

Lower Thames Crossing
6.3 Environmental Statement
Appendices
Appendix 10.10 – Unexploded
Ordnance (UXO) Desk Study &
Risk Assessment

APFP Regulation 5(2)(a)

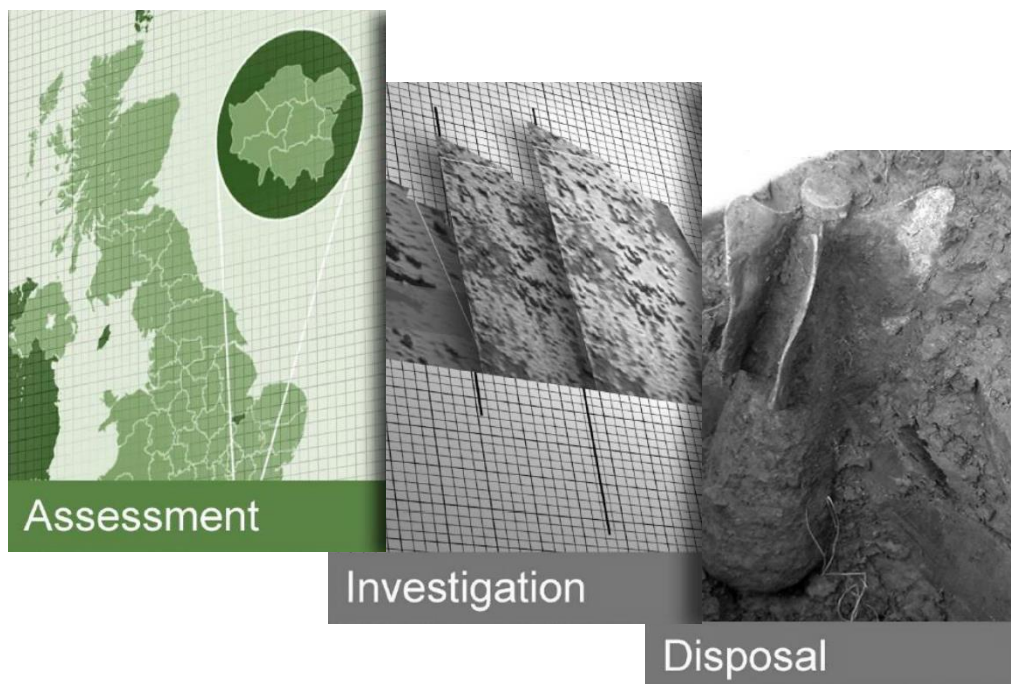
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Lower Thames Crossing - UXO Desk Study & Risk Assessment

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UXO DESK STUDY & RISK ASSESSMENT

EXECUTIVE SUMMARY

Key findings: Potential sources of Unexploded Ordnance (UXO) hazard have been identified on parts of the Site. These comprise hazards from deep-buried Unexploded Bombs (UXB) and shallow-buried UXO from military activity.

Key actions: In moderate hazard zones, non-intrusive UXO surveys are recommended in advance of intrusive works. Where piling or boreholes/cone penetration tests (CPT) are proposed in an area with a UXB hazard, deep UXB detection is recommended.

When the construction design is finalised, it is recommended that a detailed UXO risk mitigation strategy is commissioned.

UXO Hazard Assessment

The following potential sources of UXO hazard have been identified on the Site:

WWII Bombing (M1)

Records indicate that during World War Two (WWII) in excess of 512No. High Explosive (HE) bombs fell on the Site. At least 183No. of these were recorded as UXB.

It is considered prudent to assign a moderate UXO hazard level to 10No. parts of the Site where an elevated bombing density and high percentage of UXB were recorded.

Estimated bomb penetration depths in these areas vary between 2.5m and 18.5m depending on the weight of the bomb and the underlying geological materials (see **Table 4**).

River Thames (M2)

Several potential sources of UXO hazard have been identified on the part of the Site encompassing the River Thames.

The main anticipated ordnance hazard is from air-dropped UXB due to the heavy WWII raids in the region and Unexploded Anti-Aircraft (UXAA) shells fired from the numerous gun batteries in the vicinity of the Site.

This part of the Site is therefore assigned a moderate UXO hazard level.

Milton Range (M3)

Part of the Site encompasses Milton Range, which has been in use from the 19th century until the present day.

In addition to training with Small Arms Ammunition (SAA), records indicate that the range was used for mortar practice during WWII, providing a potentially significant hazard.

This part of the Site is assigned a moderate UXO hazard level due to the potential presence of mortars (and other Close Combat Munitions such as hand grenades) at shallow depths.

Pipe Mines at RAF Gravesend (M4)

Canadian Pipe Mines were laid under the runways and perimeter track at Royal Air Force (RAF) Gravesend at the beginning of WWII so that the airfield could be destroyed in the event of a German invasion.

Part of the Site encroached upon the area that was pipe mined and records suggest that not all of the mines were removed during WWII and post-WWII clearances.

Therefore, it is considered prudent to assign this part of the Site a moderate UXO hazard level to account for the possibility that pipe mines remain in situ.

Bomber aircraft crashes (M5)

There are records of 2No. WWII bomber aircraft crashes on the Site at Botany Farm, near Orsett, and at Clay Tye Hill, near North Ockendon. No records have been found to indicate whether the bombs being carried by these aircraft had already been dropped, exploded on impact, or were retrieved from the crash site.

It is therefore considered prudent to assign these parts of the Site a moderate UXO hazard level at shallow depths to account for the possibility that UXB are present.

Remainder of the Site

No records of any significant bombing or other sources of UXO hazard have been identified on the remainder of the Site, which is assigned a low UXO hazard level.

It should be noted that during WWII the Site was located in an area subjected to heavy bombing due to its proximity to Continental Europe and being on the flightpath to important strategic targets. Numerous Anti-Aircraft (AA) batteries were established on the Site and in the surrounding area to defend against air raids.

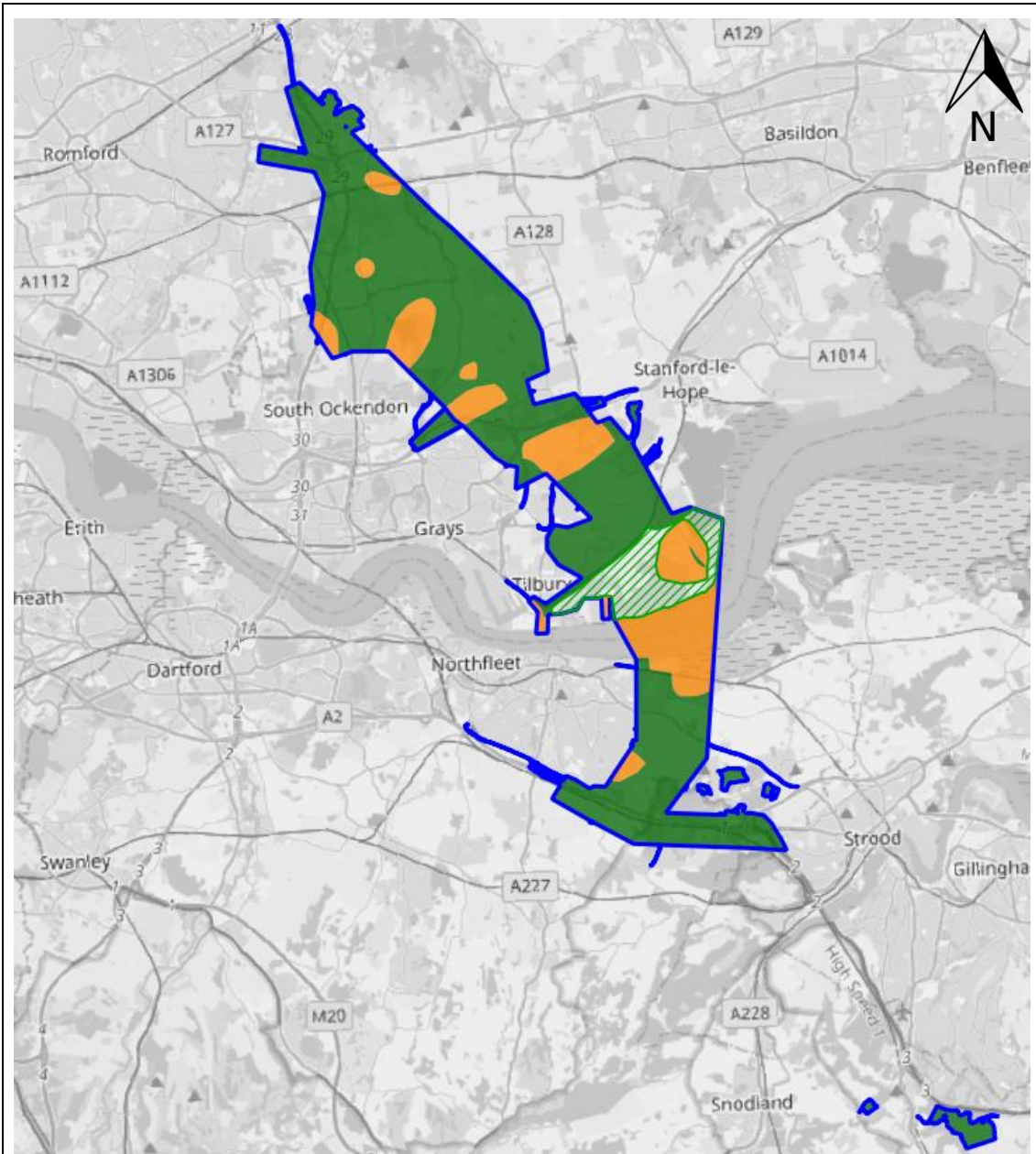
Large parts of the Site comprised marshland during WWII and it possible that bomb and shell impacts may have been missed and gone unrecorded in uninhabited areas.

As such, the potential for encountering a UXB or UXAA shell anywhere on the Site cannot be discounted.

It is considered that the UXO hazard level on the Site can be zoned from low to moderate, as shown in the Figure below, reproduced as **Figure 20** in the main report.

The UXO hazard zone plan of the Site is also given in the accompanying HE540039-ZET-GEN-GEN-MAP-GEO-00001-P05.

UXO hazard zone plan of the Site



Source: OpenStreetMap

Not to Scale

Legend	Very Low		Low		Moderate	
	High		Very High		Low (Tilbury Marsh)	
	Site boundary					

The Figures below, reproduced as **Figures 21 to 25** in the main report, provide more detailed extracts of the moderate UXO hazard level zones on the Site.

UXO hazard zone plan of the Site (Great Warley to Upminster)

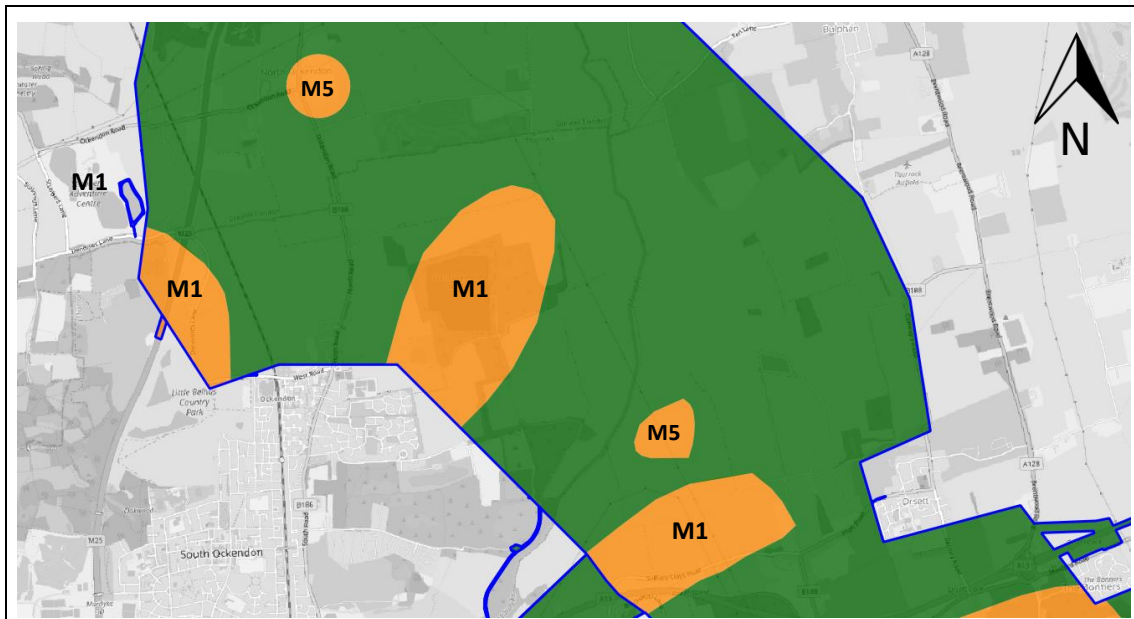


Source: OpenStreetMap

Not to Scale

Legend	Very Low		Low		Moderate	
	High		Very High		Site boundary	

UXO hazard zone plan of the Site (North Ockendon to Baker Street)

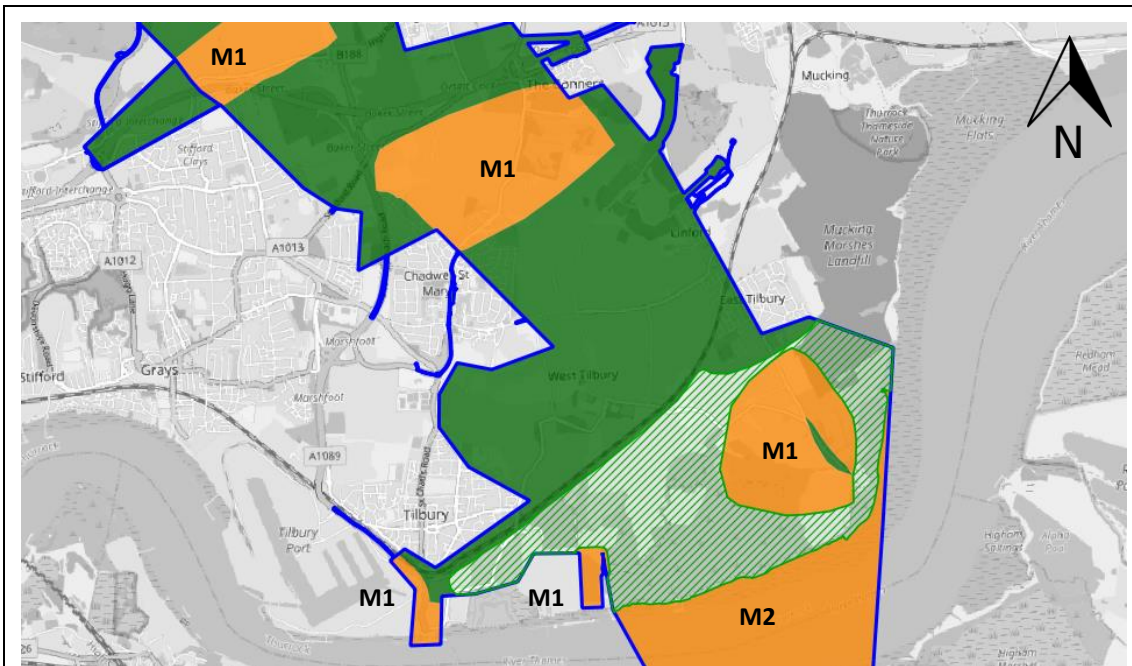


Source: OpenStreetMap

Not to Scale

Legend	Very Low		Low		Moderate	
	High		Very High		Site boundary	

UXO hazard zone plan of the Site (Baker Street to Tilbury)

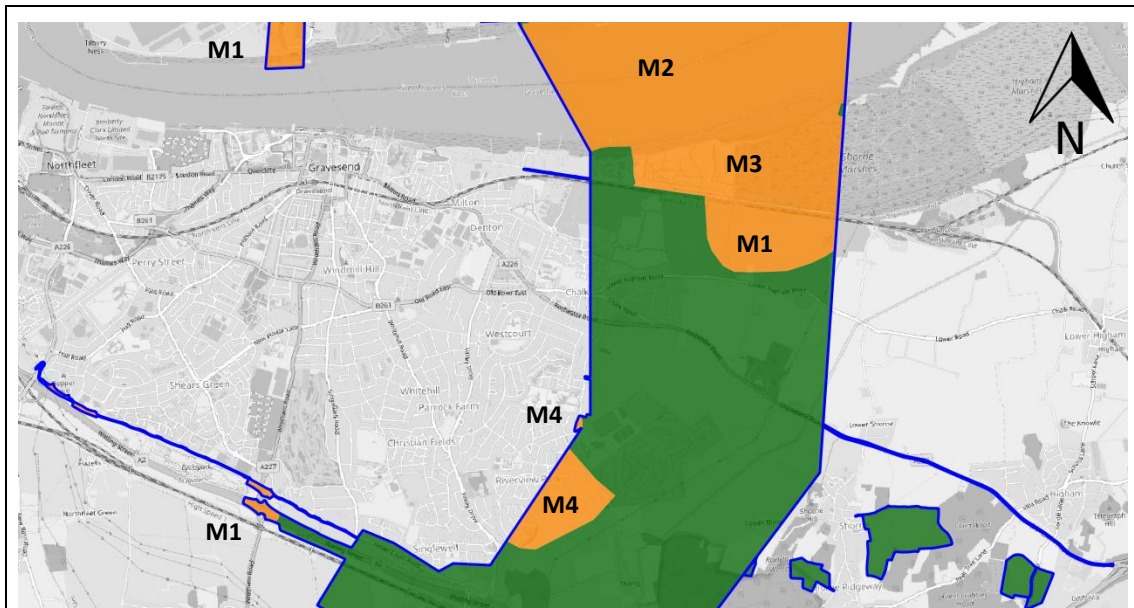


Source: OpenStreetMap

Not to Scale

Legend	Very Low		Low		Moderate	
	High		Very High		Low (Tilbury Marsh)	
	Site boundary					

UXO hazard zone plan of the Site (River Thames to Cobham)

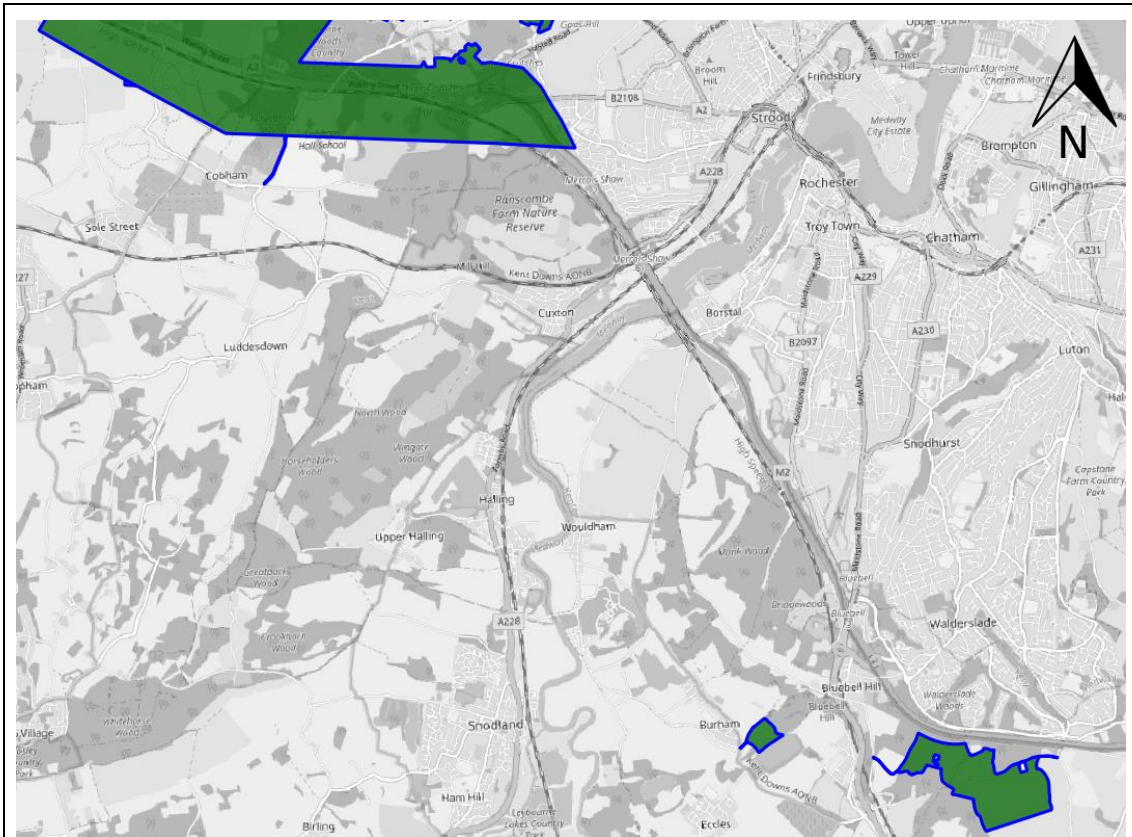


Source: OpenStreetMap

Not to Scale

Legend	Very Low		Low		Moderate	
	High		Very High		Site boundary	

UXO hazard zone plan of the Site (Cobham and Westfield Sole)



Source: OpenStreetMap

Not to Scale

Legend	Very Low		Low		Moderate	
	High		Very High		Site boundary	

Note that the UXO hazard will have been mitigated within the depth and extents of any post-WWII intrusive works.

The main findings of the report are summarised below.

- During the mid-19th century, Milton Range was established on the Site. It was used extensively for rifle training during World War One (WWI) and WWII, in addition to being used for mortar practice.
- No records of bombing on the Site during WWI have been found.
- In 1939 RAF Gravesend was established on the Site. It operated as a Fighter Command airfield. In 1940, pipe mines were laid under the airfield’s runways and perimeter track as part of the region’s anti-invasion defences.
- During WWII multiple fighter and bomber aircraft crashed in the vicinity of the Site. 2No. of these are assigned moderate UXO hazard levels.
- In 1944, large parts of the Site were encompassed by D-Day Marshalling Area ‘S’, which included military roads, storage areas and camps at Great Warley and Orsett. This activity is not considered to provide a significant source of UXO hazard to the Site.
- During WWII the main strategic targets in the vicinity of the Site included Tilbury Docks, transport infrastructure, public utilities, major industries important to the war effort, and military establishments, such as Milton Range and RAF Gravesend.

- Records have been found indicating that at least 512No. HE bombs fell on the Site during WWII. 183No. of these were recorded as UXB.
- Estimated average maximum bomb penetration depths on the Site range from 2.5m to 18.5m depending on the weight of the bomb.
- In 1956 RAF Gravesend was decommissioned. The airfield has since been redeveloped into housing. Records indicate that not all of the pipe mines laid at the airfield were removed during WWII and post-WWII clearances and may remain in situ.
- Milton Range has remained operational post-WWII. It currently operates as the practice firing area for the Metropolitan Police Specialist Training Centre.

Data Confidence Level

The findings of this report were based on fair corroborative evidence of the military activity and bombing on the Site.

It should be noted that some WWII Air Raid Precaution (ARP) records for Thurrock Urban District (UD) do not give detailed locations of where bombs fell on Tilbury Marsh, only stating that ‘bombs fell on Tilbury Marsh’.

As such, it may be prudent in these areas to undertake additional risk mitigation where intrusive works are proposed.

Proposed Works

It is understood that works on the Site associated with a proposed road tunnel crossing of the Thames estuary. Initial works on the Site will comprise the following intrusive ground investigations, including cable percussion boreholes with wireline rotary drilling following on at designated locations, dynamic and windowless sampling boreholes, trial pits and CPT.

Subsequent works on the Site will involve the construction of a twin bore tunnel under the River Thames between Tilbury and Milton. The final construction design is yet to be formalised.

Risk Assessment

The Table below, reproduced as **Table 6** in the main report, provides a UXO risk assessment for the proposed works on the Site.

Further details on the methodology for the risk assessment are provided in Section 8.2 of the main report.

