Machine Guns (SMG) such as the .45 Thompson and 9mm Sten Guns.

Other heavier Machine Guns (MG) at their disposal included Browning, Hotchkiss, Lewis, Vickers and Marlin MG. Sub-artillery weapons were developed for them, including grenade throwers (the Northover Projector) and spigot mortars (the Blacker Bombard). 2-pdr anti-tank guns and Projector, Infantry Anti Tank (PIAT) weapons were in circulation amongst some units, and the Home Guard also manned AA guns later in WWII.

Explosives were available to some Home Guard units and were used and stored by all Auxiliary Unit patrols. As well as the flame fougasse and hand grenades detailed in this Appendix, the Home Guard had stocks of Molotov Cocktails, Sticky Bombs and SIP grenades.

In October 2006 a cache of 76No. SIP grenades was found in a garden at Seend, Wiltshire. In October 2008, a further 26No. SIP grenades were discovered in a garden in Wimborne, Dorset. Similar caches were discovered in October 2009 in Hove, Sussex and during May 2010 in Halesowen in the West Midlands, and a further cache of 20No. was uncovered on a construction site at Birdlip, Gloucestershire, in July 2010.


Also in July 2010, a box of 24No. SIP grenades was found on Cogden Beach, Dorset. In April 2012, more than 8No. SIP grenades were found on a construction site in Banbury and destroyed by members of the Army Royal Logistic Corps (RLC).

In March 2015, 80No. SIP grenades were found at a building site in Eastbourne, some of which exploded before they could be made safe by a Bomb Disposal unit. In all 8No. cases, the bottles were in good condition and exploded in flames when broken.

Most recently, in May 2016, 1No. No. 76 SIP grenade was found during excavation at Chapel Point, Lincolnshire forcing works to be delayed. During WWII, the site was occupied by a pillbox and gun emplacement associated with the heavily-defended 'Coastal Crust', manned by Home Guard units. The device was removed safely.

In January 2017, a cache of 24No. SIP grenades was discovered at Derriford, Plymouth and made safe by a Royal Navy Bomb Disposal Unit.

The Plate below shows 2No. recently discovered SIP grenades.

Plate	Photograph of No. 76 SIP grenades
	
Source: Zetica Ltd	
<p>Given the irregular nature of Home Guard activity, the possibility of items of UXO or weapons being discovered at any locations occupied or used for training by them can never be totally discounted.</p>	
<h3>A2.11 UXO Migration</h3>	
<p>It is possible for explosive material, UXO or ordnance scrap to migrate to a site during landfill or dredging operations or other ground works which import Made Ground or natural materials already containing UXO. It is important to understand the nature and age of such landfill or dredging operations when assessing the potential UXO hazard level on the site.</p>	
<h3>A2.12 Effects and Consequences</h3>	
<p>There have been a limited number of recorded incidents in the UK since WWII where bombs have detonated during engineering works, though a significant number of bombs have been discovered. Incidents involving smaller ordnance are, however, relatively common in the UK.</p> <p>In the UK, there are no recorded incidents since the decade after WWII, of a UXB accidentally detonating. In recent years, bombs have been found that have fuze mechanisms that have started to operate indicating that given the right conditions a UXB may still function.</p> <p>In June 2008 the UXB uncovered in the Lea Valley caused difficulty to No. 33 Regiment (Explosive Ordnance Disposal) Royal Engineers because the fuze mechanism started to operate.</p> <p>The 1,000kg 'Hermann' bomb, the first of this size to be found in over 30 years, took 5 days to deactivate. This demonstrates that larger bombs can be found and any risk mitigation measures should provide the option to deal with this size of device. Since WWII, UXBs have been found on a regular basis in London.</p> <p>Since WWII, UXBs have been found on a regular basis throughout Britain. Some of the most recent cases are described below.</p> <p>In May 2009 1No. 50kg WWII bomb was found on a building site in Bexhill-on-Sea, Sussex, and on the 16<sup>th</sup> August 2009, 1No. 250kg WWII bomb was found near Eberston, North Yorkshire. Both of these were destroyed in controlled explosions by Bomb Disposal Units.</p> <p>On the 8<sup>th</sup> March 2010 1No. 500kg WWII bomb was found at Bowers Marsh in Essex by Zetica EOC operatives following a Zetica desk study concluding a high risk of UXB on the site. The bomb was demolished in situ by members of the Army Royal Logistics Corps (RLC).</p>	