UXO risk assessment for the Site

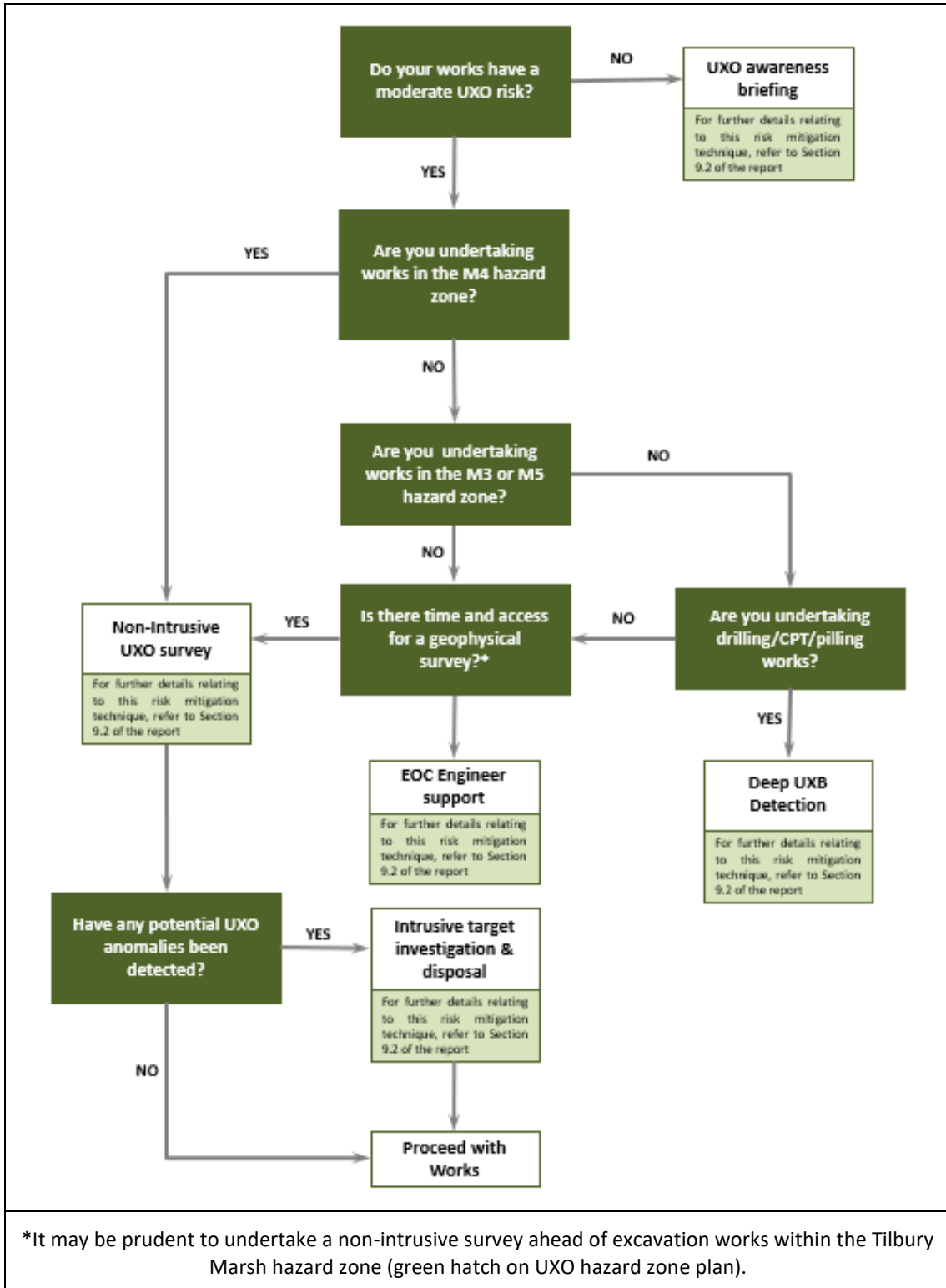
Hazard Zone	Potential UXO Hazard	Anticipated Works	PE	PD	P = PE x PD	Likelihood	Severity	Risk Rating	UXO Risk
M1	UXB	Shallow Excavations	2	3	6	3	5	15	Moderate
		Deep Excavations	3	3	9	3	5	15	Moderate
		Boreholes/CPT/Pilling	2	4	8	3	4	12	Moderate
	UXAA Shells	Shallow Excavations	1	1	1	1	4	4	Low
		Deep Excavations	1	1	1	1	4	4	Low
		Boreholes/CPT/Pilling	1	1	1	1	3	3	Low
	Close Combat Munitions	Shallow Excavations	1	1	1	1	4	4	Low
		Deep Excavations	1	1	1	1	4	4	Low
		Boreholes/CPT/Pilling	1	1	1	1	3	3	Low
	SAA	Shallow Excavations	2	1	2	2	2	4	Low
		Deep Excavations	2	1	2	2	2	4	Low

		Boreholes/CPT/Pilling	1	1	1	1	2	2	Low	
M2	UXB	Boreholes/CPT/Pilling	3	4	12	3	4	12	Moderate	
	UXAA Shells	Boreholes/CPT/Pilling	2	4	8	3	3	9	Moderate	
	Close Combat Munitions	Boreholes/CPT/Pilling	1	1	1	1	3	3	Low	
	SAA	Boreholes/CPT/Pilling	2	1	2	1	2	4	Low	
M3	UXB	Shallow Excavations	1	1	1	1	5	5	Low	
		Deep Excavations	1	1	1	1	5	5	Low	
		Boreholes/CPT/Pilling	1	1	1	1	4	4	Low	
	UXAA Shells	Shallow Excavations	1	1	1	1	4	4	Low	
		Deep Excavations	1	1	1	1	4	4	Low	
		Boreholes/CPT/Pilling	1	1	1	1	3	3	Low	
	Close Combat Munitions	Shallow Excavations	3	3	9	3	4	12	Moderate	
		Deep Excavations	3	3	9	3	4	12	Moderate	
		Boreholes/CPT/Pilling	2	4	8	3	3	9	Moderate	
	SAA	Shallow Excavations	4	1	4	2	2	4	Low	
		Deep Excavations	4	1	4	2	2	4	Low	
		Boreholes/CPT/Pilling	2	1	2	2	2	2	Low	
M4	UXB	Shallow Excavations	1	1	1	1	5	5	Low	
		Deep Excavations	1	1	1	1	5	5	Low	
		Boreholes/CPT/Pilling	1	1	1	1	4	4	Low	
	UXAA Shells	Shallow Excavations	1	1	1	1	4	4	Low	
		Deep Excavations	1	1	1	1	4	4	Low	
		Boreholes/CPT/Pilling	1	1	1	1	3	3	Low	
	SAA	Shallow Excavations	2	1	2	2	2	4	Low	
		Deep Excavations	2	1	2	2	2	4	Low	
		Boreholes/CPT/Pilling	1	1	1	1	2	2	Low	
	Pipe Mines	Shallow Excavations	2	5	10	3	4	12	Moderate	
		Deep Excavations	3	2	6	3	4	12	Moderate	
		Boreholes/CPT/Pilling	2	3	6	3	3	9	Moderate	
	M5	UXB	Shallow Excavations	2	3	6	3	5	15	Moderate
			Deep Excavations	2	3	6	3	5	15	Moderate
			Boreholes/CPT/Pilling	2	4	8	3	4	12	Moderate
UXAA Shells		Shallow Excavations	1	1	1	1	4	4	Low	
		Deep Excavations	1	1	1	1	4	4	Low	
		Boreholes/CPT/Pilling	1	1	1	1	3	3	Low	
Close Combat Munitions		Shallow Excavations	1	1	1	1	4	4	Low	
		Deep Excavations	1	1	1	1	4	4	Low	
		Boreholes/CPT/Pilling	1	1	1	1	3	3	Low	
SAA		Shallow Excavations	2	1	2	2	2	4	Low	
		Deep Excavations	2	1	2	2	2	4	Low	
		Boreholes/CPT/Pilling	1	1	1	1	2	2	Low	
Low		UXB	Shallow Excavations	1	1	1	1	5	5	Low
			Deep Excavations	1	1	1	1	5	5	Low
			Boreholes/CPT/Pilling	1	1	1	1	4	4	Low
	UXAA Shells	Shallow Excavations	1	1	1	1	4	4	Low	
		Deep Excavations	1	1	1	1	4	4	Low	
		Boreholes/CPT/Pilling	1	1	1	1	3	3	Low	
	Close Combat Munitions	Shallow Excavations	1	1	1	1	4	4	Low	
		Deep Excavations	1	1	1	1	4	4	Low	
		Boreholes/CPT/Pilling	1	1	1	1	3	3	Low	
	SAA	Shallow Excavations	1	1	1	1	2	2	Low	
		Deep Excavations	1	1	1	1	2	2	Low	
		Boreholes/CPT/Pilling	1	1	1	1	2	2	Low	
	PE (Probability of Encounter), PD (Probability of Detonation), P (Overall Probability)									
	Shallow Excavations defined as <1.0m bgl.									

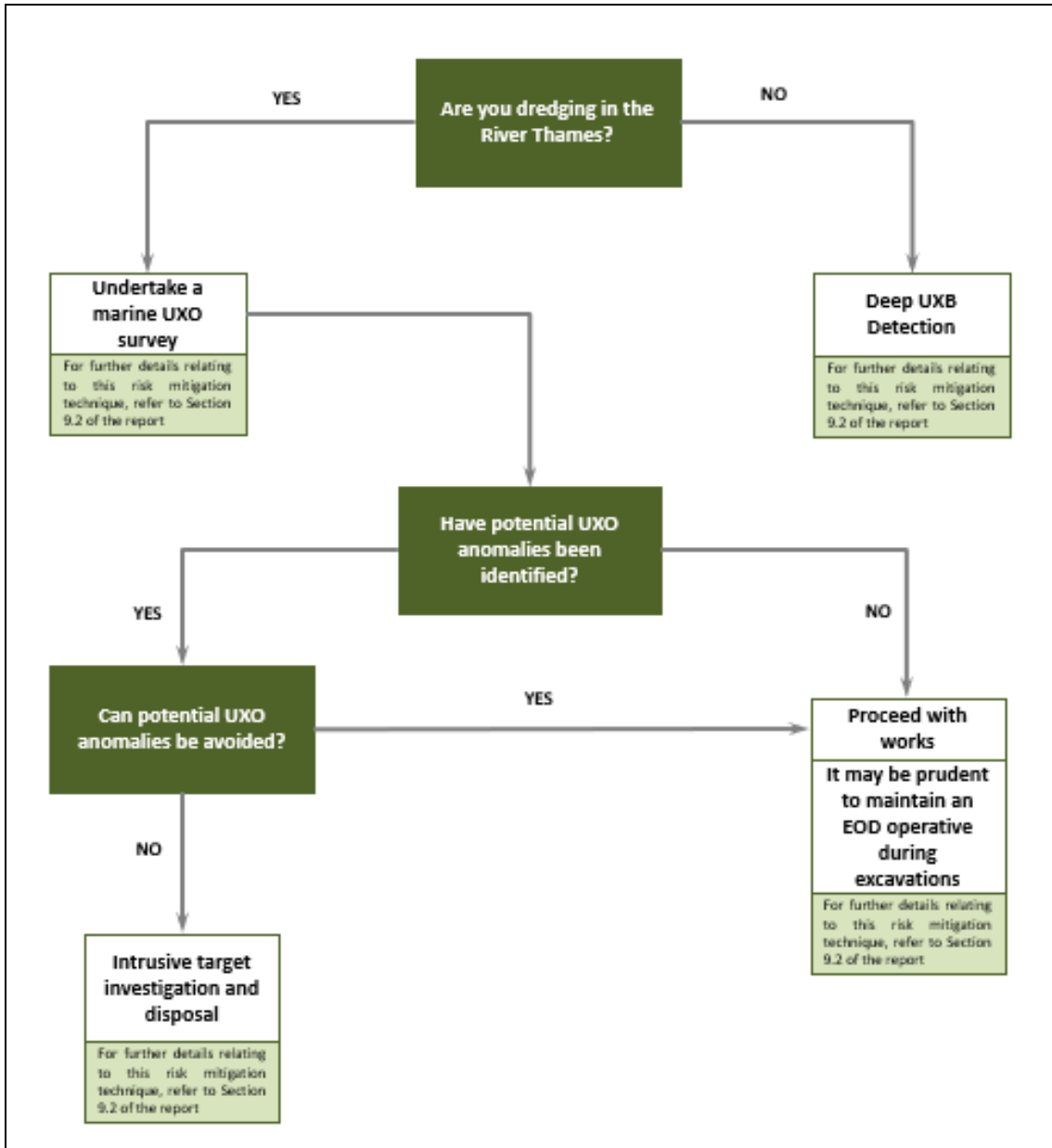
Risk Mitigation Plan

The Figures below, reproduced as **Figures 26 and 27** in the main report, provides a risk mitigation plan to ensure that the UXO risk for the proposed works is reduced to As Low As Reasonably Practicable (ALARP).

Recommended risk mitigation plan for the Site (Landward Areas)










Recommended risk mitigation plan for the Site (River Thames)



Details on the recommended risk mitigation techniques are given in Section 9.2 of this report.

The Table below, reproduced as Table 7 in the main report, summarises the UXO risk for proposed works on the Site and recommended techniques to mitigate the risk.

Summary of UXO risk and mitigation recommendations

Proposed Works	UXO Risk	Recommended Mitigation
Excavations		UXO awareness briefing – Given the Site’s military history it is recommended that a formal UXO awareness briefing is provided to staff involved in excavation.
Excavations (In hatched areas)		UXO awareness briefing – as above. It may be prudent to undertake a non-intrusive UXO survey in advance of excavations on Tilbury Marshes where there is a lower confidence in the assessed UXO hazard level.
Boreholes/CPT/Piling		Proceed with works
M1, M3, M4 and M5 - Excavations		Non-intrusive survey – where practical, a non-intrusive UXO survey should be undertaken in advance of intrusive ground investigations to detect potential shallow-buried UXO. Potential UXO targets detected can either be avoided or intrusively investigated and removed.
M1 - Boreholes/CPT/Piling		Deep UXB detection – to clear borehole and CPT locations of potential UXB, an intrusive magnetometer survey should be undertaken until either the maximum bomb penetration or maximum drilling/CPT/piling depth is reached.
M2 - Jack-up barge installation		Deep UXB detection – as above, deep UXB detection to be undertaken at jack-up barge leg positions to ensure that they are clear of UXB.
M2 - Dredging		Marine UXO survey – A non-intrusive magnetometer survey should be undertaken in advance of dredging to detect potentially hazardous UXO.

Risk Mitigation Plan

It is recommended that a detailed risk mitigation plan is devised based on the information provided in this desk study and risk assessment, the proposed construction methodology, and the requirements of any planning conditions.

This should outline the recommended risk mitigation techniques in relation to the identified UXO hazards, proposed construction methods, and intended phase of works.

These risk mitigation measures are to be discussed and confirmed with the client to ensure that the level of proposed mitigation is appropriate for the intended use and the client's risk tolerance, and carefully addresses the often emotive issue surrounding UXO and development.

Outline Explosive Ordnance Disposal (EOD) proposals are also to be detailed to account for the type of UXO anticipated.

The contents and structure of any risk mitigation plan can be discussed with Zetica prior to compilation.

What Do I Do Next?

If you wish to proceed with UXO risk mitigation, Zetica would be happy to assist. Just contact us via phone (01993 886682) or email (uxo@zetica.com) and we can provide a proposal with options and prices.

If you have requirements to identify other buried hazards (such as mapping utilities or obstructions) we can provide these surveys.

If proposed works on the Site change, or additional works are planned, contact Zetica for a re-assessment of the UXO risk and the risk mitigation requirements.

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Accompanying GIS Data

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ABBREVIATIONS

AA	Anti-Aircraft
AM	Air Ministry
ALARP	As Low As Reasonably Practicable
ARP	Air Raid Precaution
AT	Anti-Tank
AXO	Abandoned Explosive Ordnance
BD	Bomb Disposal
BDO	Bomb Disposal Officer
BDU	Bomb Disposal Unit
BL	Breech Loading
CMD	Conventional Munitions Disposal
DAB	Delayed Action Bomb
DEL	Defence Electric Lights
DEMS	Defensively Equipped Merchant Ships
DCLG	Department of Communities and Local Government
EO	Explosive Ordnance
EOC	Explosive Ordnance Clearance
EOR	Explosive Ordnance Reconnaissance
ERFTS	Elementary & Refresher Training School
ERW	Explosive Remnants of War
ESA	Explosive Substances and Articles
FFE	Free From Explosives
GDA	Gun Defended Area
HAA	Heavy Anti-Aircraft
HE	High Explosive
HMS	His Majesty's Ship
HMT	His Majesty's Trawler
HSE	Health and Safety Executive
IB	Incendiary Bomb
IED	Improvised Explosive Device
IEDD	Improvised Explosive Device Disposal
JSEODOC	Joint Services EOD Operations Centre
LAA	Light Anti-Aircraft
LG	Lewis Gun
MoD	Ministry of Defence
MU	Maintenance Unit
OB	Oil Bomb
PLUTO	Pipe Line Under The Ocean
PM	Parachute Mine
POL	Petroleum, Oils & Lubricants
PUCA	Pick Up and Carry Away
QF	Quick Firing
RA	Royal Artillery
RAF	Royal Air Force
RASC	Royal Army Service Corps
REME	Royal Electrical & Mechanical Engineers
RFC	Royal Flying Corps
RML	Rifle Muzzle-Loading

RN	Royal Navy
TEP	Time Expired Pyrotechnics
SAA	Small Arms Ammunition
SLG	Satellite Landing Ground
UXAA	Unexploded Anti-Aircraft
UXB	Unexploded Bomb
UXIB	Unexploded Incendiary Bomb
UXO	Unexploded Ordnance
VG	Vickers Gun
WWI	World War One
WWII	World War Two

UXO DESK STUDY & RISK ASSESSMENT

Please read: 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.

Boxed paragraphs in a dark green text with a green background are paragraphs providing general information and, where appropriate, links to online resources giving further detail. These are all available at www.zeticauxo.com. If you cannot gain access to these resources, Zetica can forward them on request.

1 INTRODUCTION

1.1 Project Outline

Zetica Ltd was commissioned by Arcadis on behalf of National Highways to carry out an Unexploded Ordnance (UXO) Desk Study and Risk Assessment for the Order Limits of the Lower Thames Crossing Project (the 'Site'). This comprises an approximately 100.5km² area centred on an approximately 38km long route between Great Warley in Essex and Westfield Sole in Kent.

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' and C754 'Assessment and Management of Unexploded Ordnance (UXO) Risk in the Marine Environment'.

Where appropriate, this hazard assessment includes:

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

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

1.2 Sources of Information

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

1.2.1 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.

1.2.2 Zetica Ltd Bombing Density Records and Maps

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

1.2.3 Ministry of Defence and Government Records

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 Department of Communities and Local Government (DCLG) records of abandoned bombs.

1.2.4 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 & Records Administration (NARA), the Imperial War Museum (IWM), Historic England, National Collection of Aerial Photography (NCAP), the Royal Air Force (RAF) Museum, and the Defence of Britain Project.

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

1.2.5 Local Authority Records

Information was obtained from Kent County Council, Essex County Council and Havering Borough Council.

1.2.6 Local Record Offices and Libraries

Kent Archives & Local History Service and Essex Record Office were consulted for records.

1.2.7 Local Historical and Other Groups

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

1.3 Data Confidence Level

In general, there is a high level of confidence in the researched information sources used for this report.

It should be noted that some WWII Air Raid Precaution (ARP) records for Thurrock Urban District (UD) do not give detailed locations of where bombs fell on Tilbury Marsh, only stating that 'bombs fell on Tilbury Marsh'.

Other evidence (including bomb census maps, bomb damage maps and newspaper reports) have been used to gain a corroborative assessment of the potential UXO hazard on the Site.

2 THE SITE

2.1 Site Location

The Site commences near Junction 28 of the M25 at Ordnance Survey National Grid Reference (OSNGR) TQ 569922 and terminates southeast of Junction 3, M2 at TQ 772613.

For clarity, the Site has been divided into 3No. parts. These are described below.

Northern part of the Site

The Northern part of the Site commences west of Brentwood (TQ 569922) and ends north of Baker Street (TQ 619825).

It comprises parts of the M25, A127, minor roadway, and agricultural land.

Central part of the Site

The central part of the Site commences north of Baker Street (TQ 619825) and ends at Tilbury Marshes, on the northern bank of the River Thames (TQ 682759).

It comprises parts of the A13, minor roadway, agricultural land and open marshland.

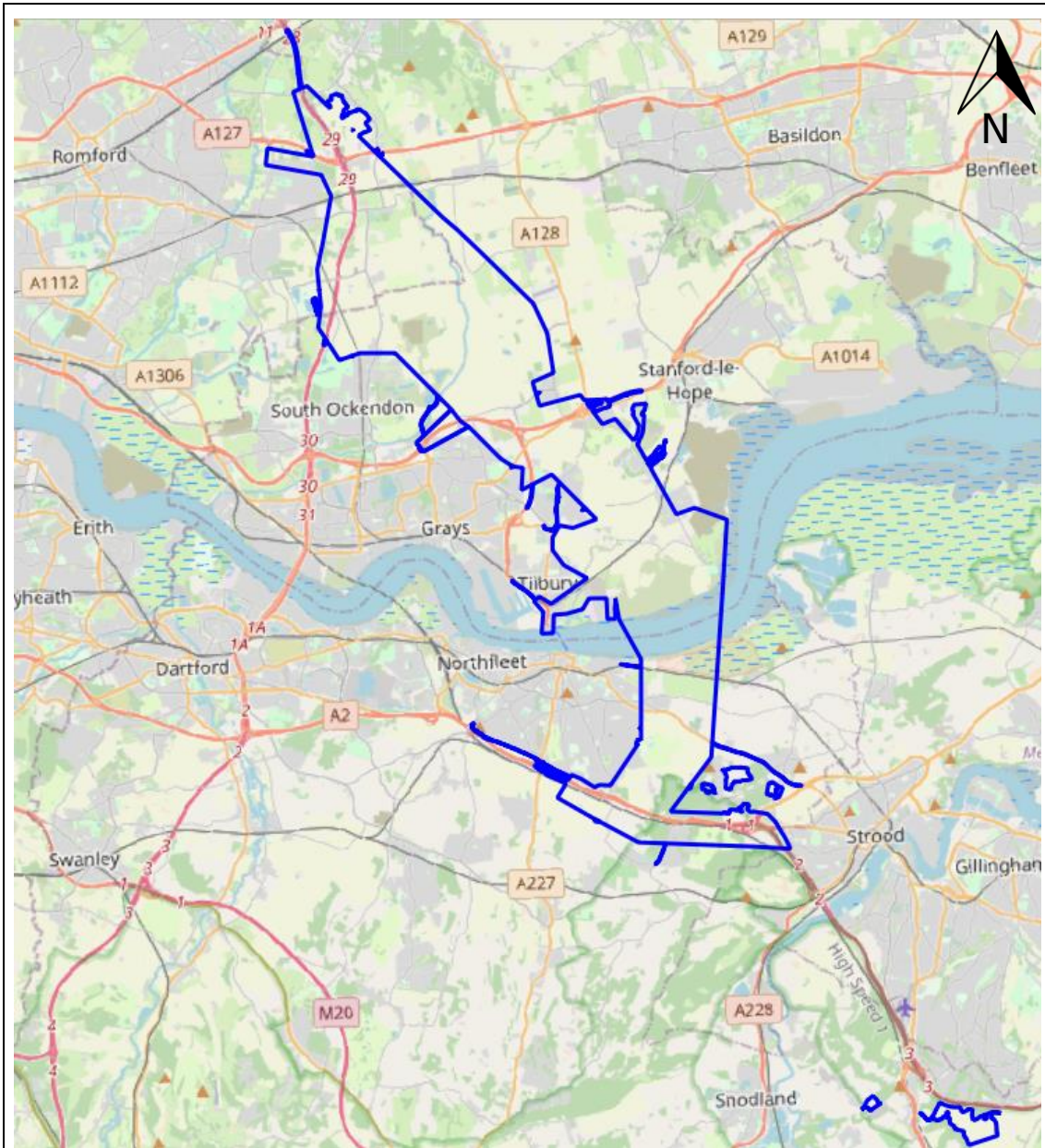
Southern part of the Site

The southern part of the Site commences at the northern bank of the River Thames (TQ 682759) and ends at Cobham (TQ 669691). 2No. additional areas are located at Westfield Sole (TQ 772613 and TQ 735616).

It comprises the River Thames crossing between Essex and Kent, open marshland and agricultural land, in addition to sections of the A2, A226 and minor roadway.

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

Figure 1 Site location map



Source: OpenStreetMap

Not to Scale


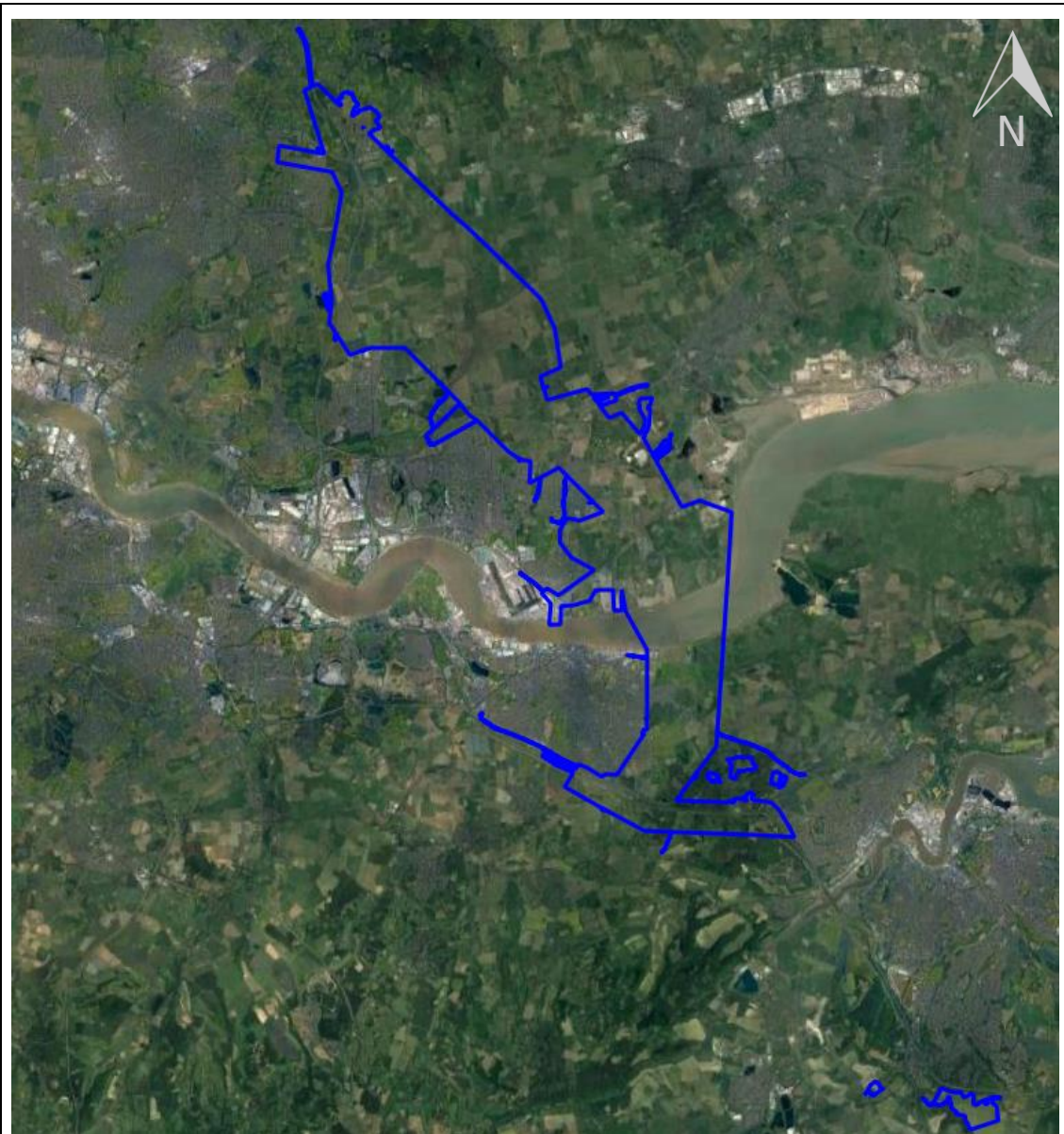

Legend	Site boundary 
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Plate 1 Recent aerial photograph of the Site



Source: Google Earth

Not to Scale

Legend	Site boundary 
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3 MILITARY ACTIVITY

The following sections outline the recorded military activity in the vicinity of the Site. The potential UXO hazard from World War One (WWI) and World War Two (WWII) bombing is detailed in Section 4.

Each sub-section provides hyperlinks to further information on potential sources of UXO hazard. These are also available at www.zeticauxo.com. If you cannot gain access to these resources, Zetica can forward them on request.

3.1 Defences

For further information on military defences, and the potential UXO hazards associated with them, follow the links below:

- [Anti-Aircraft Guns](#)
- [Anti-Invasion Defences](#)
- [Barrage Balloons](#)
- [Bombing Decoys](#)
- [Home Guard](#)
- [Mined Locations](#)
- [Mortar & Gun Emplacements](#)
- [Pillboxes](#)

The nearest military defences to the Site are described below.

3.1.1 Anti-Aircraft Guns

During WWI there were 37No. Anti-Aircraft (AA) batteries within 10km of the Site. The nearest was located at Tilbury Fort (TQ 650754), approximately 0.1km south of the central part of the Site. Its armament is unknown.

During WWII there were 46No. Heavy AA (HAA) and ZAA batteries within 10km of the Site. These formed part of the Thames & Medway Gun Defended Area (GDA). 4No. HAA gun batteries were located on the Site. These are described in Sections 3.1.3 through to 3.1.6.

Additionally, 5No. Light Anti-Aircraft (LAA) gun emplacements were established on the Site during WWII, with a further 5No. located within approximately 1km of the Site (see Section 3.1.2).

Records have been found to indicate that multiple AA shells fell on the Site during WWII. A full list of recorded WWII AA shell incidents is provided in Appendix 5.

Potential UXO Hazard

Given the number of HAA and LAA gun batteries in the surrounding area during WWII, the potential for an Unexploded AA (UXAA) shell to have fallen on the Site unnoticed cannot be discounted. This forms part of the low background risk for any similar site in the UK.

Details on the HAA and LAA guns identified on the Site are provided in the following sections.

3.1.2 LAA Gun Emplacements

During WWII vulnerable points in the vicinity of the Site, such as airfields, oil installations and docks, were protected by additional LAA gun emplacements. These typically comprised either

40mm Bofors guns, Lewis machine guns (LG) or Vickers machine guns (VG). Records indicate that 5No. LAA gun emplacements were located on the Site.

1No. .303-inch (") LG, VG2 (TQ 673718), and 1No. 40mm Bofors gun and 1No. 303" LG, VG3 (TQ 672712), were located at RAF Gravesend, on the southern part of the Site. These formed part of the airfield's AA defences (see Section 3.2.3).

1No. Quad VM was located at World's End, Tilbury (TQ 646759), on central part of the Site. This formed part of the dock's defences. 2No. 40mm Bofors guns were also located at Coalhouse Fort (TQ 691768), on the central part of the Site (see Section 3.6.5).

All LAA gun emplacements on the Site were removed or abandoned by the end of WWII.

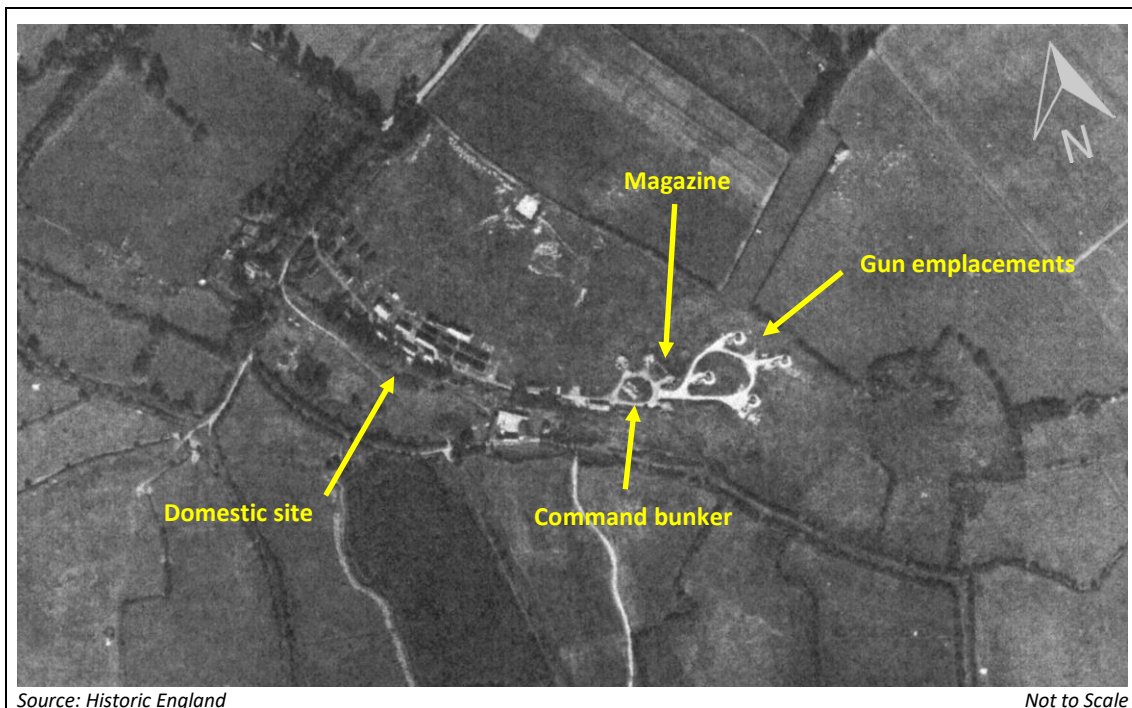
3.1.3 HAA Battery TN13, Buckland

In February 1940 HAA battery TN13 was established at Buckland Farm, East Tilbury (TQ 678771), on the central part of the Site. It was initially armed with 2No. 3.7" guns, before being upgraded to 4No. 5.25" guns by November 1944.

Plate 2 is an aerial photograph of HAA battery TN13, Buckland, dated the 11th October 1946.

Each gun emplacement had inbuilt ammunition recesses and there was a control bunker (including command post, height finder and predictor) at the centre of the battery.

Plate 2 Aerial photograph of HAA battery TN13, Buckland, 11th October 1946



The HAA gun battery at Buckland Farm was retained after WWII as an Off-Site Nucleus Battery in 1946. It currently comprises open ground as part of Buckland Farm.

3.1.4 HAA Battery TN14, Orsett

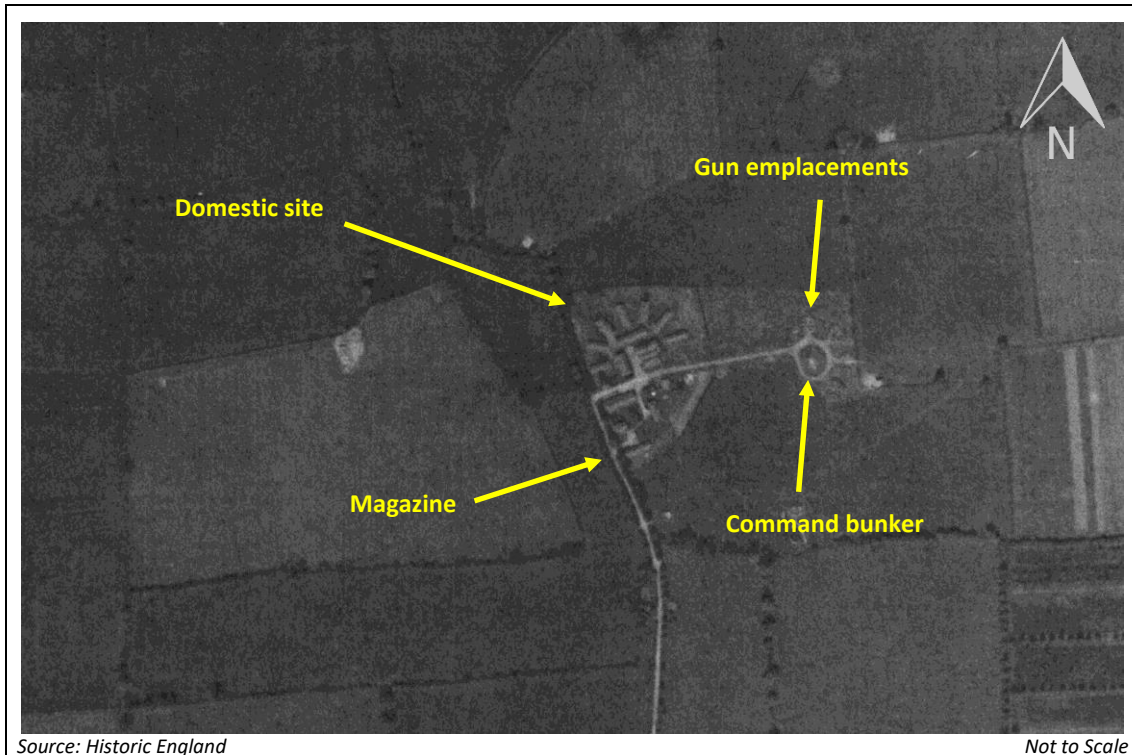
By mid-1940, HAA battery TN14 had been established at Orsett (TQ 643828), on the northern part of the Site. It is recorded as being unarmed in 1942.

Typically, gun emplacement had inbuilt ammunition recesses and there was a control bunker (including command post, height finder and predictor) at the centre of the battery.

Plate 3 is an aerial photograph of HAA battery TN14, Orsett, dated the 1st May 1946.

It indicates that the battery comprised 4No. gun emplacements.

Plate 3 Aerial photograph of HAA battery TN14, Orsett, 1st May 1946



Post-WWII the HAA gun battery was abandoned. Historical mapping indicates that the gun emplacements were removed by 1960 and the last remnants of the camp were removed by the 1970s. Part of the former camp area is occupied by housing and land occupied by the gun emplacements has been returned to agriculture.

3.1.5 HAA Battery TN15, Chadwell

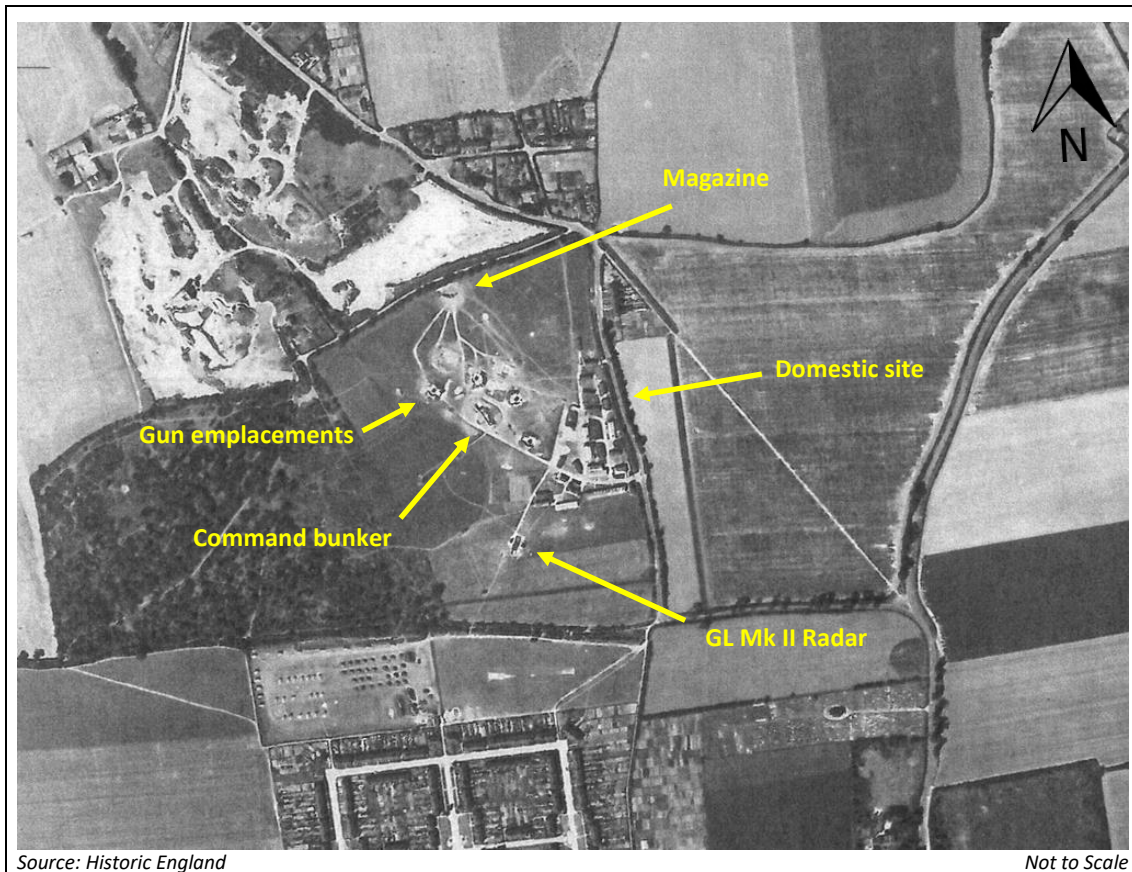
In February 1940, HAA battery TN15 was established at Chadwell (TQ 643796), on the central part of the Site. It was armed with 4No. 4.5" guns and had an associated GL Mark II radar.

Records indicate that it was manned by No. 8 Battery, 2nd Royal Artillery (RA) Regiment in 1942, and by No. 616 Battery, 184th (Mixed) RA Regiment in 1943.

Plate 4 is an aerial photograph of HAA battery TN15, Chadwell, dated the 4th August 1944.

Each gun emplacement had inbuilt ammunition recesses and there was a control bunker (including command post, height finder and predictor) at the centre of the battery.

Plate 4 Aerial photograph of HAA battery TN15, Chadwell, 4th August 1944



Post-WWII it was retained as an Off-Site Nucleus Battery. Historical mapping indicates that the land occupied by the gun emplacements and camp area had been mostly redeveloped for housing by the 1960s.

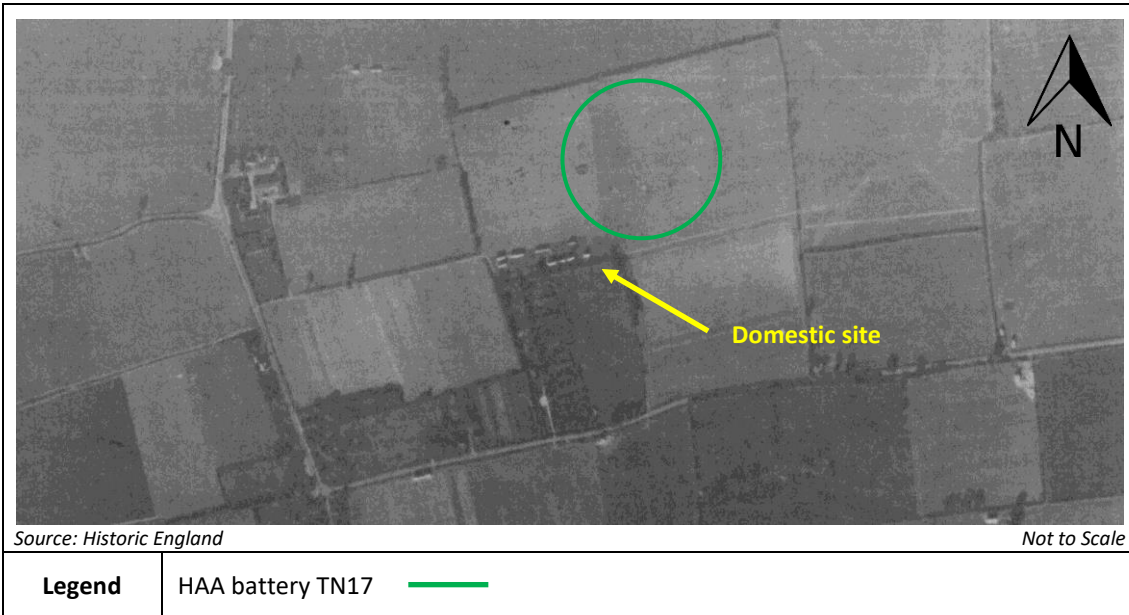
3.1.6 HAA Battery TN17, North Ockendon

By February 1940, HAA battery TN17 had been established off Fen Lane, North Ockendon (TQ 599856), on the northern part of the Site. It is recorded as being unarmed in 1942.

Plate 5 is an aerial photograph of HAA battery TN17, North Ockendon, dated the 11th October 1946. This shows the approximate position of the battery, highlighted in green.

No permanent gun emplacements appear to have been constructed for this HAA battery, and only faint remnants of their position are visible on historical photography. The camp is still present.

Plate 5 Aerial photograph of HAA battery TN17, North Ockendon, 11th October 1946



There is no evidence of the gun site or camp on post-WWII mapping and the land is currently under agricultural use.

Potential UXO Hazard

HAA and LAA gun batteries often had associated ammunition stores, which were typically removed when the positions were dismantled at the end of WWII.

While the possibility of local munitions disposal around defended positions can never be totally discounted, no evidence has been found to suggest that any disposal activities took place on the Site. This forms part of the low background risk for any similar site in the UK.

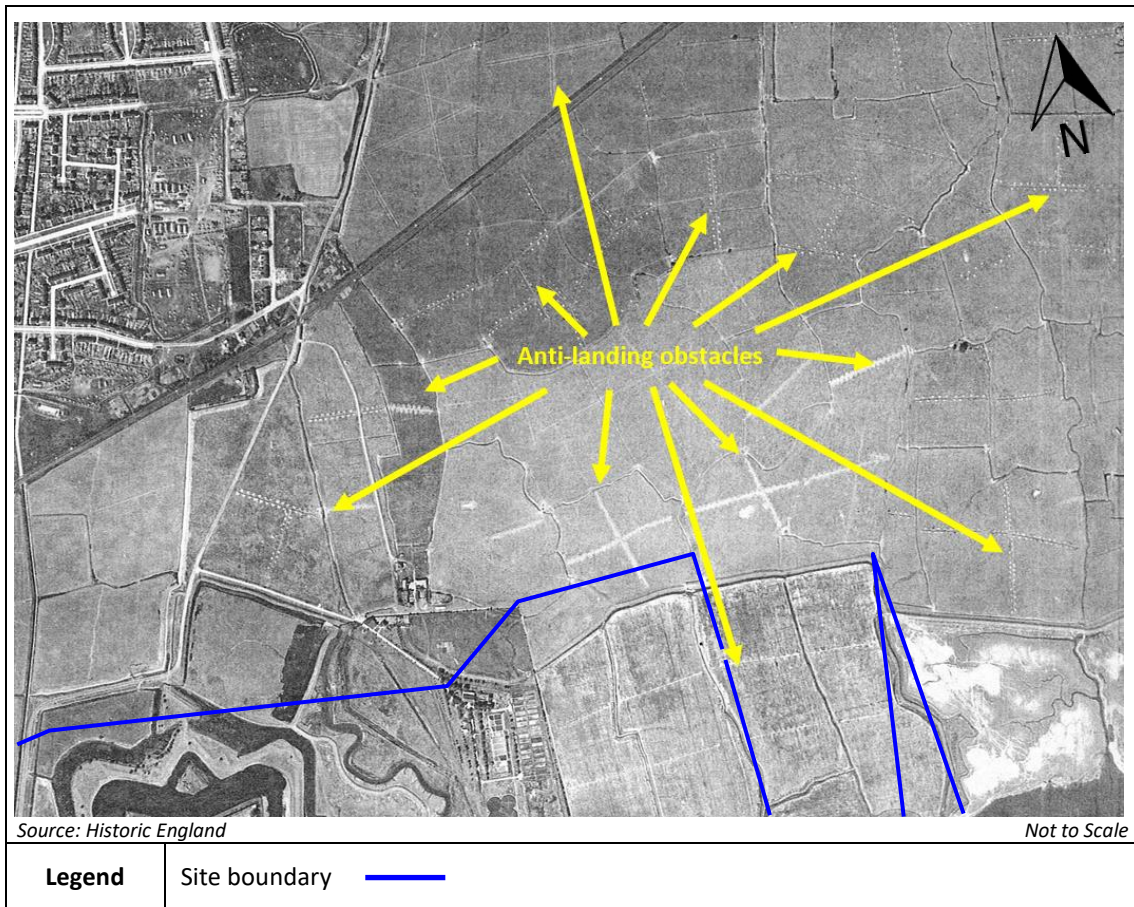
AA guns are not considered to provide a significant source of UXO hazard to the Site.

3.1.7 Anti-Invasion Defences

Due to the strategic importance of the River Thames and the direct route it offered towards London, extensive anti-invasion defences were established in the vicinity of the Site during WWII.

In the summer of 1940, anti-landing obstacles were established across Tilbury Marshes (TQ 663764), on land encompassing the central part of the Site. These typically comprised stone, wooden or concrete obstacles placed in intervals between ditches. An example is shown in Plate 6, an aerial photograph dated the 4th August 1944.

Plate 6 Aerial photograph showing anti-landing obstacles at Tilbury Marshes, 4th August 1944



Such anti-landing obstacles were typically removed towards the end of WWII once the threat of invasion had passed.

Records indicate that 1No. pillbox was located at East Tilbury (TQ 680758), on the central part of the Site, and a further 4No. pillboxes were located within approximately 1km of the Site.

The pillbox was situated on northern bank of the River Thames foreshore, as identified on Figure 2 below.

This was a Type FW3/22 pillbox and was manned by units of the Essex Home Guard (see Section 3.1.10). It comprised a river-facing loophole, with an internal mount for either a LG or VG. It remains extant.

10No. spigot mortar emplacements were also established on the Site, with a further 9No. located within approximately 1km of the Site.

Table 1 is a list of the spigot mortar positions on the Site.

Table 1 Spigot mortar positions on the Site

Grid Reference	Location
TQ 672789	2No. located on Muckingford Road near Linford
TQ 674790	1No. located on Muckingford Road near Linford
TQ 675793	George and Dragon public house in Linford
TQ 661780	Blue Anchor Lane, West Tilbury
TQ 656779	Northwest of the junction of Gun Hill and Rectory Road, West Tilbury
TQ 662777	In bushes on the south side of Church Road, West Tilbury
TQ 661777	In a field east of St James Church, West Tilbury
TQ 645774	In grassland to the east of Chadwell Road, West Tilbury
TQ 690768	2No. at Coalhouse Fort
TQ 646786	24 Brentwood Rd, Chadwell St Mary

Spigot mortars, also known as Blacker Bombarads, were widely distributed to Home Guard units throughout Britain, and were commonly used at roadblocks or near airfields as Anti-Tank (AT) weapons. They typically fired a 20-pound (lb) High Explosive (HE) projectile.

Figure 2 is a map showing the approximate locations of the spigot mortars and pillboxes on the Site.

Figure 2 Map of spigot mortars and pillboxes on the Site



Spigot mortar positions could be either fixed or mobile. At static positions, they were either affixed to a large cruciform platform or an immobile concrete pedestal and were usually emplaced in a pit with ammunition lockers nearby.

Potential UXO Hazard

Pillboxes and spigot mortars sometimes had associated munitions caches which may have stored Small Arms Ammunition (SAA), in addition to close combat munitions such as grenades and mortars.

Such caches were typically removed when the defences were dismantled at the end of WWII, although the possibility of local munitions disposal around defended positions cannot be totally discounted.

The lack of post-war UXO finds in the immediate vicinity of the Site indicates that the likelihood of such an encounter is low.

3.1.8 Barrage Balloons

Given the strategic importance of London and the southeast, extensive barrage balloons defences were deployed in the Essex and northwest Kent areas during WWII. These could be established on both onshore anchorages and floating moorings.

Barrage balloons were widely used in Britain's defence against the Luftwaffe. Balloons were made of panels of fabric sewn or glued together and inflated using hydrogen. 6No. cables were typically attached to the balloon and joined to a single cable which ran to a winch used to control the balloon's height.

There was a small amount of explosive charge 150 feet (ft) from each end of the balloon cable. If a balloon was hit by an aircraft this would ignite and the cable, which had a parachute on each end, would cause the plane to crash.

Records indicate that 1No. barrage balloon was located on the southern part of the Site. This was anchored on a submerged mooring in the River Thames, off East Court Marshes (TQ 679745).

Each anchorage typically had associated accommodation nearby for crew, as well as a SAA store. SAA is not considered to provide a significant UXO hazard (see Appendix 1).

Barrage balloons are not considered to provide a source of UXO hazard to the Site.

3.1.9 Bombing Decoys

In 1943, 1No. MQL Naval bombing decoy (NC713) was established at East Tilbury (TQ 678757), on the central part of the Site.

The decoy was designed to replicate the landing craft 'hards' and associated lighting that had been established in Tilbury as part of the preparations for D-Day.

'Hards' were roads leading to a foreshore and were commonly constructed to disembarkation points within Marshalling Areas (see Section 3.6.1).

The decoy comprised a cluster of dummy buildings and a series of electric lights and was intended to operate during enemy air raids on the region.

By the end of WWII, all decoy installations and associated buildings had been removed.

Potential UXO Hazard

No records have been found to indicate that the decoy was attacked. By 1943, when the decoy was established, the majority of heavy bombing raids on the region had ceased (see Section 4.2).

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

3.1.10 Home Guard

During WWII, elements of the 3rd (Stanford le Hope), 14th (West Thurrock), and 20th (Hornchurch) Essex Battalions and the 15th (Cobham) and 16th (Gravesend) Kent Battalions of the Home Guard operated in the vicinity of the Site.

The Home Guard was responsible for patrolling local transport links and strategic targets, such as airfields, docks, and railway lines, as well as manning regional anti-invasion defences. Detached platoons were usually concentrated around vulnerable points, and factories often had their own Home Guard units.

Records indicate that by May 1942, the 15th and 16th Kent Home Guard Battalions numbered over 1,360No. men. They were armed with 43No. Blacker Bombards, 45No. Northover Projectors, more than 940No. rifles, including 68No. AT rifles, 110No. Tommy guns and 4No. Browning machine guns.

No evidence of significant Home Guard training activities has been identified on the Site.

Potential UXO Hazard

It should be noted that records of Home Guard activities were rarely kept, and training activities were usually unofficial or unsanctioned.

Storage and disposal of munitions by the Home Guard was poorly documented and surplus supplies were often buried or dumped in ad-hoc locations.

Home Guard activities are not considered to provide a significant source of UXO hazard to the Site.

3.1.11 Mined Locations

Other than those described in Section 3.2.3, no other minefields or mined locations have been identified on the Site.

The nearest was a controlled minefield across the River Thames (TQ 700767), located near Coalhouse Fort, adjacent to the southern part of the Site.

In June 1940, Lieutenant-General Andrew McNaughton and the 1st Canadian Tunnelling Company successfully demonstrated the use of pipe mines near Shornemead Fort, encroaching on the eastern boundary of the southern part of the Site (see Section 3.6.6).

There were also approximately 85No. Flame Fougasses established in the Gravesend area during WWII, within approximately 1.5km of the Site. These formed part of the region's anti-invasion defences.

These mined locations are not considered to provide a source of UXO hazard to the Site.

Possible pipe mine locations associated with the former Royal Air Force (RAF) Gravesend are addressed in Section 3.2.3.

3.2 Military Airfields

For further information on military airfields, and the potential UXO hazards associated with them see Appendix 2.6. Alternatively, follow the link below:

- [Military Airfields](#)

The nearest military airfields to the Site are described below.

3.2.1 RFC Orsett

In July 1916, a Home Defence landing ground was established at Mucking Heath, Orsett (TQ 656806), on land encompassing the northern part of the Site.

Known as Royal Flying Corps (RFC) Orsett, it was used by Nos. 39 and 78 (Fighter) Squadrons, equipped with a variety of early-type fighter aircraft, including the Royal Aircraft Factory B.E.2, B.E.12, Sopwith 1^{1/2} Strutter, Sopwith Camel, and Sopwith 7F.1 Stripe.

RFC Orsett was decommissioned in 1919 and all associated facilities were subsequently removed. No records have been found to indicate that any munitions were stored at RFC Orsett, which comprised solely a landing ground.

RFC Orsett is not considered to provide a source of UXO hazard to the Site.

3.2.2 RAF Gravesend

Between 1939 and 1956, RAF Gravesend encroached on the southern part of the Site. A brief operational history of the airfield is provided below.

Operational History of RAF Gravesend

In June 1932, a civilian landing ground was established near the village of Chalk (TQ 668712), on land encroaching on the southern part of the Site. After undergoing substantial development work, it was officially opened as Gravesend Airport (London East) on the 12th October 1932 and was used for limited commercial flying.

On the 1st October 1937, the Air Ministry (AM) formed No. 20 Elementary & Refresher Training School (ERFTS) at the airfield. They were equipped with de Havilland DH.82 Tiger Moth and Hawker Hart biplanes for the instruction of future RAF and Fleet Air Arm (FAA) pilots.

On the outbreak of WWII, Gravesend Airport was officially requisitioned by the AM, becoming RAF Gravesend. It was placed under Fighter Command, serving as a Satellite Landing Ground (SLG) for RAF Biggin Hill, approximately 22.8km southwest of the Site.

During the early years of WWII, RAF Gravesend was used by a variety of Fighter Squadrons involved in the defence of London and the southeast. On the 25th July 1940, No. 501 Squadron arrived at RAF Gravesend, equipped with Hawker Hurricanes. After flying near round-the-clock operational sorties, they were relieved by No. 66 Squadron, equipped with Supermarine Spitfires.

From November 1940, the airfield was home to a detachment of Boulton Paul Defiant night-fighters from No. 141 Squadron.

During this initial period, RAF Gravesend comprised a central grass landing field, a small technical area, and grass dispersals. It was bounded on all sides by a concrete perimeter track.

Plate 7 is a Luftwaffe target photograph of RAF Gravesend, dated the 8th November 1940. It shows the airfield's boundary (GB 10 89), highlighted in red, encroaching on the southern part of the Site.

Plate 7 Luftwaffe target photograph of RAF Gravesend, 8th November 1940



Source: NARA

Not to Scale

Legend	Site boundary —
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From May 1941 to November 1942, RAF Gravesend accommodated many Spitfire Squadrons involved in offensive operations. This included Nos. 74, 124, 133, 232, and 165 Squadrons, whose tasks ranged from bomber escort duties, convoy protection, home defence, and tactical support during the Dieppe Landings of August 1942.

On the 7th December 1942, No. 277 Squadron arrived at RAF Gravesend equipped with Westland Lysander liaison aircraft, Supermarine Spitfires, and Supermarine Walrus amphibious biplanes. This was an air-sea rescue unit tasked with operating around the Kentish coast.