The Plate below is a photograph of the bomb in situ.

<b>Plate</b>	Photograph of the 500kg WWII UXB at Bowers Marsh, 8 <sup>th</sup> March 2010
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Source: Zetica Ltd

On the 23<sup>rd</sup> February 2011, 1No. WWII UXB was found on a building site in Notte Street in Plymouth City centre. The bomb was removed by EOD personnel and demolished at sea.

On the 22<sup>nd</sup> July 2012, a landslip in the cliffs at Mappleton in the East Riding of Yorkshire exposed over 1,000No. UXO items, including practice bombs, mortars, rockets, shells and grenades. The cliff was part of a former bombing and artillery range, used during WWII and until the 1970s.

UXO items were removed by Explosive Ordnance Disposal (EOD) officers from Catterick and MoD staff from Leconfield. 15No. controlled explosions were undertaken by the Royal Engineers (RE) to detonate the more volatile items in situ, while other less hazardous UXO devices were left in place to be dealt with at a later date.

1No. WWI bomb (shown in the Plate below) was found on the Isle of Sheppey on the 2<sup>nd</sup> August 2012 during a geophysical survey following desk study research by Zetica Ltd which had established that a previously unknown WWI bombing range existed on the site. A further WWI bomb was found in the same location in August 2015.

<b>Plate</b>	Photograph of WWI bomb, Isle of Sheppey, 2 <sup>nd</sup> August 2012
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Source: Zetica Ltd



On the 23<sup>rd</sup> March 2015, 1No. WWII 500kg UXB was found on a building site in The Grange, Bermondsey. The bomb was made safe by EOD personnel and removed for demolition.

On the 21<sup>st</sup> May 2015, 1No. 50kg UXB was found on a building site near Wembley Stadium, London Borough of Brent. The bomb was made safe by EOD personnel and removed for demolition.

On the 10<sup>th</sup> August 2015, 1No. 250kg UXB was found under the basement of a building site at Bethnal Green, London Borough of Tower Hamlets. It was made safe and removed by an EOD team from the RLC.

On the 21<sup>st</sup> September 2015, 1No. UXB was uncovered on a construction site in Cheylesmore, Coventry, by the operator of a mechanical digger. It was destroyed in situ by an EOD team from the RLC.

In January 2016, Zetica discovered 3No. 500lb British UXB at a former airfield in Cambridgeshire. These were destroyed in controlled explosions. The Plate below is a photograph of one of the bombs.

**Plate** Photograph of a recently excavated WWII British 500lb GP bomb



Source: Zetica Ltd

On the 12<sup>th</sup> May 2016, 1No. 250kg UXB was found on a building site in Bath. It was made safe and then taken to a local quarry for demolition.

In September 2016 1No. 500kg UXB and 1No. torpedo were discovered during dredging works in Portsmouth Harbour. An additional 250kg HE bomb was discovered on the 16<sup>th</sup> November 2016. These devices were towed out to sea and destroyed in controlled explosions.

On the 19<sup>th</sup> January 2017, 1No. 50kg UXB was found during dredging works along the River Thames Victoria Embankment in Central London. The device was towed to Tilbury in Essex where it was destroyed in a controlled explosion.

On the 25<sup>th</sup> January 2017, 1No. 500lb British UXB and 1No. mortar shell were found in King's Forest, Thetford. They were destroyed in a controlled explosion.