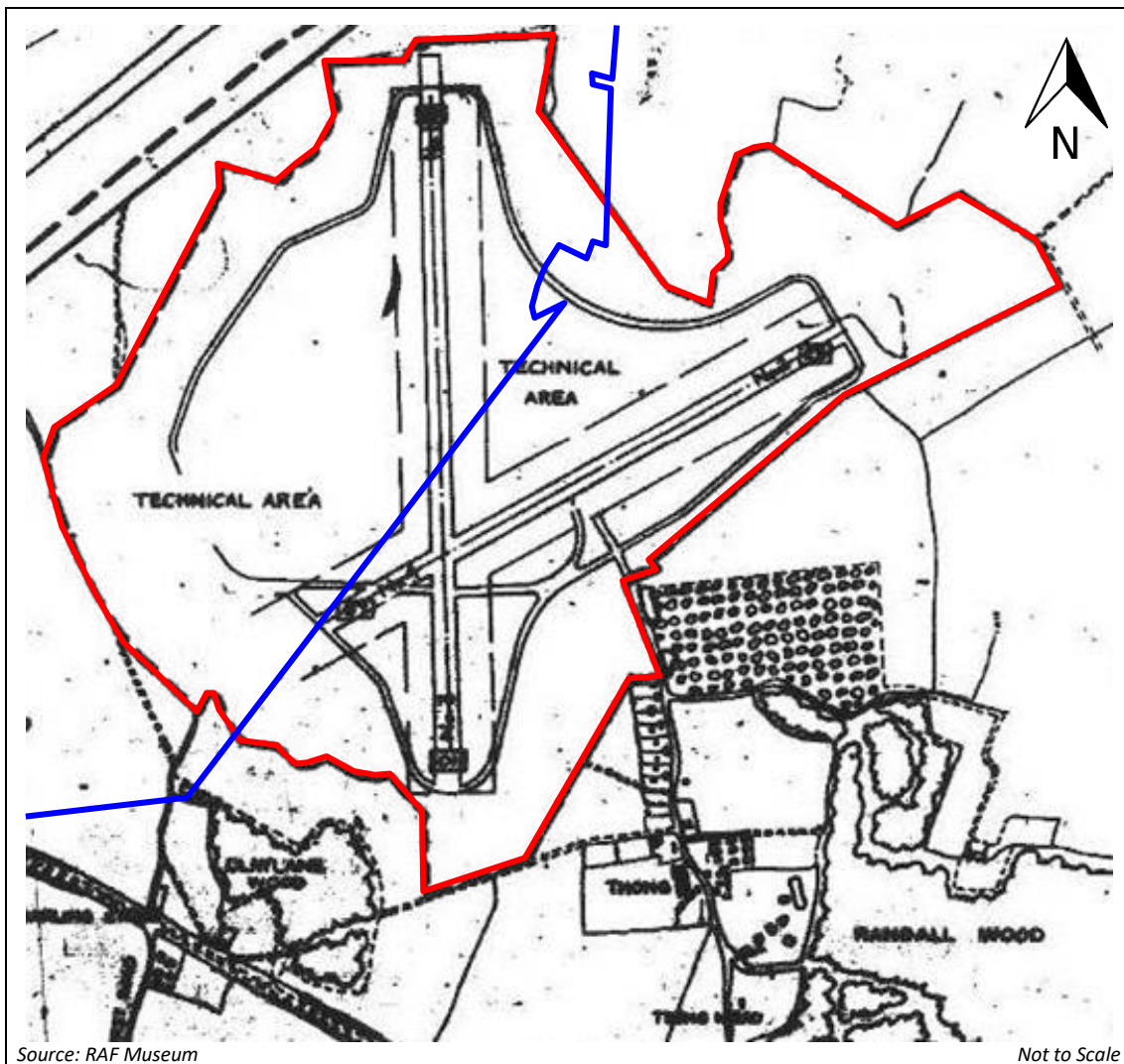
From late-1942 to early-1943, RAF Gravesend underwent considerable expansion and development work to support its growing operational requirements. 2No. converging runways were established with steel ‘Sommerfeld’ tracking, and new perimeter tracks were built. By 1944, the runways had been upgraded to concrete.

Individual fighter ‘pan’ dispersal areas were constructed around the airfield’s perimeter, and RAF Gravesend’s munitions stores were expanded to accommodate 650,000No. rounds of belted machine gun ammunition.

The main technical area, on the Site, also appears to have been upgraded at this time.

The upgraded airfield layout is shown in Figure 3, a plan dating from 1945.

Figure 3 Plan of RAF Gravesend, 1945



Legend	Site boundary 	Airfield boundary 
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RAF Gravesend's upgrades allowed the airfield to accommodate larger and more powerful aircraft, notably the Hawker Typhoon fighter-bomber, which came to RAF Gravesend with the arrival of No. 181 Squadron in March 1943.

From this period on, a variety of operational fighter squadrons were stationed at the airfield, equipped with a mixture of fighter aircraft, including Supermarine Spitfires, Hawker Typhoons, and North American P-51 Mustangs. In October 1943, HQ 122 Airfield was transferred to RAF Gravesend, which was involved in supporting the tactical build up to 'D-Day', the upcoming invasion of Northern Europe.

On the 12th April 1944, HQ 122 Airfield was replaced by No. 122 Wing of the 2nd Tactical Air Force. Equipped with de Havilland DH.98 Mosquito FBVI fighter-bombers, this group was tasked with mounting a night-time interdictor campaign against German movements in Normandy.

In June 1944, operational activities were abruptly ceased with the start of Germany's V1 offensive against London and the southeast (see Section 4.2), and No. 122 Wing was transferred. The airfield was subsequently designated No. 23 Balloon Centre and was tasked with controlling the deployment of barrage balloons throughout the north Kent region (see Section 3.1.9).

Following end of WWII, RAF Gravesend was reduced to care and maintenance status. Essex Aero Ltd subsequently retained a small manufacturing works on the airfield, producing aircraft components, before liquidation in March 1956.

In June 1956 the AM relinquished control of the airfield, and the area was subsequently redeveloped for housing.

Details of activities at RAF Gravesend which may provide a source of UXO hazard to the Site are given in the following Sections.

3.2.3 Airfield Activities at RAF Gravesend

Pipe Mines

Records have been found indicating that pipe mines were laid across the main landing area, the perimeter track, and sections of the technical area at RAF Gravesend by 1941. No documentation of the original layout plans of the pipe mines has been located.

Part of the Site encroached upon the south-eastern area of the original airfield (see Plate 8), and it is therefore considered likely that pipe mines were laid in this location.

The part of the Site encroaching upon the extended area of the airfield is unlikely to have been pipe mined as the main invasion threat had passed by the time this extension occurred.

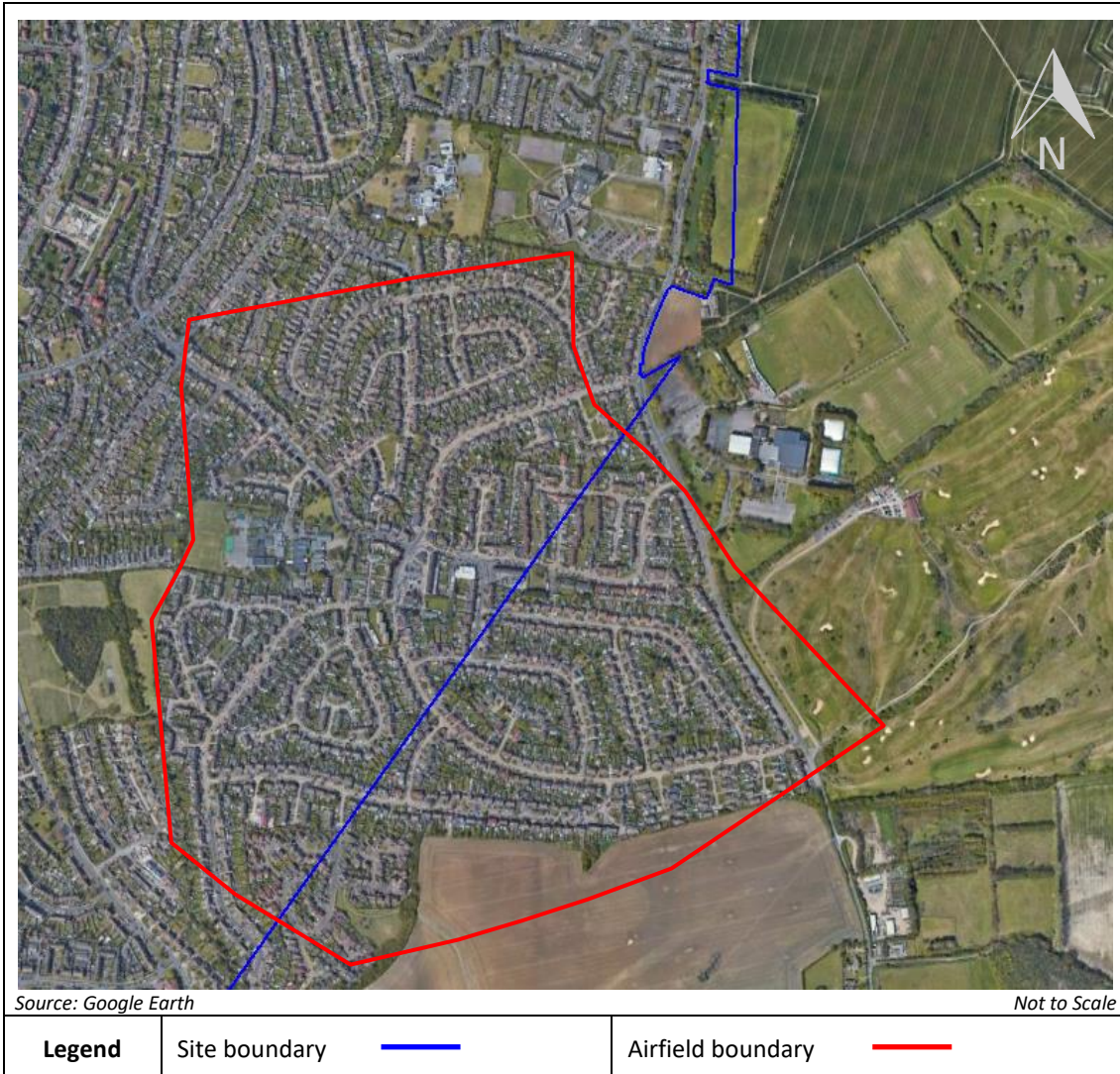
Typically, efforts were made to remove pipe mines either when the threat of invasion had passed or when the airfield closed. No records of any WWII pipe mine clearances taking place at RAF Gravesend have been found.

Anecdotal evidence has been found indicating that empty pipe mines were removed from RAF Gravesend during the 1960s and then again during 'Operation Crabstick' in the 1990s. This evidence indicates that the original clearance was incomplete, similar to several other airfields that were equipped with pipe mines.

For example, Her Majesty's Ship (HMS) Daedalus, Lee-on-Solent, which was subject to clearances at the end of WWII and in 'Operation Crabstick', was subject to further clearances when more pipe mines were discovered during works in 1990 and 2006.

Plate 8 is an aerial photograph giving the approximate location of the original airfield boundary in relation to the Site. This demonstrates the area in which pipe mines are likely to have been laid.

Plate 8 Recent aerial photograph of the Site in relation to the original boundary of RAF Gravesend



Potential UXO Hazard

Part of the pipe mined area on the Site has since been redeveloped for housing. It is possible that remaining mines were removed during this development, although no records have been found to confirm this.

It should also be noted that pipe mines on airfields could be laid at depths up to 5.0m bgl, beyond the typical detection capabilities of geophysical instruments of the time, and also potentially below post-WWII housing foundations.

Therefore, if intrusive works are to take place in this area, it is considered prudent to undertake proactive risk mitigation to ensure that any residual risk from pipe mines is suitably mitigated.

Pipe Mines are considered to provide a source of UXO hazard to the former RAF Gravesend part of the Site.

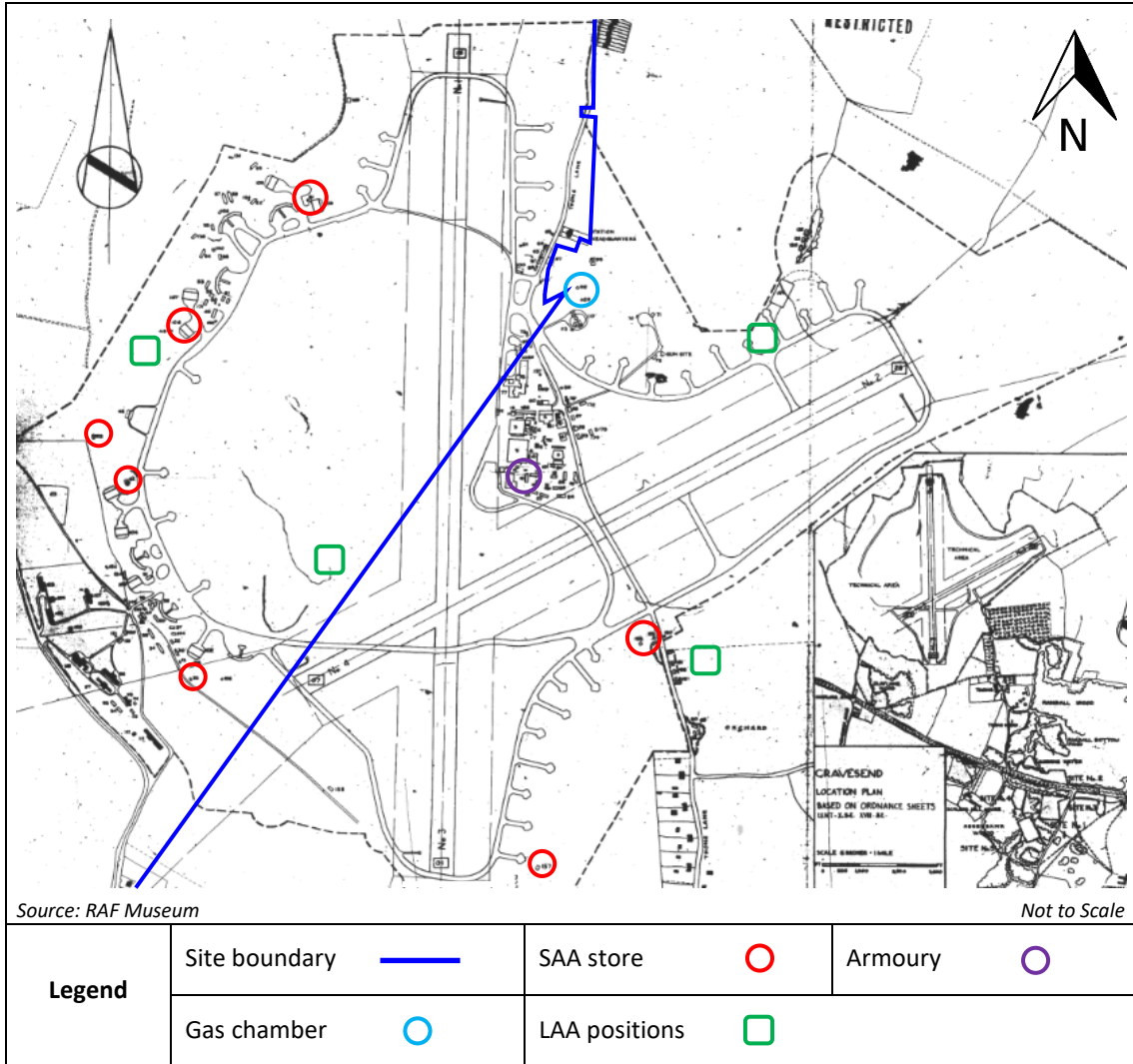
This area is identified as M4 on **Figure 24** and shown on HE540039-ZET-GEN-GEN-MAP-GEO-00001-P05.

Munitions Stores

During WWII, RAF Gravesend was equipped with 8No. dispersed SAA stores, of 2No. main patterns, at several locations around the airfield. 2No. of these stores were located on the Site.

Figure 4 is a plan of RAF Gravesend showing the armoury and SAA stores, dating from 1945. It also identifies the stations gas chamber and LAA gun emplacements (see Section 3.1.2).

Figure 4 Plan of RAF Gravesend showing the armoury and SAA stores, 1945



These munitions stores were emptied and demolished on closure of the airfield.

Munitions stores are not considered to provide a significant source of UXO hazard to the Site.

Ranges

1No. Machine gun butt was located within the airfield’s technical area, approximately 0.2km west of the Site.

Post-WWII the butt was decommissioned and removed when the airfield was redeveloped.

The machine gun butt at RAF Gravesend is not considered to provide a source of UXO hazard to the Site.

Airfield Defences

During WWII, RAF Gravesend was defended by 4No. LAA gun emplacements. 2No. of these were located on the Site (see Section 3.1.2). A summary is provided in Table 2 below.

Table 2 LAA gun emplacements at RAF Gravesend

Grid Reference	Location	Serial No.	Type	Approximate Distance from Site
TQ 673712	RAF Gravesend	VG3	1No. .303" Quad Lewis gun	On the Site
TQ 673718	RAF Gravesend	VG2	1No. 40mm and 1No. .303" Lewis gun	On the Site
TQ 665714	RAF Gravesend	VG4	1No. .303" Quad Lewis gun	0.1km W
TQ 661719	RAF Gravesend	VG1	1No. 40mm and 1No. .303" Lewis gun	0.7km NW

Records have been found indicating that 1No. roadblock was located at Thong Lane (TQ 671711), on the Site. Further static defences are also likely to have been located around the perimeter of RAF Gravesend, including pillboxes.

Potential UXO Hazard

Defended positions, such as gun emplacements and roadblocks, sometimes had associated munitions caches which may have stored SAA, in addition to close combat munitions such as grenades and mortars.

Such caches were typically removed when the defences were dismantled at the end of WWII, although the possibility of local munitions disposal around defended positions cannot be totally discounted. This forms part of the low background risk for any similar site in the UK.

Airfield defences are not considered to provide a significant source of UXO hazard to the Site.

Aircraft Breaking

No records of any official aircraft breaking activities at RAF Gravesend have been found.

Crashed aircraft were either removed to the regional Maintenance Unit (MU) Salvage Depot at RAF Faygate, Surrey or taken to an aircraft repair plant at Cowley, Oxford.

Essex Aero, a specialist firm in aircraft conversions, had a facility in the Technical Area at RAF Gravesend, on the Site. They worked on self-sealing fuel tanks for several aircraft types, particularly fighter aircraft. This activity did not involve work on any aircraft carrying munitions.

Aircraft breaking is not considered to provide a source of UXO hazard to the Site.

Munitions Disposal Areas

No records of any official munitions disposal areas at RAF Gravesend have been found.

During the course of normal operations it is likely that some munitions became unserviceable and had to be disposed of. This disposal would have been of relatively small quantities and was usually carried out in remote areas of the airfield.

Such disposal operations would have been conducted by either burning or a controlled explosion in a small destructor house. There are no indications of such facilities on airfield plans for RAF Gravesend.

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

Bombing Ranges

No records of any bombing ranges at RAF Gravesend have been found.

3.3 Aircraft Crashes

For further information on military aircraft crashes, and the potential UXO hazards associated with them see Appendix 2.7. Alternatively, follow the link below:

- [Aircraft Crashes](#)

The nearest aircraft crashes to the Site are described below.

3.3.1 Bomber Aircraft Crashes

24th August 1940

1No. Heinkel He111H-A1+KT bomber aircraft crashed on a field at Clay Tye Hill, North Ockendon, on the northern part of the Site. This aircraft was recorded as carrying a full bomb load. It was completely destroyed on impact.

15th September 1940

1No. Heinkel He111H-2 (5120) A1+EL bomber aircraft crashed on farmland at Botany Farm, Orsett, on the northern part of the Site. This aircraft was recorded as carrying a full bomb load and it is unknown whether these were cleared.

4th July 1943

1No. Vickers Wellington X (HE630) bomber aircraft crashed on open ground near Henhurst Cottages, Henhurst Road, Gravesend, on the southern part of the Site.

24th February 1944

1No. Junkers Ju188E-1 (260321) U5+GP bomber aircraft crashed on a field at Queen's Farm, Shorne, approximately 0.2km east of the southern part of the Site.

3.3.2 Fighter Aircraft Crashes

30th August 1939

1No. Supermarine Spitfire Ia (N3031) fighter aircraft crashed on a field near Nutberry School, Nutberry Road, within approximately 0.3km south of the central part of the Site.

19th August 1940

1No. Supermarine Spitfire Ia (P8744) fighter aircraft crashed on a field near the Orsett Cock crossroads, southeast of Orsett, within approximately 50m east of the central part of the Site.

26th August 1940

1No. Hawker Hurricane I (P3157) fighter aircraft crashed in a field south of Cranham Hall, Upminster, approximately 0.5km west of the northern part of the Site.

14th September 1940

1No. Supermarine Spitfire Ia (N3029) fighter aircraft crashed on woodlands at Thong, on the southern part of the Site.

23rd September 1940

1No. Supermarine Spitfire Ia (X4060) fighter aircraft crashed on the southeast side of RAF Gravesend, on the southern part of the Site.

20th October 1940

1No. Supermarine Spitfire Ia (P7445) fighter aircraft crashed outside the main hangar at RAF Gravesend, on the southern part of the Site.

16th December 1940

1No. Hawker Hurricane I (V6774) fighter aircraft crashed near Tilbury Docks, on the central part of the Site.

31st December 1943

1No. Republic Thunderbolt P-74D (42-75080) fighter aircraft crashed on a field opposite the Crown Garage, Shorne, approximately 0.2km east of the southern part of the Site.

Plate 9 is a photograph of the crash dating from 1943. This demonstrates how a fighter aircraft wreckage can lead to the spread of both debris and SAA over a wide area.

Plate 9 Photograph showing crashed Republic Thunderbolt (42-47080), Shorne, 1943

Source: *Aircrew Remembered*

28th February 1944

1No. North American Mustang III (FX996) fighter aircraft crashed in a field at Barrington's Farm, Orsett Cock, on the east-bound carriageway of the A13, on the central part of the Site.

This aircraft turned back from a mission with engine failure, and it is possible that SAA is scattered at shallow depths. Records have been found indicating that the crash site was excavated in the late 1980s, potentially removing any remnant ordnance.

26th March 1945

1No. North American Mustang III (FZ117) fighter aircraft crashed on RAF Gravesend, within approximately 0.3km west of the southern part of the Site.

Potential UXO Hazard**Heinkel crashes**

No records have been found to indicate whether the bombs being carried by the Heinkel He111H-2 (5120) bomber aircraft that crashed at Botany Farm, Orsett had already been dropped, exploded on impact, or were retrieved from the crash site.

Part of the bomb load of the Heinkel He111H-A1+KT bomber aircraft which crashed at Clay Tye Hill, North Ockendon, is recorded as having exploded on impact. No records have been found to confirm that all the bombs were accounted for.

As such, it is considered possible that some UXB may still remain in the vicinity of the 2No. crash sites, in addition to aircraft ammunition.

These crash areas are identified as M5 on **Figure 22** and shown on HE540039-ZET-GEN-GEN-MAP-GEO-00001-P05.

Other crashes

It is considered likely that many of the crashes detailed above would have resulted in SAA from the aircraft guns being scattered across a wide area, potentially including the Site.

The potential for encountering SAA in these areas therefore cannot be discounted, although SAA is not typically considered to provide a significant UXO hazard (see Appendix 1).

It should also be noted that any aircraft that crashed into the River Thames is unlikely to have been recovered at the time, and some crashes may not have been recorded. If the wreckage broke up it would contribute SAA and other munitions to the marine environment which may be subject to tidal migration along the bed of the river (see Section 5).

3.4 Explosives Factories, Munitions Depots and Disposal Areas

For further information on explosives factories, munitions depots and disposal areas, and the potential UXO hazards associated with them, follow the links below:

- [Explosives Factories](#)
- [Munitions Depots](#)
- [Munitions Disposal Areas](#)

Other than those detailed in Section 3.2.3, no records of any explosives factories, munitions depots or munitions disposal areas on the Site have been found.

Records have been found to indicate that periodical munitions disposal operations were conducted at Tilbury Fort (TQ 650753) during WWII, within approximately 0.3km south of the central part of the Site. These operations involved the detonation of aerial-dropped bombs by local disposal teams.

No records have been found to indicate that this activity encroached on to the Site.

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

3.5 Firing Ranges and Military Training Areas

For further information on firing ranges and military training areas, and the potential UXO hazards associated with them see Appendix 2.4 & 2.5. Alternatively, follow the links below:

- [Artillery Ranges](#)
- [Bombing Ranges](#)
- [Military Training Areas](#)
- [Small Arms Ranges](#)

The nearest firing ranges and military training areas to the Site are described below.

3.5.1 Milton Range

In 1862, a 900yd rifle range was established on Eastcourt Marshes (TQ 681741), between the River Thames and the Thames Medway Canal, on land encompassing the southern part of the Site.

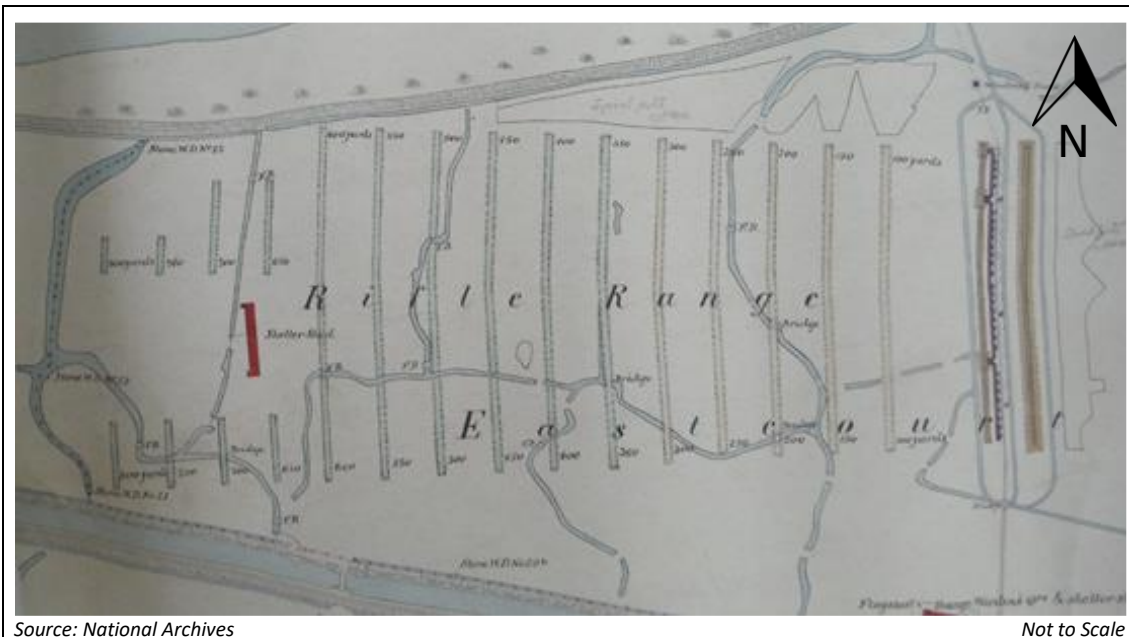
Known as Milton Range, it comprised a series of low earthen mound firing points placed between 50yd intervals. Firing was orientated from west to east, with 20No. target points located on 5No. target butts at the eastern end.

The range was initially used by 3No. depot battalions of the Royal Marines and Royal Engineers for individual target practice, in addition to group volley and skirmish training.

During the 1890s, the range was shortened to 800yds and reorganised for Lee-Metford Magazine service rifle training. Records indicate that 1No. new target butt was built, in addition to a series of movable target frames, approximately 150yds west of the original target butts.

An overview is shown on Figure 5, a plan of Milton Range dating from 1895.

Figure 5 Plan of Milton Range, 1895



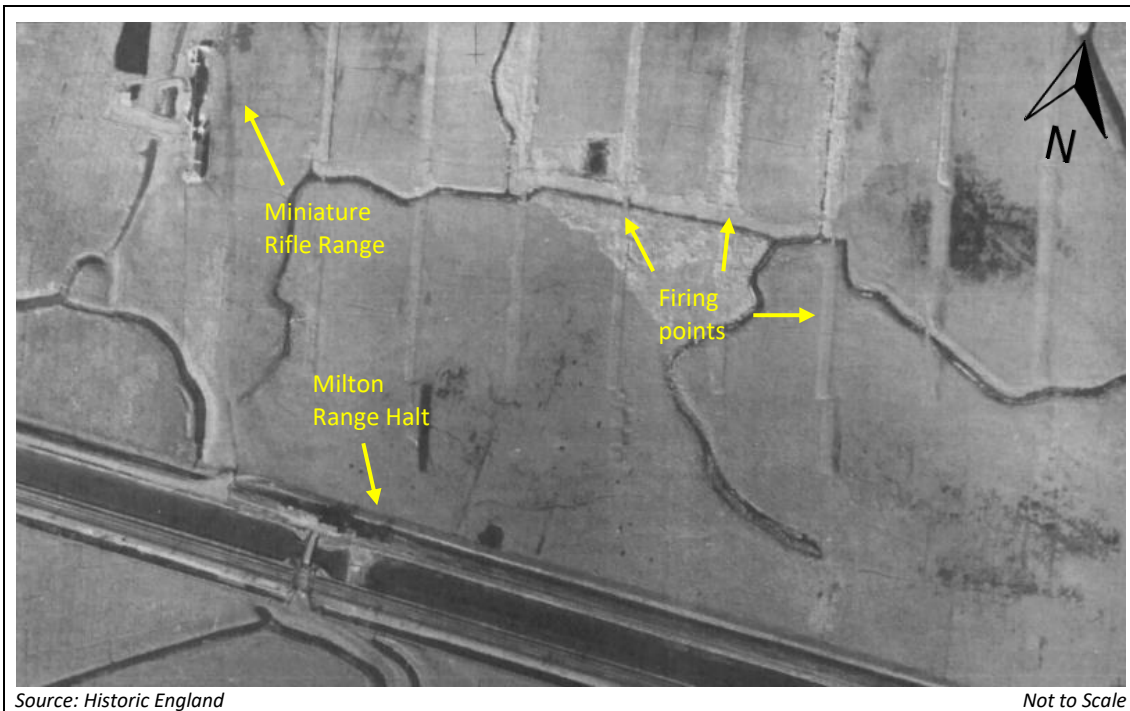
In 1906, Milton Range Railway Halt was established on the South Eastern Railway's North Kent line (TQ 675739). This offered direct access to troops stationed at Chatham Barracks, approximately 4.6km east-southeast of the Site.

Milton Range was used extensively for training during both WWI and WWII. Records have been found indicating that mortar training was undertaken on the range during WWII, and it is considered possible that other close combat munitions, such as grenades, were used during training exercises by both regular troops and the Home Guard.

Records have been found indicating that a 'gas compound' was also located at Milton Range. For a short period during WWII, this contained a small store of Mustard Gas, and was used to train troops in decontamination procedures. War diaries indicate that this compound was regularly inspected and vented before being removed.

Plate 10 is an aerial photograph of Milton Range, dated the 28th February 1950. A miniature rifle range has also been identified within the range extents.

Plate 10 Aerial photograph of Milton Range, 28th February 1950



Milton Range continued to be used as a military firing range until 1995. It currently operates as the practice firing area for the Metropolitan Police Specialist Training Centre.

Potential UXO Hazard

Milton Range was used by the military for 'live firing' training between 1862 and 1995. This primarily involved the use of small arms.

Concentrations of SAA are likely to be present within the immediate vicinity of the target butts. Given the possibility of spillages and accidental discharges, it is also considered that SAA will be located at shallow depths across the range extents.

Whilst SAA does not provide a kinetic hazard typical of other UXO (i.e. it relies on the firing of a metal bullet to cause harm rather than blast from high explosive), in large concentrations it may provide a source of metal contamination, particularly lead, antimony and zinc.

More significantly, records indicate that Milton Range was used for mortar training during WWII. Given the long use of the range, it is considered likely that other close combat training (including grenades) has also occurred. Zetica has experience of finding such munitions on historic ranges theoretically designated for the use of small arms only.

Given this, there is the potential for encounter of ordnance at surface or shallow-buried depths within the range extents.

Milton Range is considered to provide a possible source of UXO hazard to the Site.

This area is identified as M3 in **Figure 24** and shown on HE540039-ZET-GEN-GEN-MAP-GEO-00001-P05.

3.5.1 Shornemead Fort Training Area

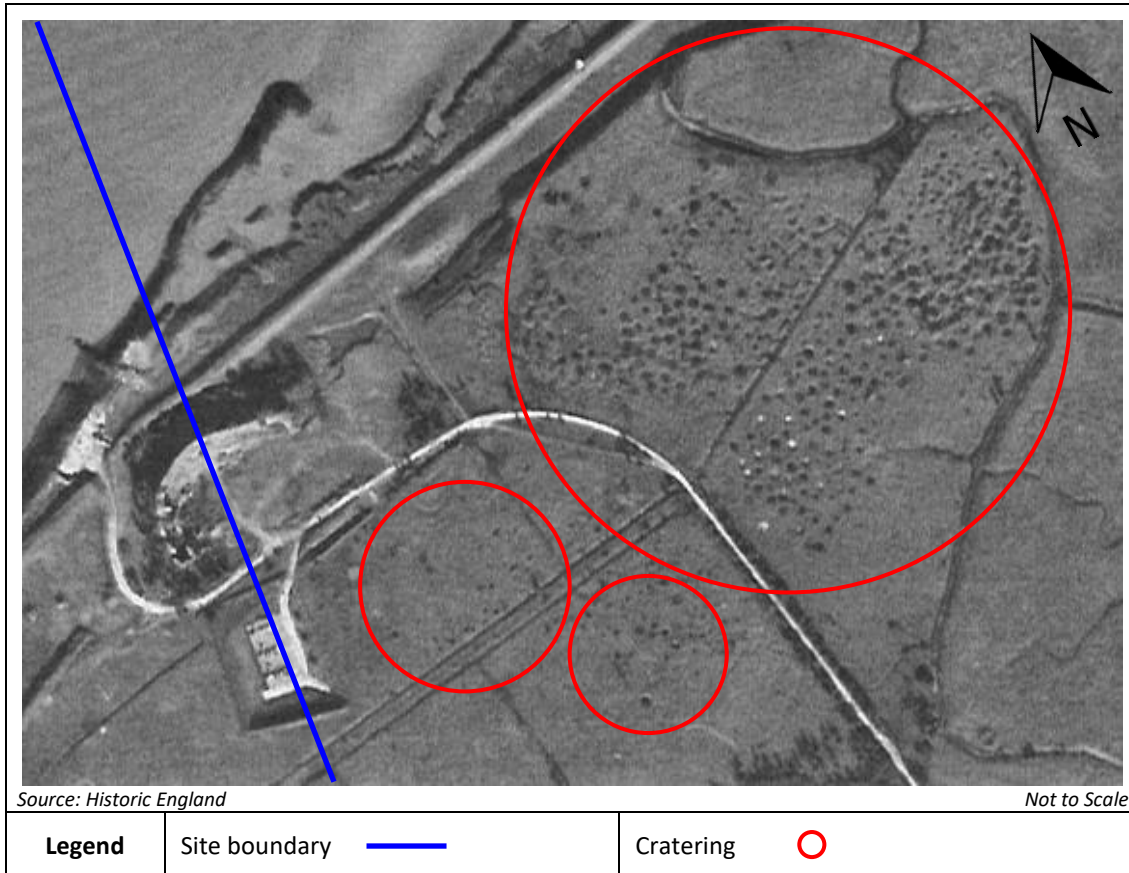
Records indicate that military training also took place near Shornemead Fort post-WWII (see Section 3.6.6), on the eastern boundary of the southern part of the Site.

Aerial photography suggests that training exercises began in the 1950s, and it is considered likely that cratering visible on land adjacent to the fort was caused by training involving close

combat munitions, such as grenades and mortars, or during demolition or disposal exercises undertaken by the Royal Engineers.

Plate 11 is an aerial photograph of the Shornemead Fort Training Area, dated the 19th January 1975. This shows the heavy cratering associated with military training exercises.

Plate 11 Aerial photograph of the Shornemead Fort Training Area, 19th January 1975



Potential UXO Hazard

The cratering is concentrated over 0.1km east of the Site, with few craters in the immediate vicinity of the Site, and given the substation on the Site was operational during this period, it is considered unlikely that training activities would have encroached on the Site.

Shornemead Fort Training Area is not considered to provide a source of UXO hazard to the Site.

3.6 Other Military Establishments

The nearest remaining military establishments to the Site are described below.

3.6.1 Marshalling Area 'S'

In 1944, during preparations for the D-Day invasions of Normandy, a series of Marshalling Areas, used to assemble troops, vehicles and equipment, were established throughout southern England.

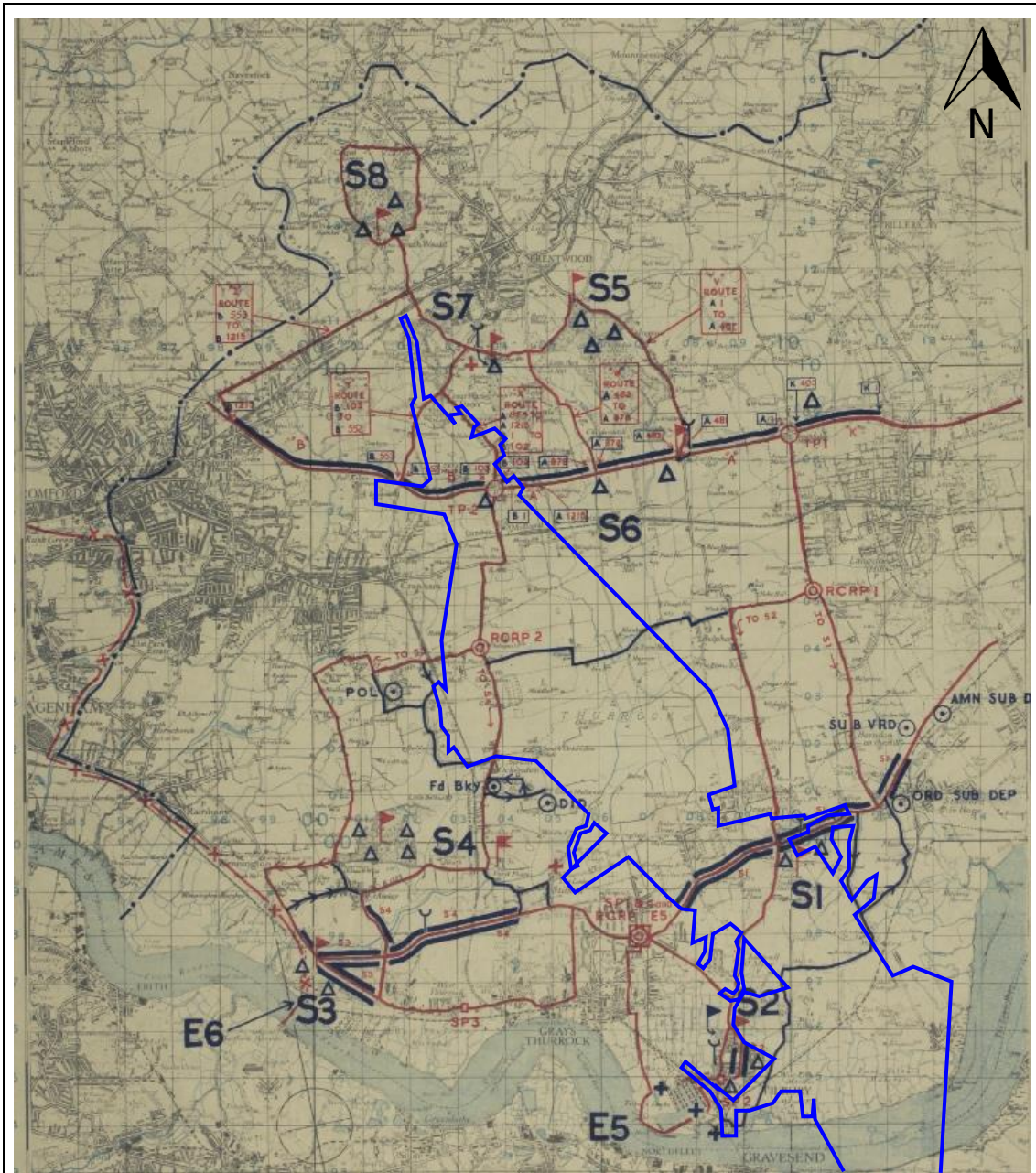
Marshalling Area 'S', within Eastern Command, was established in a wide area encompassing the northern and central parts of the Site. As such, several large accommodation camps, administrative facilities, stores, depots, and vehicle assembly areas were established in the immediate vicinity of the Site.

Figure 6 is an extract from a plan of Marshalling Area 'S', dated the 25th May 1944. This shows that a tented camp, designated as 'S1', was located on Orsett Golf Course (TQ 659809), encroaching on the central part of Site. Records indicate that this was mainly used to accommodate elements of the 51st (Highland) Division, which disembarked for France on the 7th June 1944 (see Section 3.6.2).

A small military camp was also located at Great Warley Hall (TQ 593885), on the northern part of the Site (see Section 3.6.3). The road adjacent to this part of the Site was used as military vehicle park, serviced by a Royal Electrical and Mechanical Engineers (REME) post.

No evidence of any further military activity on the remainder of the Site is shown.

Figure 6 Plan of Marshalling Area 'S', 25th May 1944



Source: Essex Record Office

Not to Scale

Legend	Site boundary		Camp		Sub Area HQ		Vehicle Park	
	Storage Depots		Port		Admin route		One way route	
	REME Post		CRS		Start Point		Road Convoy Post	

The nearest ordnance depot associated with Marshalling Area 'S' was located near Standford-le-Hope (TQ 679820), approximately 0.9km east of the central part of the Site.

A Petroleum, Oils & Lubricants (POL) depot was also located at Stubbers Wood, North Ockendon, adjacent to the northern part of the Site.

By the end of WWII, Marshalling Area 'S' was disbanded, and all associated facilities were dismantled.

Potential UXO Hazard

As Marshalling Area 'S' was used primarily for vehicle storage and troop movement, it is not considered to provide a significant source of UXO hazard to the Site.

Details on the potential sources of UXO hazard associated with Orsett Camp and Great Warley Camp are provided in the following Sections.

3.6.2 Orsett Camp

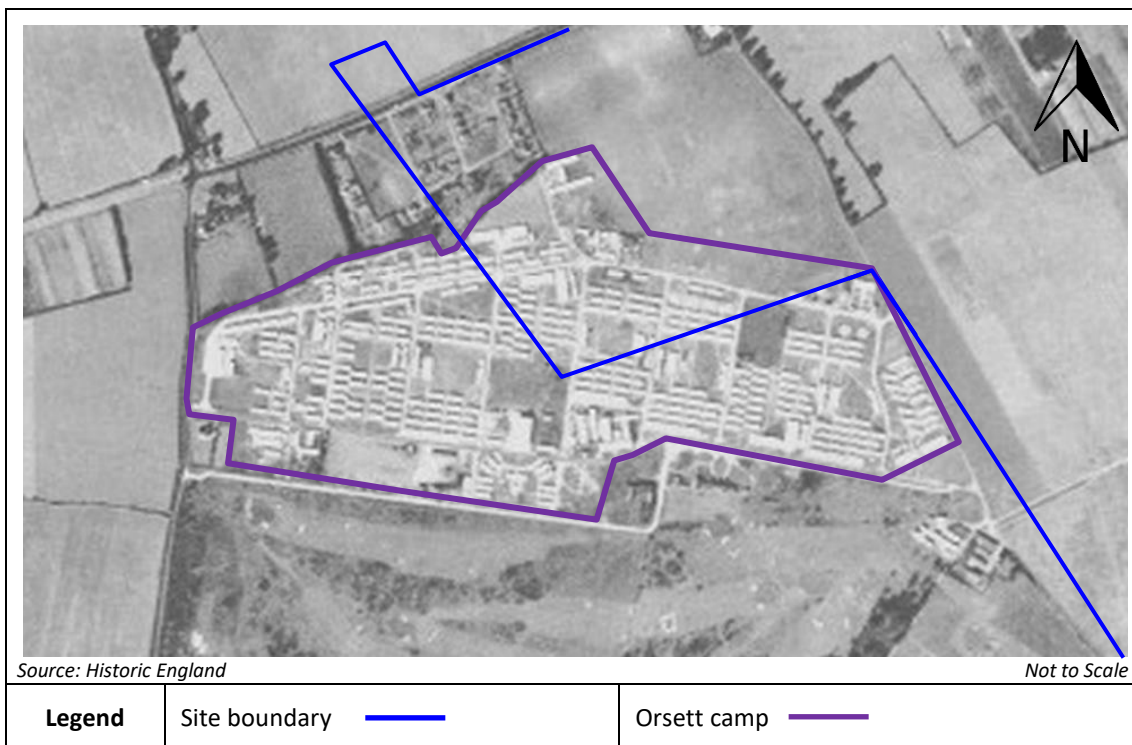
In 1944, Marshalling Area camp 'S1', was established at Orsett Golf Course (TQ 659809), encroaching on the central part of the Site.

The camp was used primarily as a transit camp for troops before embarking to mainland Europe, as part of the D-Day invasions of Normandy (see Section 3.6.1).

Following the end of WWII, Orsett Camp was redeveloped as a British Army transit camp, comprising approximately 300 No. brick buildings. During the 1940s, it accommodated a series of units, including the 6th Company (Motor Transport) Royal Army Service Corps (RASC) and elements of the Royal Corps of Signals.

Plate 12 is an aerial photograph of Orsett Camp dating from circa 1946. This shows the extents of the camp, encroaching on the central part of the Site.

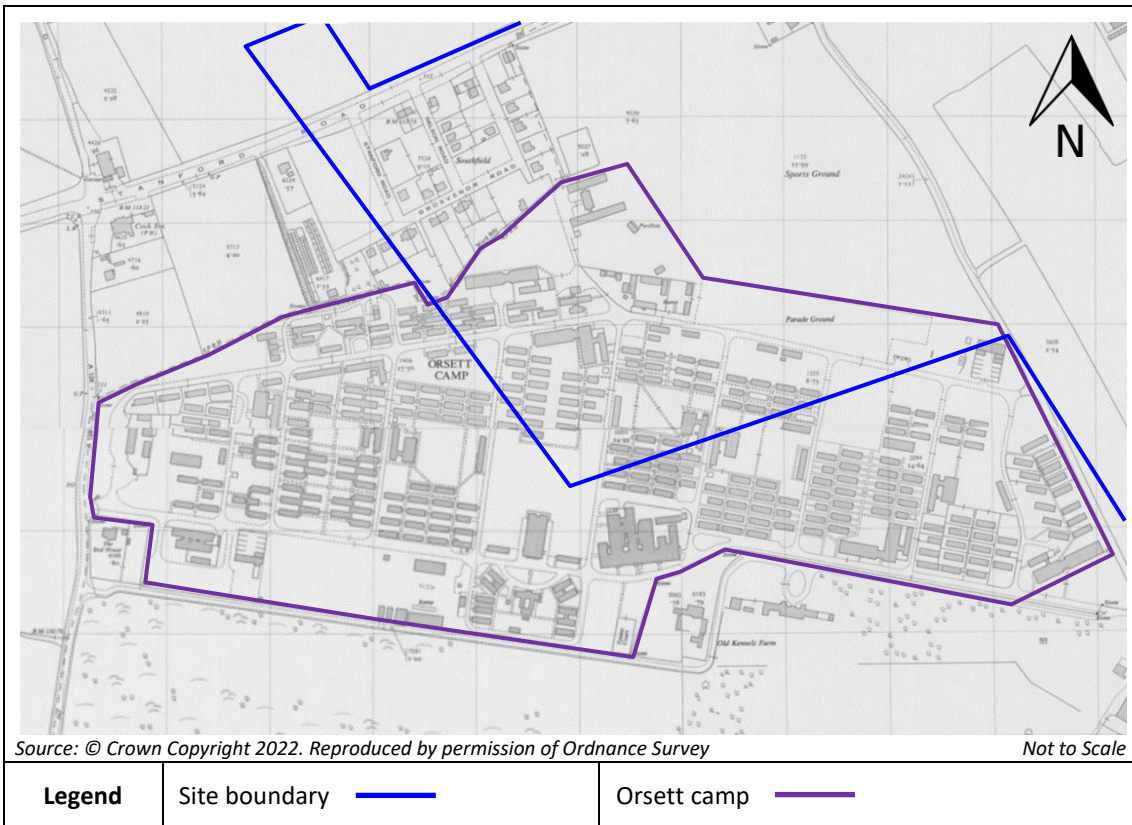
Plate 12 Aerial photograph of Orsett Camp, c. 1946



Throughout the 1950s, Orsett Camp was predominately used to accommodate the 57th HAA Regiment RA.

The camp remained largely unchanged during this period, as highlighted in Figure 7, a historical map dating from 1960.

Figure 7 Historical Map showing Orsett Camp, 1960



By the 1970s, Orsett Camp had been closed, and the land was subsequently reworked for quarrying.

Potential UXO Hazard

No evidence has been found indicating that Orsett Camp was used for military training, and no designated munition stores have been identified on the Site.

Whilst troops based at Orsett Camp during WWII are likely to have been issued with SAA, which may have been discarded, SAA is not considered to provide a significant source of UXO hazard (see Appendix 1).

Any munitions that may have been present at the camp on its closure are likely to have been removed during subsequent quarrying activities.

Orsett Camp is not considered to provide a significant source of UXO hazard to the Site.

3.6.3 Great Warley Camp

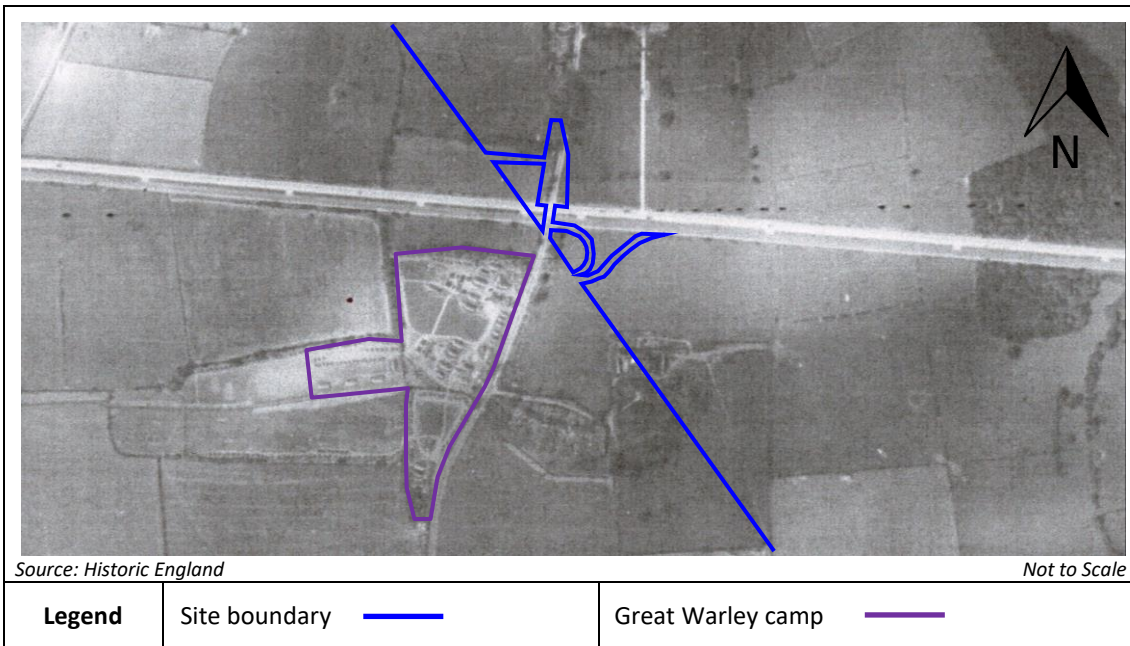
In 1944, land along the Southend Arterial Road, Great Warley was requisitioned as Marshalling Area Zone 'S6'. 4,500No. military personnel were accommodated in tented camps in surrounding fields, one of which was located on the northern part of the Site (TQ 593885).

Known as Great Warley Camp, the units stationed here included the 51st (Highland) Division.

Marshalling Area Zone 'S6' also had storage capacity for 2,450No. military vehicles. Many of these were parked on any suitable open ground along the Southen Arterial Road, encroaching on the northern part of the Site (see Figure 6).

Plate 13 is an aerial photograph of Great Warley Camp, dated the 6th July 1944.

Plate 13 Aerial photograph of Great Warley Camp, 6th July 1944



Post-WWII the camp was closed, and the land was reverted to agricultural use.

Potential UXO Hazard

During WWII Great Warley Camp was used to accommodate troops before disembarkation to mainland Europe. Although Marshalling Area 'S' had designated munitions stores located near Stanford-le-Hope, it is considered likely that British troops would have used the surrounding fields and woods as a training area, with the possibility of leaving behind both inert, blank and live munitions.

This forms part of the low background risk for any former military site in the UK.

Great Warley Camp is not considered to provide a significant source of UXO hazard to the Site.

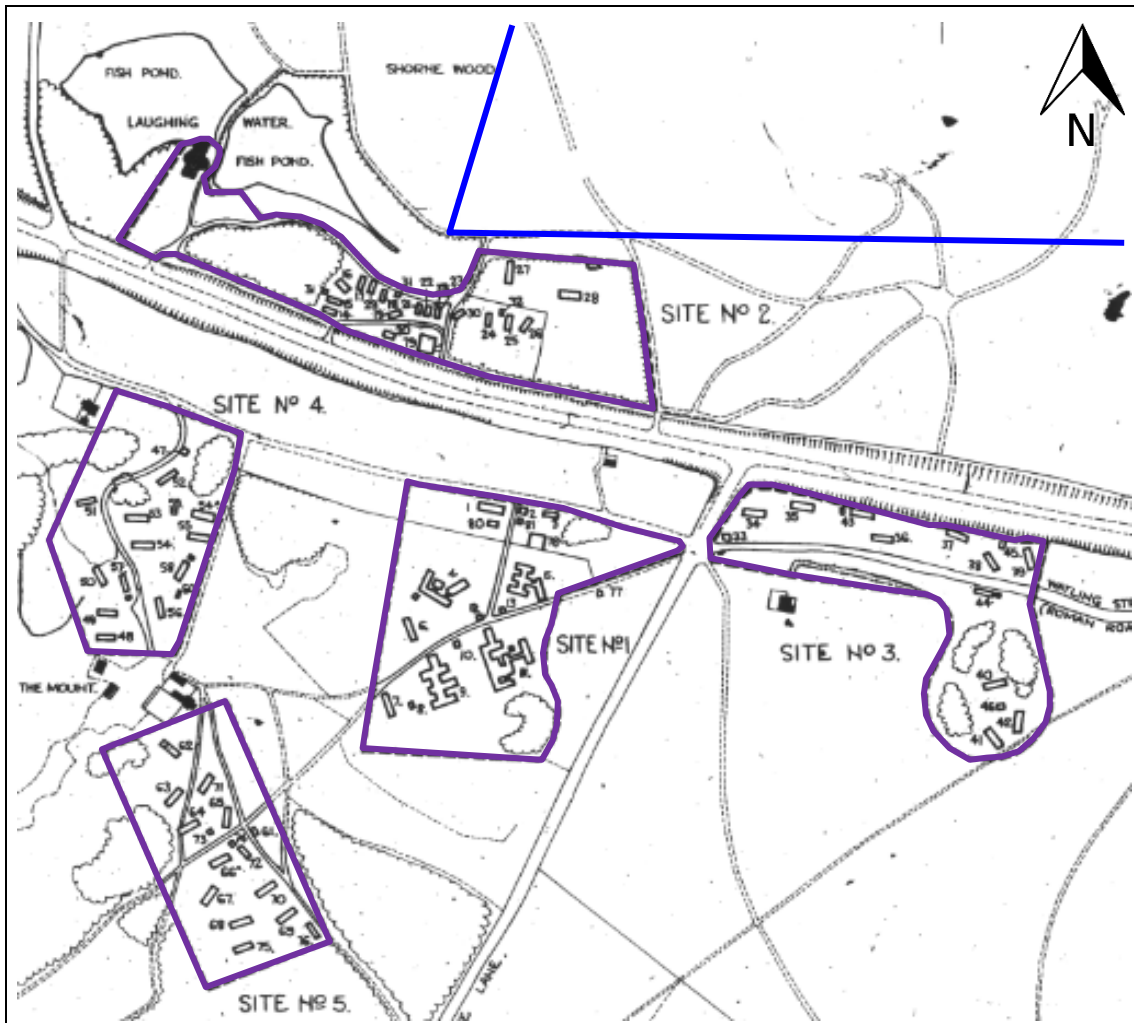
3.6.4 Ashenbank Wood Camp

During WWII land surrounding Watling Street, north of Cobham, was used to accommodate personnel stationed at RAF Gravesend (see Section 3.2.2). Three dispersed camps were established at TQ 674696, TQ 677695 and TQ 675693, on the southern part of the Site.