On the 2<sup>nd</sup> March 2017, 1No. 250kg German UXB was found on a building site in Brondesbury Park in the London Borough of Brent. It was defuzed by an EOD team and removed to a safe location where it was destroyed in a controlled explosion.

On the 31<sup>st</sup> August 2017, 1No. 50kg German UXB was found in a quarry in Kings Hill, West Malling, Kent. It was destroyed in a controlled explosion.

During October and November 2017, approximately 150No. canisters of Mustard Gas were found in a lake and adjacent woodland near the former WWII military airfield RAF Woodhall Spa, Lincolnshire. The canisters were removed to the DSTL at Porton Down for safe disposal.

On the 11<sup>th</sup> February 2018, 1No. 500kg UXB was found in King George V Dock, adjacent to London City Airport, during construction work. The airport was closed for two days while the UXB was made safe by an EOD team from the Royal Navy. It was removed and destroyed in a controlled explosion off Shoesburyness on the 14<sup>th</sup> February 2018.

On the 26<sup>th</sup> February 2018, an EOD team destroyed numerous items of ordnance including shells and 20mm ammunition which had been exposed by storms on Selsey Beach.

On the 3<sup>rd</sup> April 2018, 1No. WWI shell was found in Steeton near Bradford. It was destroyed in a controlled explosion after being made safe and moved to a nearby field.

On the 9<sup>th</sup> June 2018, 1No. WWII shell was found in Winchester. It was detonated in situ.

On the 29<sup>th</sup> August 2018, 1No. WWII shell was found on Church Manorway in Erith. It was removed for disarmament.

There is a long list of incidents during construction work in Germany that in some cases have led to the deaths of workers.

In June 2010, 3No. members of a bomb disposal team were killed, and 6No. others injured, whilst attempting to defuze an unexploded WWII bomb in Goettingen, Central Germany.

The bomb, the second found in Goettingen in the space of a few days, was unearthed at a depth of 7.5m during excavations for a sports stadium.

In September 2008, 17No. people were injured and considerable damage occurred to adjacent buildings when a bomb exploded on a construction site in Hattingen, Germany.

In October 2006 during road works on a motorway near Aschaffenburg in Bavaria, southern Germany, a bomb was struck by a machine and detonated. The plant driver was killed and 5No. others injured, including passing motorists.

In a similar incident in October 2004 in Linz, Austria a bomb exploded injuring 3No. workers and causing considerable damage to plant. In the same month, a WWII bomb under a back garden in Vienna, Austria, was detonated without warning by a minor earth tremor, after remaining undiscovered for over 60 years.

Further details of similar finds can be found at <http://zeticauxo.com/news/>.

The effects of a partial or full detonation of ordnance are usually shock, blast, heat and shrapnel damage. A 50kg buried bomb can damage brick / concrete structures up to a distance of approximately 16m away. Unprotected personnel on the surface up to 70m away from the blast could also be seriously injured. Larger ordnance would obviously be more destructive.

Explosives rarely lose effectiveness with age, although over time mechanisms such as fuzes and gaines can become more sensitive and therefore more prone to detonation, regardless of whether the device has been submersed in water or embedded in silt, clay or similar materials.

The effects of a detonation of explosive ordnance are usually extremely fast, often catastrophic and invariably traumatic to any personnel involved.