Ashenbank Wood Camp was also used briefly as a Royal Navy (RN) training establishment. 2No. additional dispersed accommodation sites were located at Laughing Water (TQ 677697 and TQ 681695), also on the Site.

Figure 8 is a plan of the dispersed accommodation camps at Ashenbank Wood, dating from 1945.

Figure 8 Plan of dispersed accommodation at Ashenbank Wood, RAF Gravesend, 1945



Source: RAF Museum

Not to Scale

Legend	Site boundary	Dispersed camps
---------------	---------------	-----------------

In 1947 Ashenbank Wood Camp was repurposed as temporary civilian accommodation. In the mid-1950s, the majority of the buildings were demolished. A small number of air raid shelters remain extant.

Potential UXO Hazard

During WWII Ashenbank Wood Camp was used to station personnel based at RAF Gravesend.

No evidence has been found indicating that this area was used for military training, and no designated munition stores have been identified on the Site.

Any munitions that may have been present at the camp on its closure are likely to have been removed when the camp was demolished.

Ashenbank Wood Camp is not considered to provide a significant source of UXO hazard to the Site.

3.6.5 Coalhouse Fort

In the 1860s a coastal defence fort was constructed at East Tilbury, on the central part of the Site (TQ 690767). Known as Coalhouse Fort, it was designated with protecting the approaches

to the River Thames, and was initially armed with 4No. 12.5" Rifle Muzzle-Loading (RML) guns and 13No. 11" RML guns.

In 1891, a supplementary battery was constructed approximately 0.4km northwest of Coalhouse Fort. Known as East Tilbury Battery, this was armed with 2No. 10" and 4No. 6" long range firing guns, mounted on disappearing carriages. In 1913 it was decommissioned and subsequently sold. It remains private land.

In 1893, a detached wing Quick Firing (QF) battery was established approximately 0.1km south of Coalhouse Fort. This was armed with 2No. 6-pounder (pdr) guns for engaging smaller vessels, such as Destroyers and Torpedo Boats. Records indicate that the QF Wing Battery fell into disuse from 1902.

By the outbreak of WWI, Coalhouse Fort's armaments had been replaced with 4No. Mk. VII 6" breech loading (BL) guns and 4No. 12pdr QF BL guns. During the war, the fort was manned by units of No. 2 Company, Royal Garrison Artillery. Post-WWI, the fort was reduced to care and maintenance status.

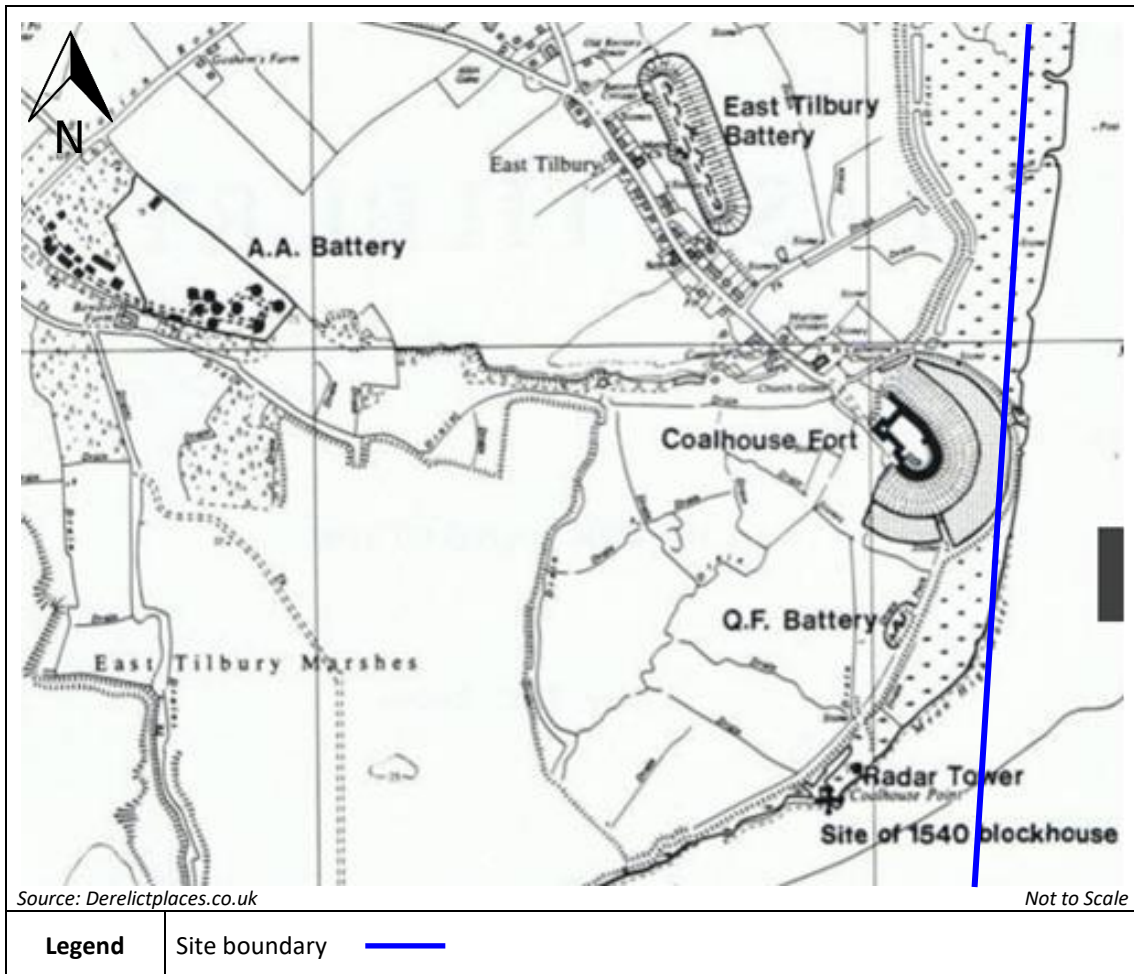
During WWII Coalhouse Fort was designated an emergency battery and was armed variety of armaments, including 2No. 5.5" naval guns and 2No. 40mm Bofors guns (see Section 3.1.2). Several designated munitions storage areas were also constructed in the fort.

Additionally, a concrete observation tower was constructed north of the fort to control electrically detonated mines in the River Thames. This worked in conjunction with a radar station to the south of the fort. This radar station was occupied by naval forces, covering the approach to the minefield.

In 1944, Coalhouse Fort was transferred to the Home Guard's No. 356 Coastal Battery detachment.

Figure 9 is a plan of the WWII defences at East Tilbury. This shows the locations of Coalhouse Fort, East Tilbury Battery, the QF battery, and HAA Battery TN13, Buckland (see Section 3.1.3).

Figure 9 Plan of WWII defences at East Tilbury



Post-WWII, Coalhouse Fort was used briefly for the training of Sea Cadets and nautical youth groups. It was decommissioned in 1949 and subsequently used as a storage facility. In 1962 the fort became a scheduled monument and was partially restored. It remains extant.

Potential UXO Hazard

Since its construction Coalhouse Fort has been regularly rearmed and modernised, and several munitions storage areas have been located in the fort.

It is considered likely that these munitions stores were cleared post-WWII once the fort was decommissioned and opened to the public as a scheduled monument.

Coalhouse Fort is not considered to provide a source of UXO hazard to the Site.

3.6.6 Shornemead Fort

In the 1860s a coastal defence fort was constructed at Shorne Marshes (TQ 692747), encroaching on southern part of the Site. Known as Shornemead Fort, it was constructed to supplement Coalhouse Fort (see Section 3.6.5), by covering the southern banks of the River Thames.

It was initially equipped with 11No. 11” RML guns. In the 1870s, a submarine mining depot was established to the west of the fort, consisting of mine stores and mine servicing areas. This facility was removed during or shortly before WWI.

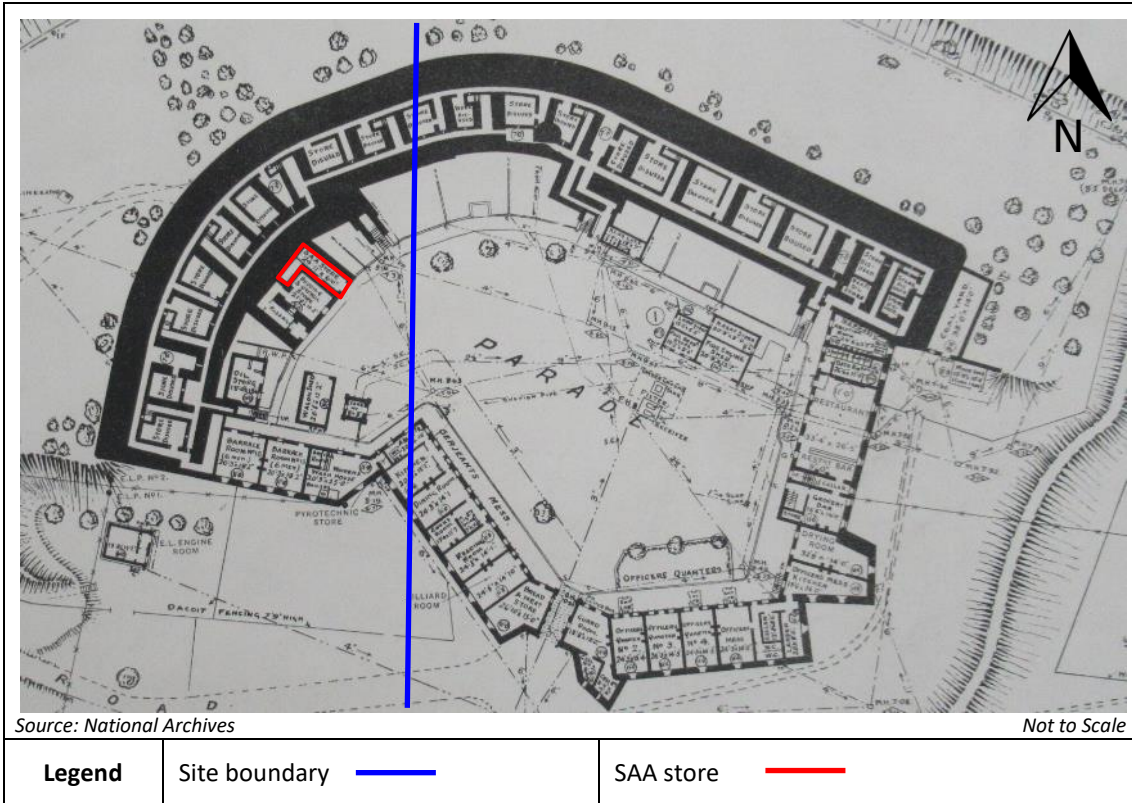
By the late 19th century, Shornemead Fort was disarmed and was used as a training facility by the Thames Militia Division (Submarine Miners), Royal Engineers.

During WWI, the fort was rearmed with 2No. 12-pdr QF guns.

Figure 10 is a plan of Shornemead Fort dating from 1930. During this period, the majority of the fort was being used as a barracks, and the battery casemates are marked as disused stores.

1No. SAA store has been identified on the Site.

Figure 10 Plan of Shornemead Fort, 1930



During WWII, the Shornemead Fort was designated as an emergency battery and rearmed with 2No. 5.5" naval guns, as well as a landing 'hard' for the embarkation of troops. The fort was also used to station troops training at the nearby Milton Range (see Section 3.5.1).

Post-WWII Shornemead Fort was decommissioned. During the 1960s it was used by the Royal Engineers demolition squad for explosives practice, which destroyed the barracks at the rear of the fort (See Section 3.5.2). By the 1970s, the staff accommodation and associated mining establishment had also been cleared.

Potential UXO Hazard

During WWII Shornemead Fort was armed with 2No. naval guns and included SAA stores on the Site. It is likely that the fort would have also had storage for shells, which were connected to the battery's firing points with lifts.

It is considered likely that these munitions were removed once the fort was decommissioned, although the possibility of local munitions disposal cannot be totally discounted. This forms part of the low background risk for any military site in the UK.

Shornemead Fort is not considered to provide a significant source of UXO hazard to the Site.

4 BOMBING

4.1 WWI Bombing

For further information on WWI bombing in the UK, and the potential UXO hazard associated with it, see Appendix 2.1. Alternatively, use the following link.

- [WWI Bombing](#)

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

4th June 1915

5No. HE bombs and 3No. Incendiary Bombs (IBs) fell on Gravesend, within approximately 2km of the southern part of the Site.

2nd September 1916

1No. IB was dropped in the River Thames to the east of Gravesend, within approximately 0.3km west of the southern part of the Site.

A Zeppelin airship dropped bombs (exact number and type unspecified) in the vicinity of Tilbury, within approximately 1km of the central part of the Site. The exact locations are not recorded.

23rd-24th September 1916

23No. HE bombs and 21No. IBs fell between South Ockendon and North Ockendon, potentially on the northern part of the Site.

31st October 1917

Gotha bomber aircraft dropped HE bombs and IBs (number unspecified) on Gravesend, within approximately 2km west of the southern part Site.

Potential UXO Hazard

Given the small numbers of bombs that were dropped at any one time during WWI air raids, and the minimal damage caused, it is considered unlikely that an Unexploded Bomb (UXB) would have fallen unnoticed on the Site.

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

4.2 WWII Bombing

For further information on WWII bombing in the UK, and the potential UXO hazard associated with it, see Appendix 2.2. Alternatively, use the following link.

- [WWII Bombing](#)

Records indicate that parts of the Site were bombed during WWII. Further details on bombing in the vicinity of the Site are given in the following sections.

4.2.1 Bombing in Essex & Kent

From 1939 Essex and the southeast coast were subject to reconnaissance flights by the Luftwaffe which was building up a photographic record of potential targets. From the onset of WWII, mine laying by the Luftwaffe along the coast and in the estuaries of the River Thames and the River Medway became increasingly frequent.

The Thames Estuary and the River Thames were heavily mined during WWII. This included both defensive mines on beaches in order to prevent enemy landings, as well as marine mines laid at sea by both the British and the German forces to destroy ships entering the Thames Estuary. The Thames Estuary was also guarded against enemy submarines by mines and submarine nets.

Inland bombing raids began in the summer of 1940 and continued until the end of WWII. The main Luftwaffe flightpaths to and from London and the industries along the River Thames, including the Tilbury Docks and the Royal Docks, crossed the Site. The region was consequently subject to 'tip-and-run' raids throughout WWII from aircraft flying to and from London and the industrialised Midlands.

There were also strategic targets in the area including oil facilities, explosives and munitions factories and other military establishments, which were actively targeted. Operational airfields in the area, such as RAF Eastchurch, RAF Gravesend and RAF Hornchurch, were attacked by the Luftwaffe. Records for heavy raids on many of the region's airfields were suppressed until after WWII.

From mid-September until the end of 1940, Essex and Kent were raided on the majority of nights. The raids continued through the early months of 1941 becoming less frequent, although often more intense.

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

These weapons arrived at any time of day and caused considerable blast damage. In an attempt to prevent them from reaching London, a defence plan known as Operation Diver was devised. This involved the deployment of AA guns, barrage balloons and fighter aircraft in an attempt to intercept the V1s.

In September 1944 the V2 (Long Range Rocket) offensive began. Falling from a height of some 50 miles (80km) above the ground, these ballistic missiles caused larger craters and greater damage to underground utilities than the V1s, but their surface blast effect was generally less. Records show that in excess of 406No. V1s and 375No. V2s fell in Essex during WWII.

The counties of Essex and Kent recorded approximately 14,810No. and 24,664No. HE bombs respectively during WWII.

4.2.2 Strategic Targets

During WWII large parts of the Site comprised open marshland and farmland, with few significant strategic targets located in close proximity to the majority of the Site.

Other possible strategic targets in the vicinity of the Site are described below.

Tilbury Docks

Tilbury Docks (GB 45 6), encroaching on the central part of the Site, and their associated warehouses, wharves, railway lines, factories and power stations, were principal targets of the Luftwaffe. They were widely used throughout WWII to handle military cargo and troops.

The land adjacent to Tilbury Docks was also used for the construction of the 'Pipe Line Under The Ocean' (PLUTO) and the construction of Mulberry Harbours for the D-Day landings.

Plate 14 is a Luftwaffe target photograph of Tilbury Docks (Target A), dating from August 1938.

Plate 14 Luftwaffe target photograph of Tilbury Docks, August 1938



Industrial Targets

Essex Aero Ltd, located at RAF Gravesend, on the southern part of the Site, produced components for aircraft and HAA guns, and manufactured magnesium alloy fuel and oil tanks for Spitfire and Sunderland aircraft.

Bowaters Paper Mill, Gravesend, approximately 2km southwest of the central part of the Site, machined and assembled Bofors 40mm Light AA guns.

Several engineering works were located the Red Lion Wharf, Gravesend, approximately 2km southwest of the central part of the Site, including the Holloway Brothers and WT Henley Telegraph Works, who produced a range of wartime items including gas masks, mortar components, and connectors and wiring for radar installations.

Gas works were also located at Milton, approximately 1.1km west of the southern part of the Site.

Military Targets

Milton Range, on the southern part of the Site, was used by regular Army troops and by the Home Guard for small arms and close-combat training (see Section 3.5.1).

RAF Gravesend, encroaching on the southern part of the Site, was used to station squadrons of Fighter Command. A Luftwaffe target photograph of RAF Gravesend is presented in Plate 7 (Section 3.2.2).

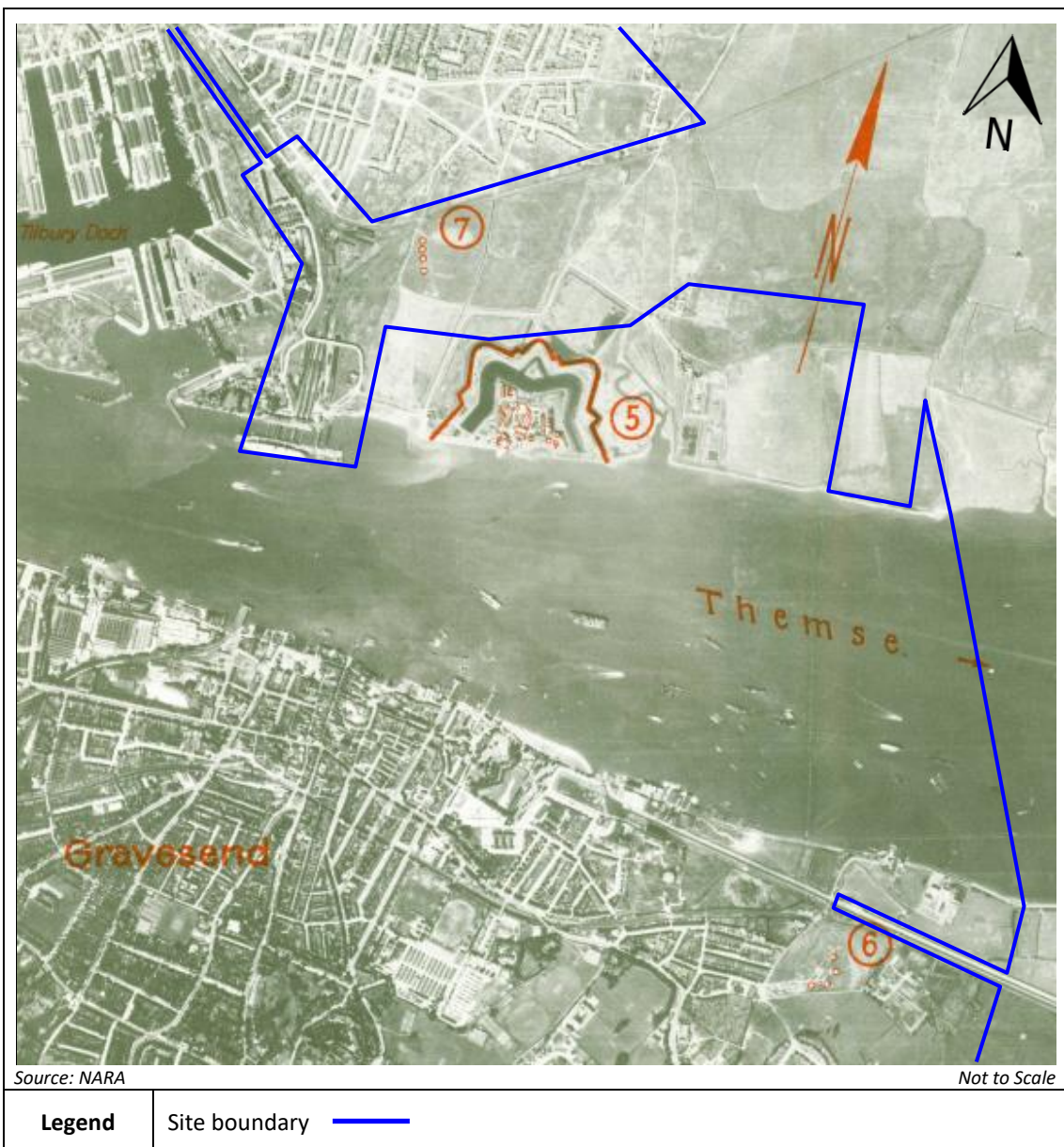
Several coastal batteries were also located on the Site, including Coalhouse Fort and Shornemead Fort (see Sections 3.6.5 and 3.6.6).

There were numerous HAA gun batteries in the vicinity of the Site, each of which had associated ammunition storage and accommodation camps. 4No. HAA batteries were located on the Site at Orsett, Buckland, North Ockendon, and Chadwell (see Section 3.1.1).

Tilbury Fort, approximately 0.2km south of the Site, was used to billet troops and served as an AA operations base.

Plate 15 is a Luftwaffe target photograph of Tilbury Fort, dated the 4th June 1939. Tilbury Fort (GB 16 23) has been designated Target 5. AA gun emplacements are marked as Targets 6 and 7.

Plate 15 Luftwaffe target photograph of Tilbury Fort, 4th June 1939



4.2.3 Bombing Densities and Incidents

Table 3 gives details of the overall bombing statistics recorded for the Local Authority Districts of the Site. 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 Low.

15-50 bombs per 405ha is Moderate.

50-250 bombs per 405ha is High.

>250 bombs per 405ha is Very High.

Table 3 Bombing statistics

Area	Bombs Recorded				Bombs per 405ha (1000 acres)
	High Explosive	Parachute Mines	Other	Total	
Northfleet UD	364	3	7	374	99.2
Gravesend MB	272	0	14	286	71.3
Hornchurch UD	1,012	41	38	1,091	55.1
Brentwood UD	744	14	34	792	43.4
Thurrock UD	1,614	44	21	1,679	41.4
Strood RD	1,804	24	55	1,883	38.6

Note that Table 3 excludes the figures for V1s, V2s 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

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.

The maps and aerial photographs below identify the extent of bombing across the Site. Appendix 6 provides a list of recorded bombing incidents on the Site.

The compiled maps show the approximate locations of bomb impacts on the Site. IBs shown are indicative of larger numbers of similar devices that fell within the given area.

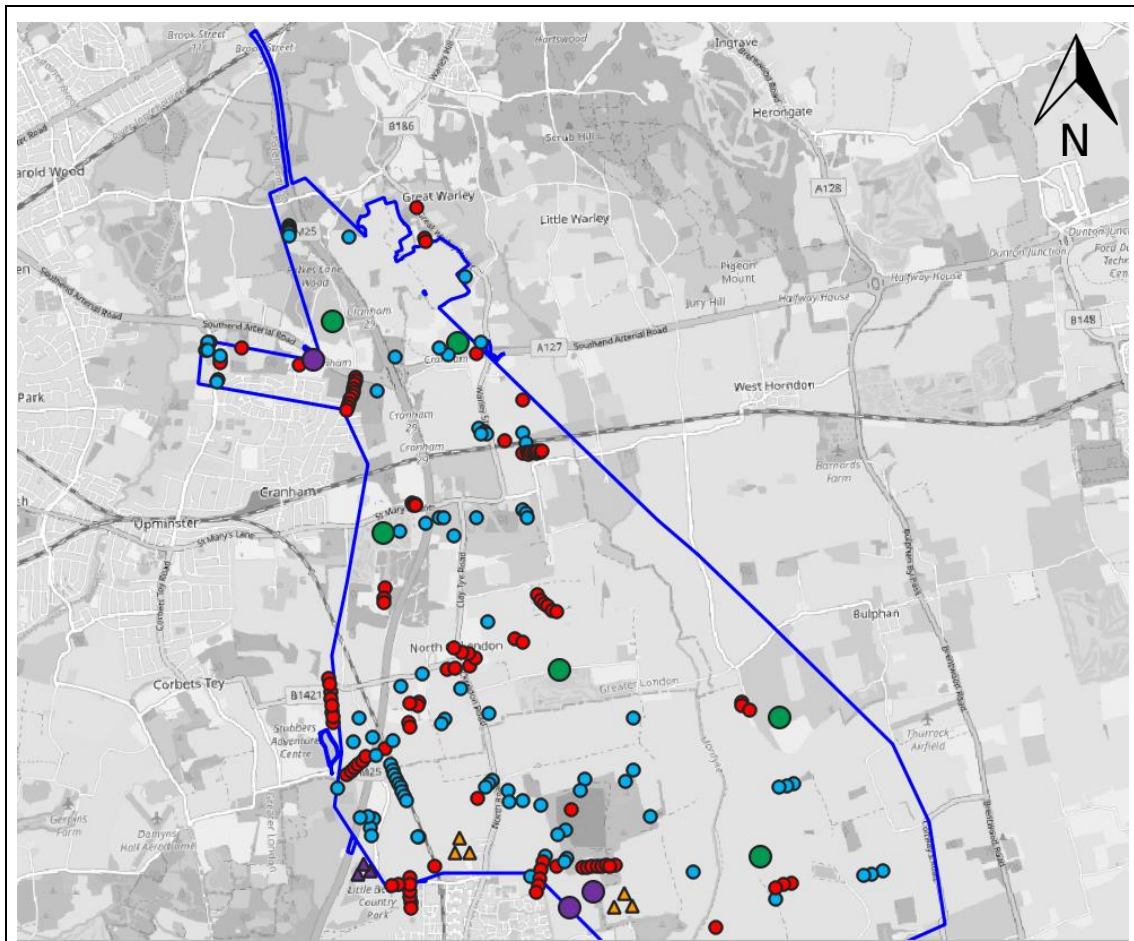
The compiled bomb maps are also given in the accompanying HE540039-ZET-GEN-GEN-REP-GEO-00001-P05.

4.2.4 Northern Part of the Site

Figure 11 is a compiled bomb impact map for the northern part of the Site.

It shows several incidents recorded on the Site, including a concentration of bombing south of Great Warley and at South Ockendon, where numerous UXB are recorded as falling.

Figure 11 Compiled bomb impact map for the northern part of the Site



Source: OpenStreetMap

Not to Scale

Legend	Site boundary		HE bomb		UXB	
	V1		V2		IBs	

Plate 16 is an aerial photograph of the Great Warley area of the Site, dated the 11th October 1946.

Only 2No. possible bomb craters have been identified on the Site and there is no evidence of any heavy cratering.

Plate 16 Aerial photograph, 11th October 1946 (Great Warley)



Source: Historic England

Not to Scale



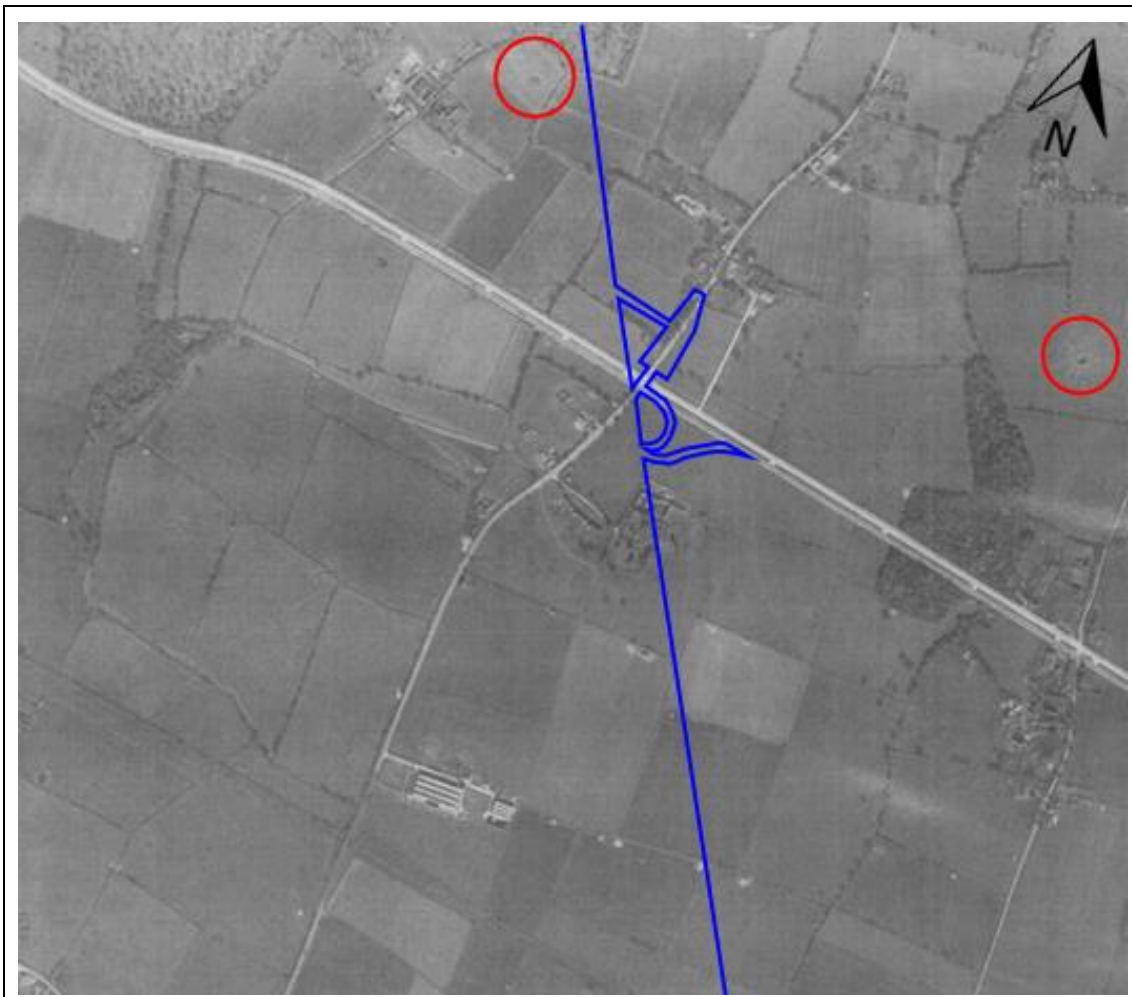
Legend	Site boundary 	Possible bomb cratering 
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Plate 17 is an aerial photograph of the Warley Street area of the Site, dated the 18th April 1944. Only 1No. possible bomb crater has been identified on the Site and there is no evidence of any heavy cratering.

Plate 17 Aerial photograph, 18th April 1944 (Warley Street)



Source: Historic England

Not to Scale



Legend	Site boundary 	Possible bomb cratering 
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Plate 18 is an aerial photograph of the Upminster area of the Site, dated the 1st May 1946.

Some possible residual bomb damage has been identified on the Site, although there is no evidence of any heavy cratering.

Plate 18 Aerial photograph, 1st May 1946 (Upminster)



Source: Historic England

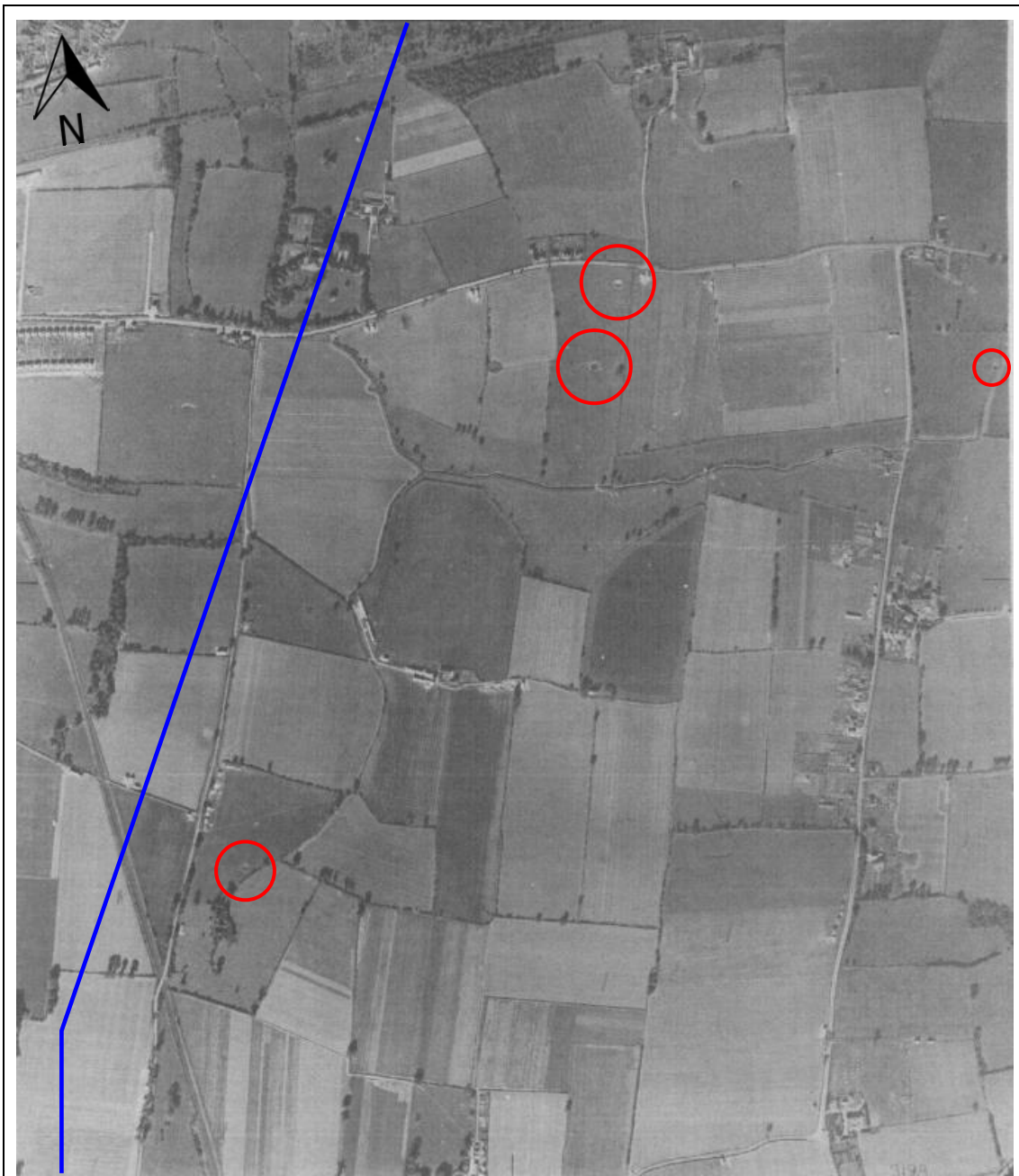
Not to Scale

Legend	Possible bomb damage ○
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Plate 19 is an aerial photograph of the Thames Chase area of the Site, dated the 11th October 1946.

Some possible bomb damage has been identified on the Site, although there is no evidence of any heavy cratering.

Plate 19 Aerial photograph, 11th October 1946 (Thames Chase)



Source: Historic England

Not to Scale



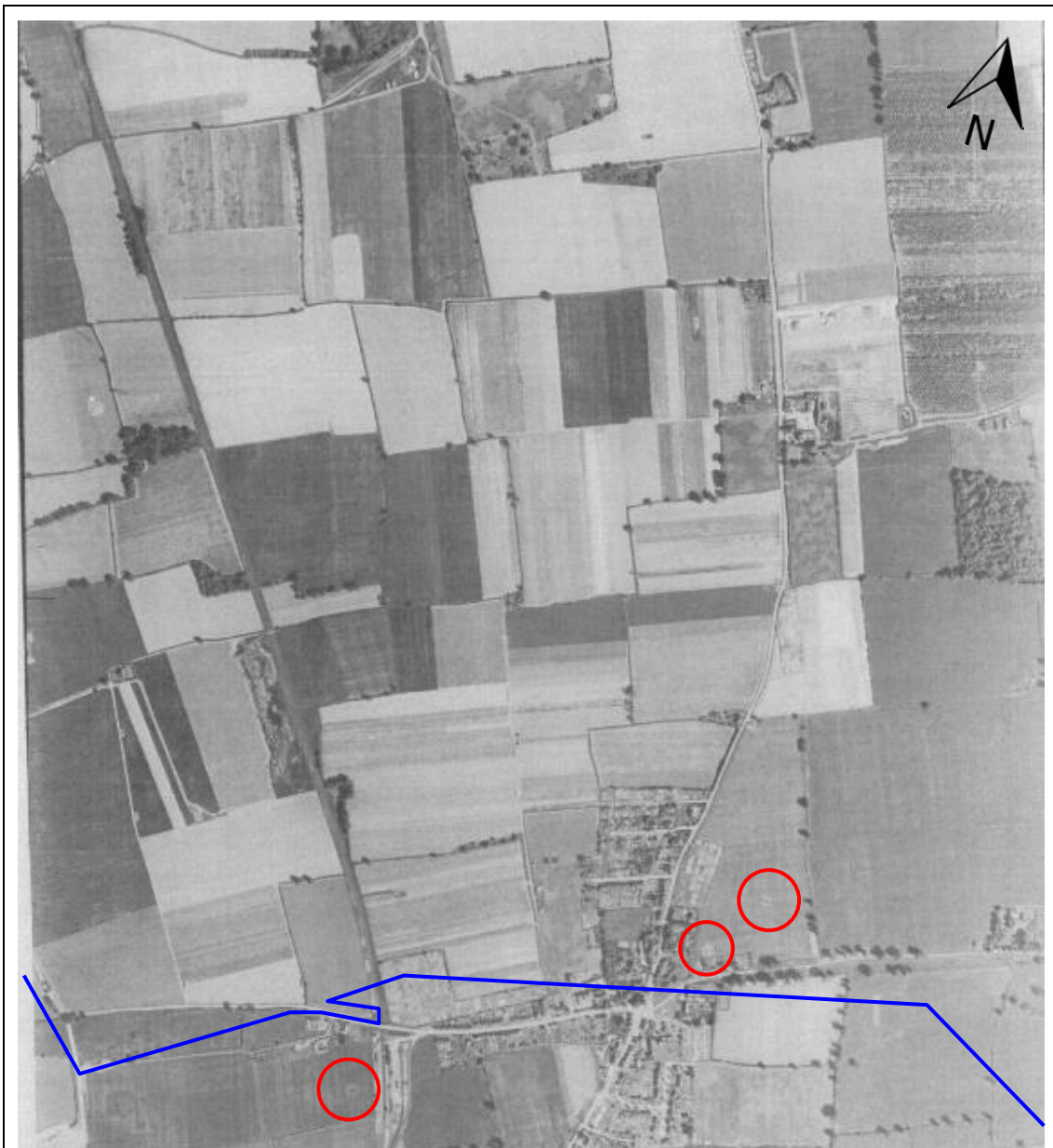
Legend	Site boundary 	Possible bomb cratering 
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Plate 20 is an aerial photograph of the area of the Site east of Dennis Road, dated the 7th June 1946.

Only 2No. possible bomb craters have been identified on the Site and there is no evidence of any heavy cratering.

Plate 20 Aerial photograph, 7th June 1946 (East of Dennis Road)



Source: Historic England

Not to Scale



Legend	Site boundary 	Possible bomb cratering 
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Plate 21 is an aerial photograph of the South Ockendon area of the Site, dated the 1st May 1946.

Some possible bomb cratering has been identified on the Site.

Plate 21 Aerial photograph, 1st May 1946 (South Ockendon)



Potential UXO Hazard

Warley Street/St Mary’s Lane

Records indicate that at least 16No. HE bombs fell in close proximity to Warley Street and St Mary’s Lane. 6No. of these were recorded as UXB.

Given this elevated localised bombing density, it is considered possible that further UXB could have fallen unnoticed on this part of the Site and remained in situ.

This area is identified as M1 on **Figure 21** and shown on HE540039-ZET-GEN-GEN-MAP-GEO-00001-P05.

Kemps Farm

Records indicate that at least 17No. HE bombs fell on the Site in the vicinity of Kemps Farm, half of which were recorded as UXB.

Heavy bombing also occurred to the west and northwest of Kemps Farm due to it being on the flightpath to the strategically-important RAF Hornchurch, approximately 3.6km west of the Site, which was raided on numerous occasions.

Given this concentrated localised bombing density, it is considered possible that further UXB could have fallen unnoticed on this part of the Site and remained in situ.

This area is identified as M1 on **Figure 22** and shown on HE540039-ZET-GEN-GEN-MAP-GEO-00001-P05.

South Ockendon area

Records indicate that at least 35No. HE bombs fell on the Site around South Ockendon. More than 50% of these were recorded as UXB, far higher than the generally accepted national average UXB rate of 10%.¹

Given this elevated bombing density, it is considered possible that further UXB could have fallen unnoticed on this part of the Site and remained in situ.

This area is identified as M1 on **Figure 22** and shown on HE540039-ZET-GEN-GEN-MAP-GEO-00001-P05.

Remainder of the northern part of the Site

On the remainder of the northern part of the Site, bombing densities were generally lower and no records have been found of any extensive air raids on this part of the Site.

It should be noted that during WWII areas of the northern part of the Site comprised open fields and it possible that bomb and shell impacts may have been missed and gone unrecorded in uninhabited areas.

As such, the potential for encountering a UXB on any part of the Site cannot be totally discounted.

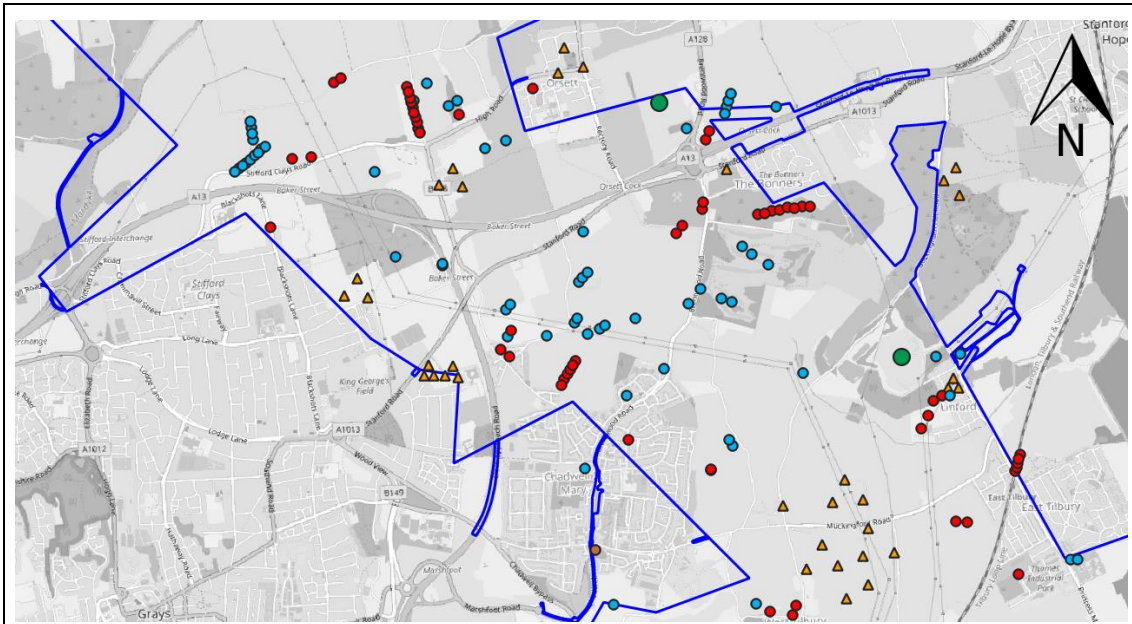
4.2.5 Central part of the Site

Figure 12 is a compiled bomb impact map for the Orsett and Baker Street area on the central part of the Site.

This region was subjected to extensive bombing throughout WWII. This included air raids involving mixed loads of HE bombs and IBs which caused severe fire damage in the area.

¹ The reasons for elevated percentages of UXB, above the national WWII recorded MEAN figure of 10% -15%, are numerous and varied. Besides the observational intensity during and after air raids, bomb types and fuzes varied throughout WWII, as did their efficiency. Some sticks of bombs were accidentally released in the 'safe' mode, some were deliberately sabotaged and some fuzes were set for different operational release heights to those enforced by defensive AA artillery or fighter aircraft attacks. There is also the possibility that ground conditions influenced the number of UXB. The important thing to note is that these figures are collated directly from the detailed ARP and other records of the time.

Figure 12 Compiled bomb impact map for the central part of the Site (Orsett Area)



Source: OpenStreetMap

Not to Scale

Legend	Site boundary	HE bomb	UXB	IBs
	DAB	V1		

Plate 22 is an aerial photograph of the Orsett Heath area of the Site, dated the 4th August 1944. Significant bomb damage and cratering has been identified on and in close proximity to the Site.

Plate 22 Aerial photograph, 4th August 1944 (Orsett Heath)

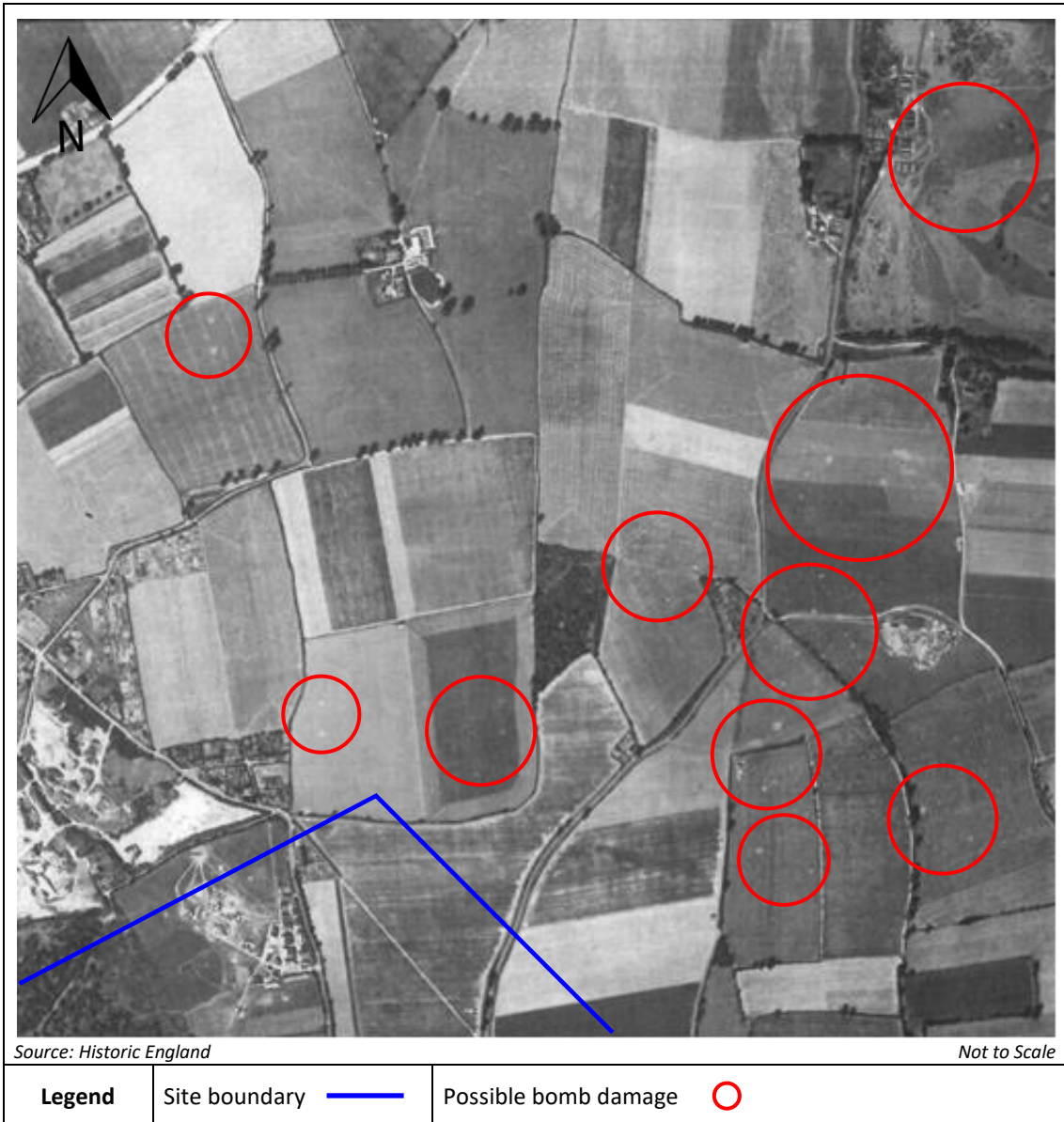
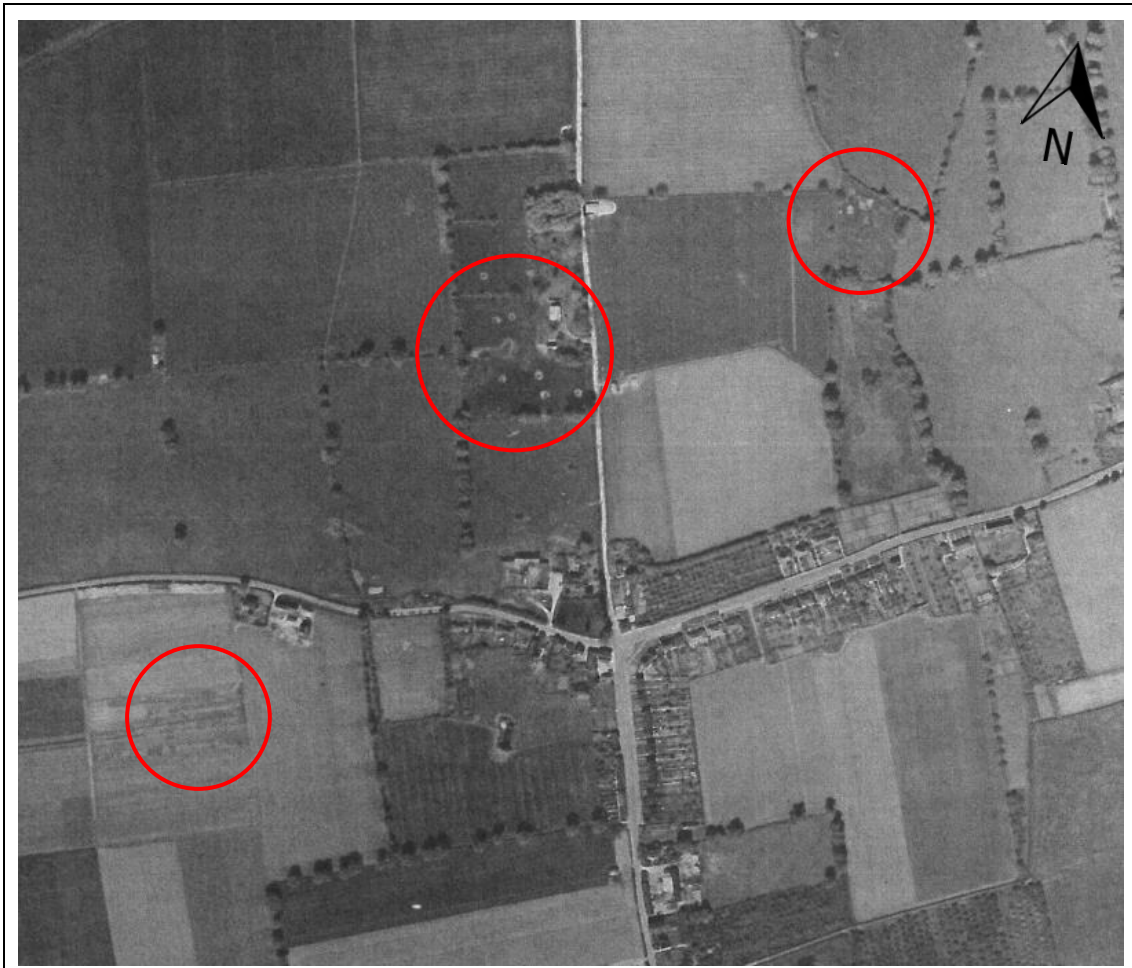


Plate 23 is an aerial photograph of the Baker Street area of the Site, dated the 1st May 1946, Some possible residual bomb damage has been identified on the Site.

Plate 23 Aerial photograph, 1st May 1946 (Baker Street)



Source: Historic England

Not to Scale

Legend	Possible bomb damage ○
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Figure 13 is a compiled bomb impact map for the area surrounding Tilbury on the central part of the Site.