Appendix 3 Abbreviations	
AA	Anti-Aircraft
ACPO	Association of Chief Police Officers
ALARP	As Low As Reasonably Practicable
ARP	Air Raid Precaution
ASACS	Air Surveillance and Control System
AXO	Abandoned Explosive Ordnance
BD	Bomb Disposal
BDO	Bomb Disposal Officer
BDU	Bomb Disposal Unit
CBRN	Chemical, Biological, Radiological and Nuclear
CMD	Conventional Munitions Disposal
DAB	Delayed Action Bomb
DCLG	Department of Communities and Local Government
EO	Explosive Ordnance
EOC	Explosive Ordnance Clearance
EOR	Explosive Ordnance Reconnaissance
ERW	Explosive Remnants of War
ESA	Explosive Substances and Articles
FFE	Free From Explosives
HAA	Heavy Anti-Aircraft
HE	High Explosive
HSE	Health and Safety Executive
JSEODOC	Joint Services EOD Operations Centre
IB	Incendiary Bomb

IED	Improvised Explosive Device
IEDD	Improvised Explosive Device Disposal
LAA	Light Anti-Aircraft
MoD	Ministry of Defence
OB	Oil Bomb
PhIB	Phosphorus Incendiary Bomb
PM	Parachute Mine
PUCA	Pick Up and Carry Away
RAF	Royal Air Force
SAA	Small Arms Ammunition
SIP	Self-Igniting Phosphorous
TEP	Time Expired Pyrotechnics
USAAF	United States Army Air Forces
UXB	Unexploded Bomb
UXO	Unexploded Ordnance

Appendix 4 Glossary & Definitions	
<b>Abandoned Explosive Ordnance (AXO)</b>	Abandoned Explosive Ordnance is explosive ordnance that has not been used during an armed conflict, that has been left behind or disposed of by a party to an armed conflict, and which is no longer under control of that party. Abandoned explosive ordnance may or may not have been primed, fuzed, armed or otherwise prepared for use.
<b>Camouflet</b>	The type of cavity produced when a charge explodes underground without breaking the surface of the earth to form a crater.
<b>Demil</b>	Derived from the term 'Demilitarisation', it refers to the break down and the recycling or disposal of ordnance components.
<b>Detonation</b>	The high-speed chemical breakdown of an energetic material producing heat, pressure, flame and a shock wave.
<b>Device</b>	This term is used for any component, sub-assembly or completed ordnance, which may or may not have an explosive risk. It can apply to detonators, primers, gaines, fuzes, shells or bombs.
<b>Explosive</b>	The term explosive refers to compounds forming energetic materials that under certain conditions chemically react, rapidly producing gas, heat and pressure. Obviously, these are extremely dangerous and should only be handled by qualified professionals.
<b>Explosive Ordnance (EO)</b>	Explosive Ordnance is all munitions containing explosives, nuclear fission or fusion materials and biological and chemical agents. This includes bombs and warheads, guided and ballistic missiles, artillery, mortar, rocket, small arms ammunition, mines, torpedoes, depth charges, pyrotechnics, cluster bombs & dispensers, cartridge & propellant actuated devices, electro-explosive devices, clandestine & improvised explosive devices, and all similar or related items or components explosive in nature.
<b>Explosive Ordnance Clearance (EOC)</b>	Explosive Ordnance Clearance is a term used to describe the operation of ordnance detection, investigation, identification and removal, with EOD being a separate operation.
<b>Explosive Ordnance Disposal (EOD)</b>	Explosive Ordnance Disposal is the detection, identification, on-site evaluation, rendering safe, recovery and final disposal of unexploded explosive ordnance.
<b>Explosive Ordnance Reconnaissance (EOR)</b>	Explosive Ordnance Reconnaissance is the detection, identification and on-site evaluation of unexploded explosive ordnance before Explosive Ordnance Disposal.
<b>Explosive Remnants of War (ERW)</b>	Explosive Remnants of War are Unexploded Ordnance (UXO) and Abandoned Explosive Ordnance (AXO), excluding landmines.

<b>Explosive Substances and Articles (ESA)</b>	<p>Explosive substance are solid or liquid substance (or a mixture of substances), which is either:</p> <ul style="list-style-type: none"> <li>capable by chemical reaction in itself of producing gas at such a temperature and pressure and at such a speed as to cause damage to the surroundings.</li> <li>designed to produce an effect by heat, light, sound, gas or smoke, or a combination of these as a result of a non-detonative, self-sustaining, exothermic reaction.</li> </ul> <p>Explosive article is an article containing one or more explosive substances.</p>
<b>Fuze</b>	<p>A fuze is the part of an explosive device that initiates the main explosive charge to function. In common usage, the word fuze is used indiscriminately, but when being specific (and in particular in a military context), fuze is used to mean a more complicated device, such as a device within military ordnance.</p>
<b>Gaine</b>	<p>Small explosive charge that is sometimes placed between the detonator and the main charge to ensure ignition.</p>
<b>High Explosive</b>	<p>Secondary explosives (commonly known as High Explosives (HE)) make up the main charge or filling of an ordnance device. They are usually less sensitive than primary explosives. Examples of secondary explosives are: Nitro glycerine (NG), Trinitrotoluene (TNT), AMATOL (Ammonia nitrate + TNT), Gunpowder (GP), and Cyclotrimethylenetrinitramine (RDX).</p>
<b>Munition</b>	<p>Munition is the complete device charged with explosives, propellants, pyrotechnics, initiating composition, or nuclear, biological or chemical material for use in military operations, including demolitions. This includes those munitions that have been suitably modified for use in training, ceremonial or non-operational purposes. These fall into three distinct categories:-</p> <ul style="list-style-type: none"> <li>inert - contain no explosives whatsoever.</li> <li>live - contain explosives and have not been fired.</li> <li>blind - have fired but failed to function as intended.</li> </ul>
<b>Primary Explosive</b>	<p>Primary explosives are usually extremely sensitive to friction, heat, and pressure. These are used to initiate less sensitive explosives. Examples of primary explosives are: Lead Azide, Lead Styphnate, and Mercury Fulminate. Primary explosive are commonly found in detonators.</p>
<b>Propellants</b>	<p>Propellants provide ordnance with the ability to travel in a controlled manner and deliver the ordnance to a predetermined target. Propellants burn rapidly producing gas, pressure and flame. Although usually in solid form they can be produced in liquid form. Examples of propellants are: Ballistite often found in a flake form and Cordite used in small arms ammunition.</p>
<b>Pyrotechnic</b>	<p>A pyrotechnic is an explosive article or substance designed to produce an effect by heat, light, sound, gas or smoke, or a combination of any of these, as a result of non-detonative, self-sustaining, exothermic chemical reactions.</p>

<b>Small Arms Ammunition (SAA)</b>	SAA includes projectiles around 12mm or less in calibre and no longer than approximately 100mm. They are fired from a variety of weapons, including rifles, pistols, shotguns and machine guns.
<b>Unexploded Anti-Aircraft (UXAA) Shell</b>	UXAA shells are army ordnance commonly containing HE, though they can also contain pyrotechnic compounds that produce smoke.  Most commonly, these were 3.7" and 4.5" HE shells, although they ranged from 2" to 5.25" calibre.
<b>Unexploded Bomb (UXB)</b>	UXB is a common term for unexploded air-dropped munitions.
<b>Unexploded Ordnance (UXO)</b>	UXO is explosive ordnance that has been either primed, fuzed, armed or prepared for use and has been subsequently fired, dropped, launched, projected or placed in such a manner as to present a hazard to operations, persons or objects and remains unexploded either by malfunction or design.
<b>V1</b>	The Vergeltungswaffe-1, V-1, also designated Fieseler Fi 103/FZG-76, known colloquially in English as the Flying Bomb, Buzz Bomb or Doodlebug, was the first guided missile used in WWII and the forerunner of today's cruise missile.
<b>V2</b>	The Vergeltungswaffe 2 (V-2) ('Reprisal Weapon 2') was the first ballistic missile. It was used by the German Army primarily against Belgian and British targets during the later stages of WWII. The V-2 was the first manmade object launched into space, during test flights that reached an altitude of 189km (117 miles) in 1944.

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