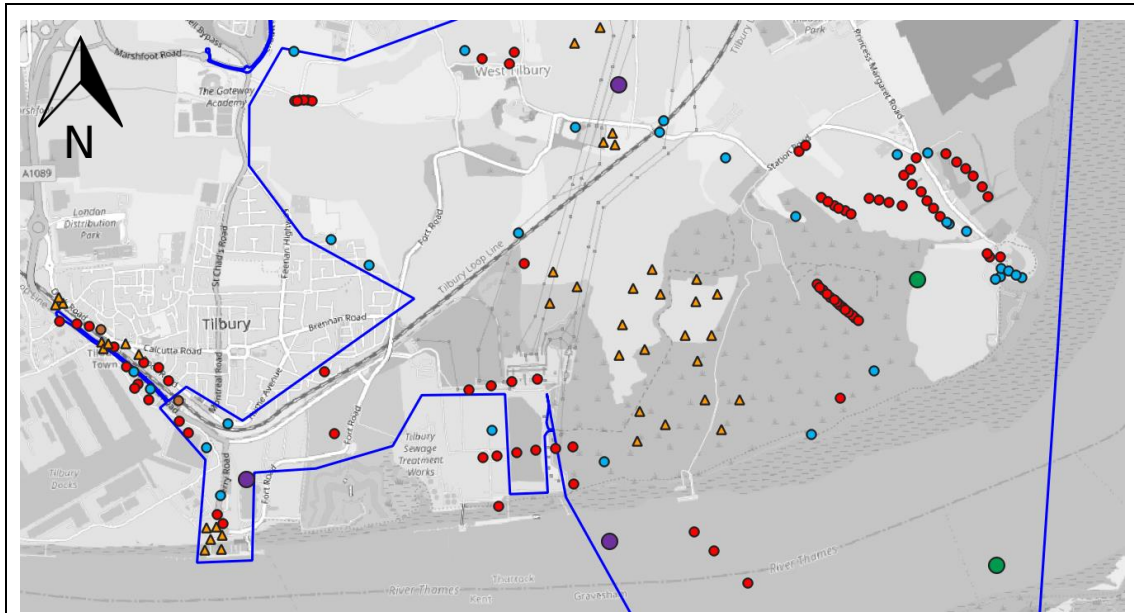
In excess of 20No. HE bombs fell in the vicinity of Coalhouse Fort, East Tilbury, 6No. of which were recorded as UXB. A further 14No. HE bombs also fell on the nearby saltings.

Records have been found indicating a concentration of at least 14No. HE bombs fell on the southwestern part of the Tilbury Marshes. 2No. of which were records as UXB.

While the recorded HE bombing density on the central Tilbury Marshes was lower, it should be noted that the recording of bombs falling in uninhabited marshland areas was generally less comprehensive than for more urban areas.

For instance, several ARP records state that bombs fell ‘on Tilbury Marshes’ without specifying exactly where.

Figure 13 Compiled bomb impact map for the central part of the Site (Tilbury)



Source: OpenStreetMap

Not to Scale

Legend	Site boundary		HE bomb		UXB		IBs	
	DAB		V1		V2			

Plate 24 is an aerial photograph of the East Tilbury area of the Site, dated the 11th October 1946.

Some possible bomb cratering has been identified on the Site.

Plate 24 Aerial photograph, 1st May 1946 (East Tilbury)

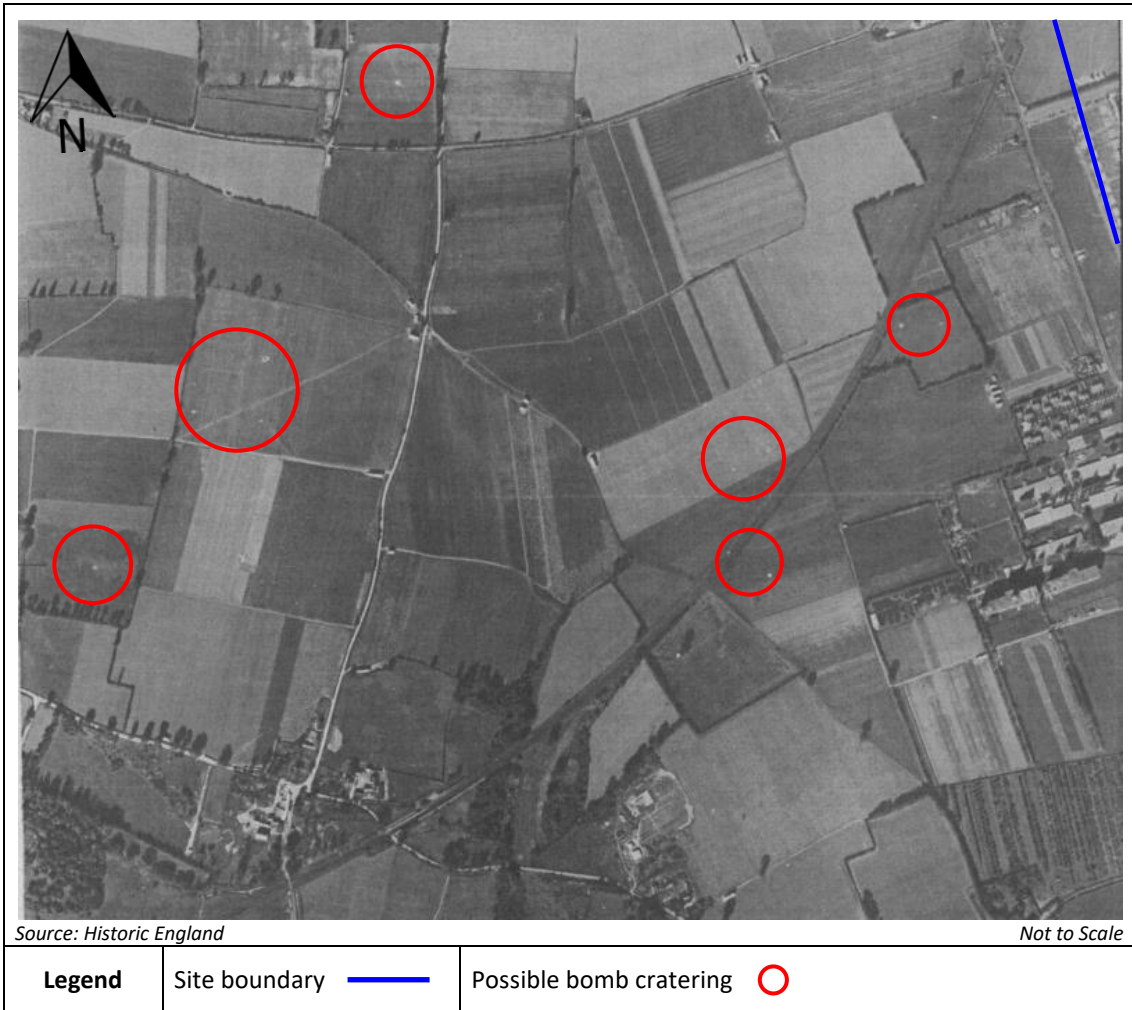


Plate 25 is an aerial photograph of the Coalhouse Fort area of the Site, dated the 1st May 1946, Some possible bomb cratering has been identified on the Site.

Plate 25 Aerial photograph, 1st May 1946 (Coalhouse Fort)



Source: Historic England

Not to Scale

Legend	Site boundary ———	Possible bomb cratering ○
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Plate 26 is an aerial photograph of the West Tilbury area of the Site, dated the 4th August 1944. Some possible bomb cratering has been identified on the Site.

Plate 26 Aerial photograph, 4th August 1944 (West Tilbury)

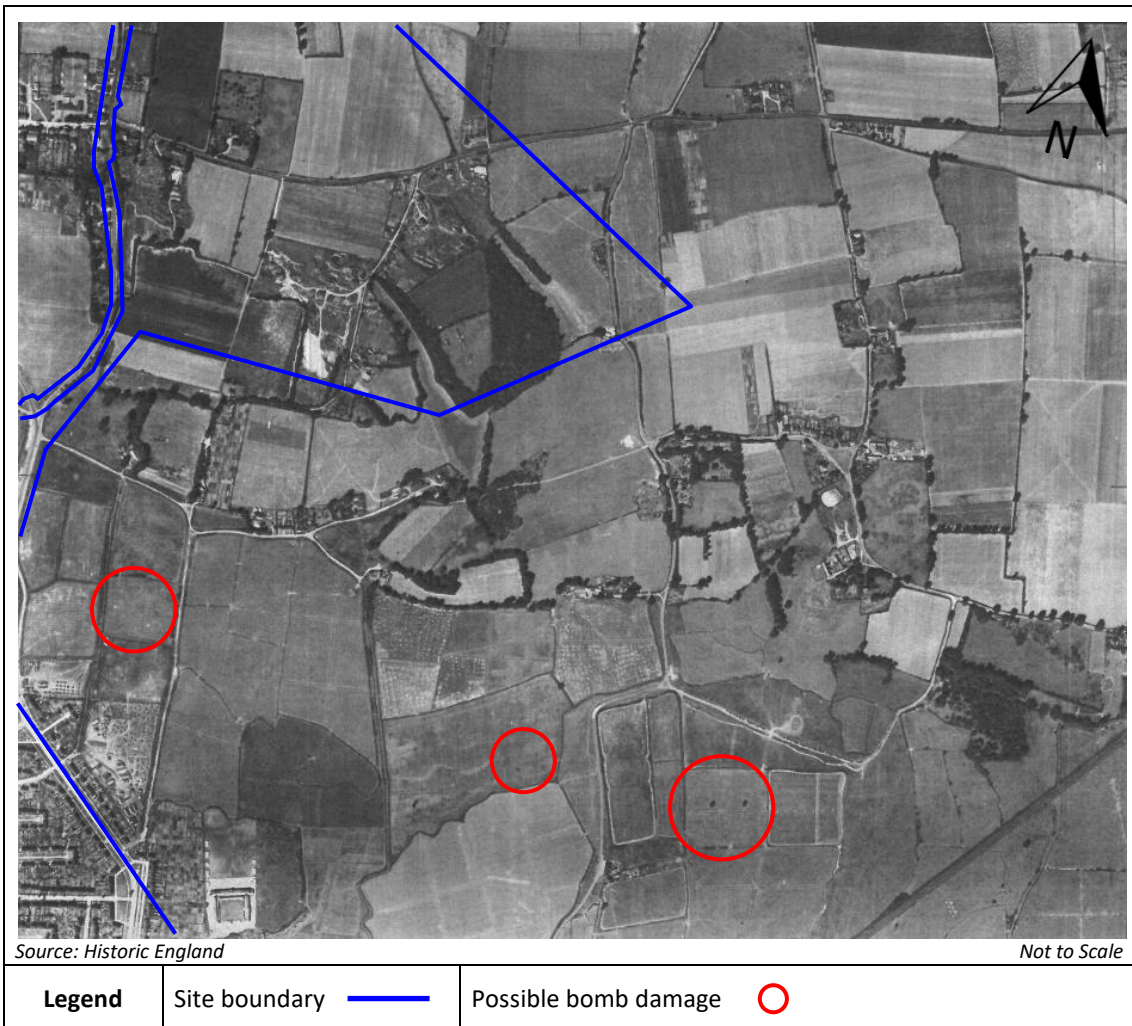
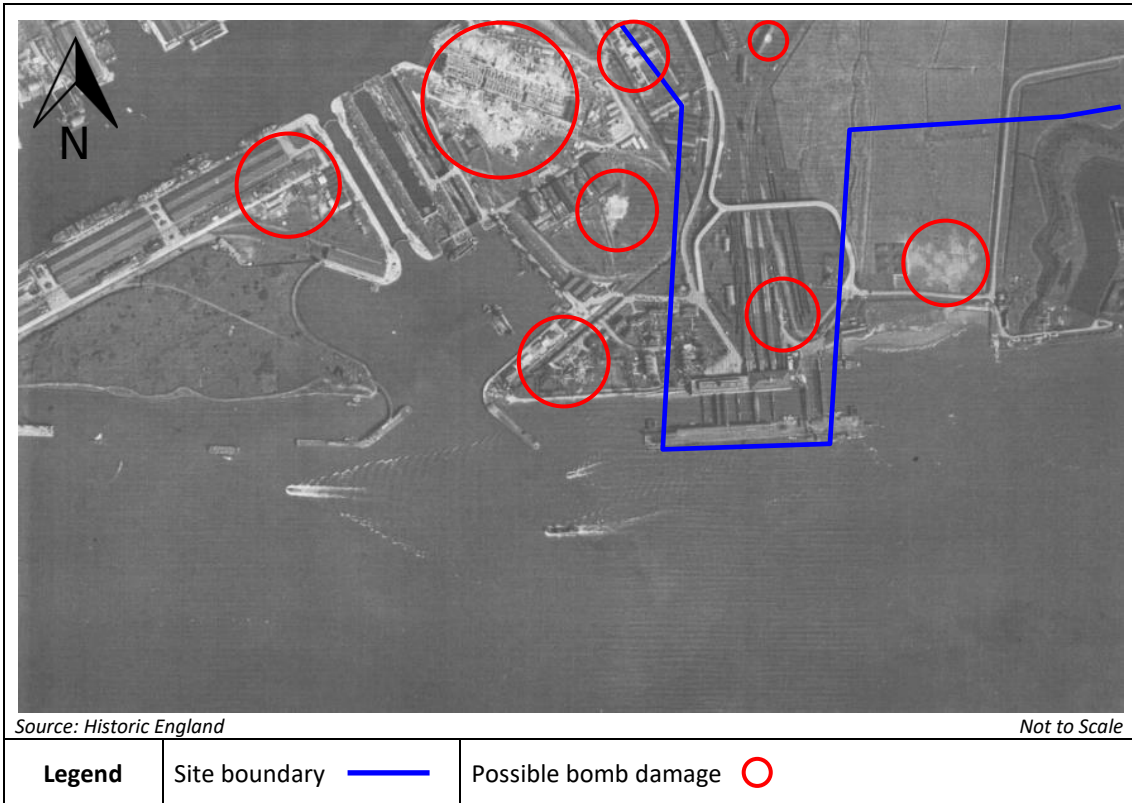


Plate 27 is an aerial photograph of the Tilbury Docks area of the Site, dated the 18th April 1944. Significant bomb damage has been identified on and in the immediate vicinity of the Site, notably in the area surrounding Tilbury Docks, which sustained heavy damage during several air raids.

Plate 27 Aerial photograph, 18th April 1944 (Tilbury Docks)



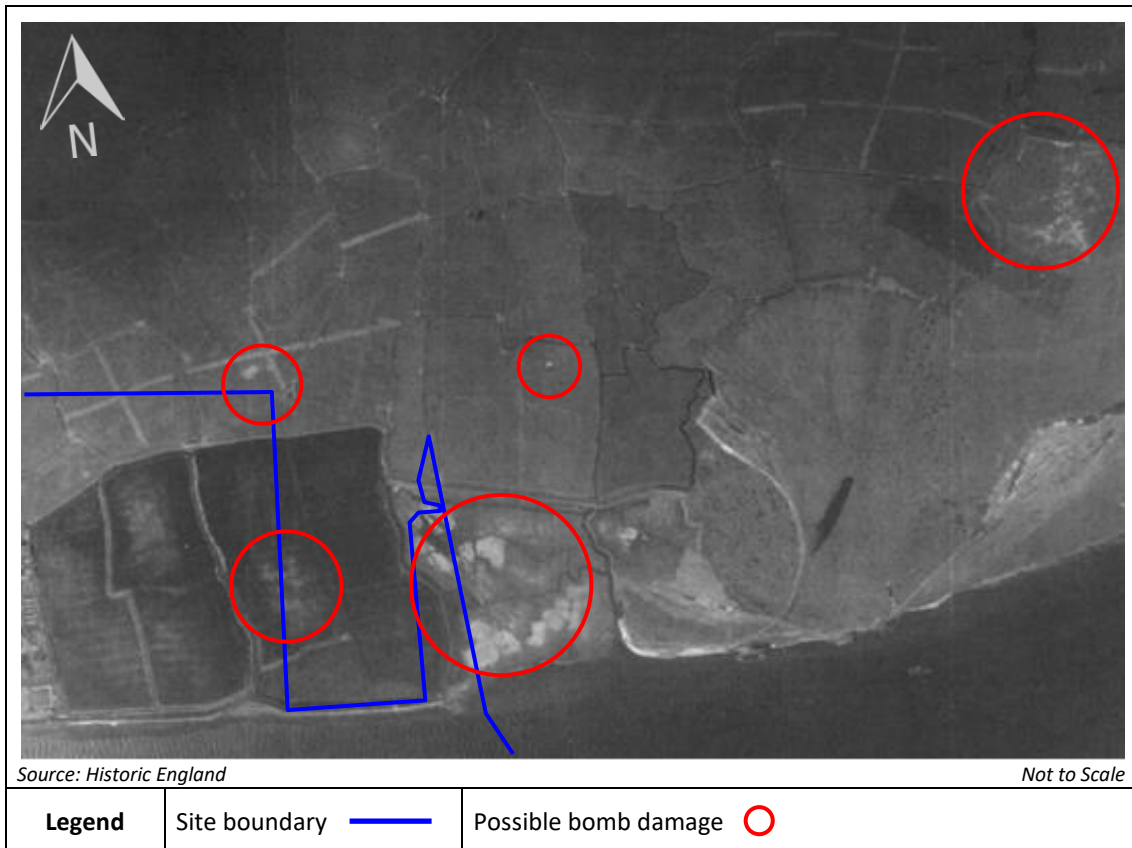
Records indicate that most of the bombing on Tilbury Marshes involved IBs. For instance, during a raid in December 1940, more than 1,000 No. IBs fell across the marshland, setting fire to extensive areas of vegetation.

Plate 28 is an aerial photograph of the Tilbury Marshes area of the Site, dated the 6th July 1944.

This shows some evidence of scarring on and in the vicinity of the Site at Tilbury Marshes consistent with IB fire damage.

It should be noted that in marshland, bomb impact features are often difficult to distinguish due to deeper penetration and the development of camouflets.

Plate 28 Aerial photograph, 6th July 1944 (Tilbury Marshes)



Potential UXO Hazard

Orsett area

Records indicate that at least 51No. HE bombs fell on the Site between Baker Street and Orsett (TQ 624826 to TQ 653800). More than 50% of these were recorded as UXB, far higher than the generally accepted national average UXB rate of 10%.²

There are several possible reasons for the elevated concentration of bombing, including its location on the flight path to London, interception by RAF fighters and military presence such as Orsett Camp.

Given the elevated bombing density and intensity of raids in this area, it is considered possible that further UXB could have fallen unnoticed on this part of the Site and remained in situ.

This area is identified as M1 on **Figure 23** and shown on HE540039-ZET-GEN-GEN-MAP-GEO-00001-P05.

East Tilbury area

Records indicate that in excess of 20No. HE bombs fell on the Site in the vicinity of Coalhouse Fort, of which at least 6No. were recorded as UXB. An additional 14No. HE bombs fell on the nearby saltings. Given the elevated localised bombing density, it is considered possible that further UXB could have fallen unnoticed on this part of the Site and remained in situ.

This area is identified as M1 on **Figure 23** and shown on HE540039-ZET-GEN-GEN-MAP-GEO-00001-P05.

² See previous footnote.

Tilbury Docks

During WWII in excess of 50No. HE bombs and numerous IBs fell on Tilbury Docks and the surrounding area, encroaching on the Site. This caused extensive damage to buildings on the Site, including the railway station, Tilbury Hotel and Tilbury Laundry.

Given the elevated localised bombing density, and it is considered possible that a UXB could have fallen on the Site unnoticed.

This area is identified as M1 on **Figure 23** and shown on HE540039-ZET-GEN-GEN-MAP-GEO-00001-P05.

Southwestern Tilbury Marshes

Records have been found indicating a concentration of at least 14No. HE bombs fell on the southwestern part of the Tilbury Marshes. 2No. of which were records as UXB. Given the elevated localised bombing density, it is considered possible that further UXB could have fallen unnoticed on this part of the Site and remained in situ.

This area is identified as M1 on **Figure 23** and shown on HE540039-ZET-GEN-GEN-MAP-GEO-00001-P05.

Central Tilbury Marshes

The area of the Site on the central Tilbury Marshes was subjected to extensive IB raids. Whilst the possibility of finding an IB at shallow depths on this part of the Site cannot be discounted, IBs were predominantly designed to ignite and burn and had a small HE content. As such, they are typically considered to provide a low UXO hazard (see Appendix 1).

Given the low recorded HE bombing density on this part of the Site, and that no significant cratering indicative of HE bombing has been identified on historical aerial photographs, the potential of encountering a UXB is considered to be low.

Remainder of the central part of the Site

On the remainder of the central part of the Site, bombing densities were generally lower and no records have been found of any extensive air raids on this part of the Site.

It should be noted that during WWII areas of the central part of the Site comprised marshland and open fields and it possible that bomb and shell impacts may have been missed and gone unrecorded in uninhabited areas.

As such, the potential for encountering a UXB on any part of the Site cannot be discounted.

4.2.6 Central Part of the Site

Figure 14 is a compiled bomb impact map for the Gravesend area of the southern part of the Site.

The area around Filborough Marshes recorded several air raids, although bombing densities tended to decrease away from Gravesend and the industrialised wharves along the River Thames to the west.

Figure 14 Compiled bomb impact map for the southern part of the Site (Gravesend)

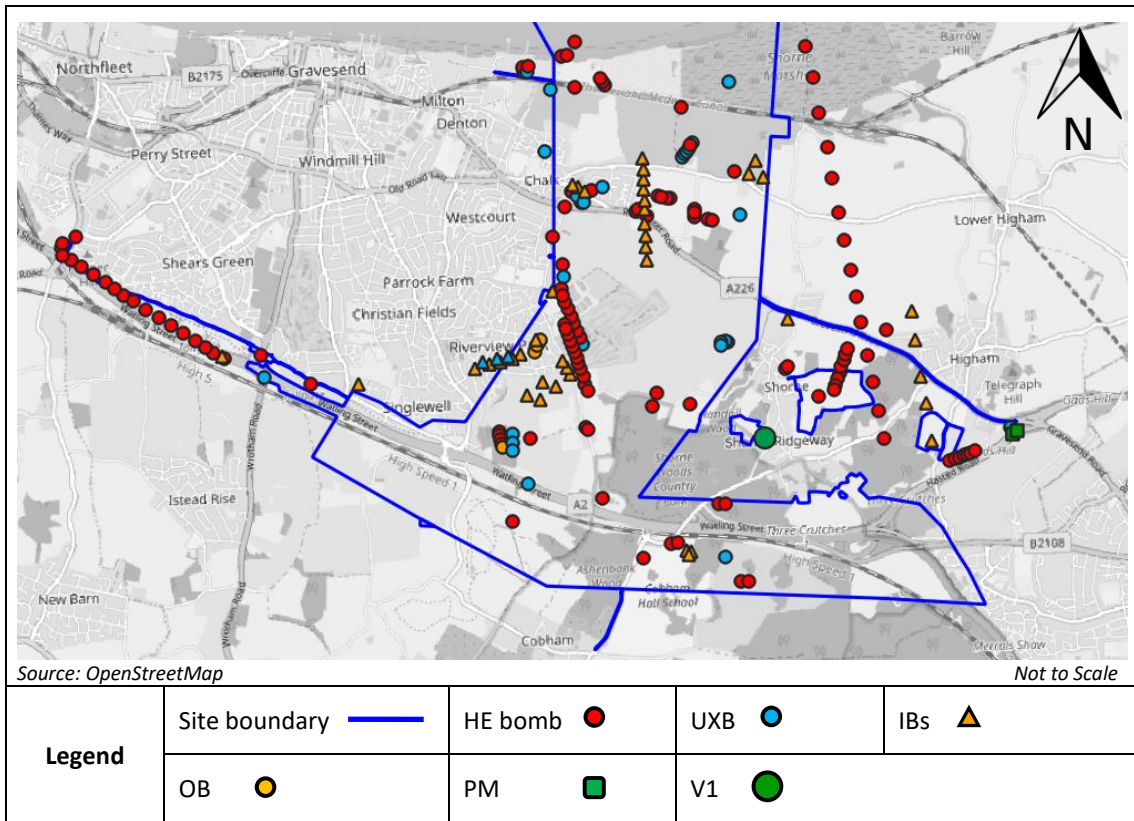


Plate 29 is an aerial photograph of the Filborough Marshes area of the Site, dated the 11th October 1946.

Some possible bomb cratering has been identified on the Site.

Plate 29 Aerial photograph, 11th October 1946 (Filborough Marshes)



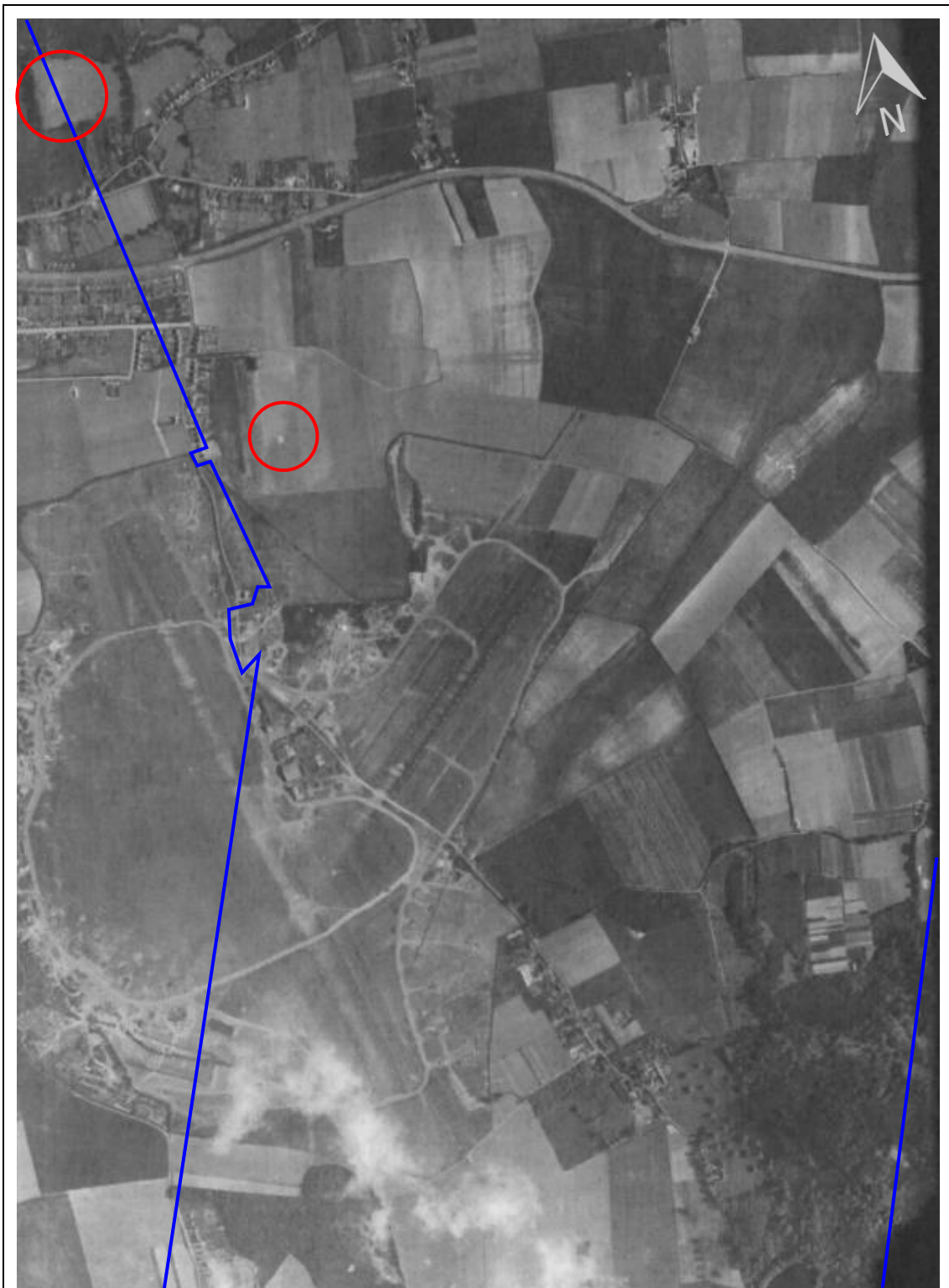
Source: Historic England

Not to Scale

Legend	Possible bomb cratering ○
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Plate 30 is an aerial photograph of the Chalk area of the Site, dated the 14th March 1948. Some possible isolated bomb cratering has been identified on the Site.

Plate 30 Aerial photograph, 14th March 1948 (Chalk)



Source: Historic England

Not to Scale



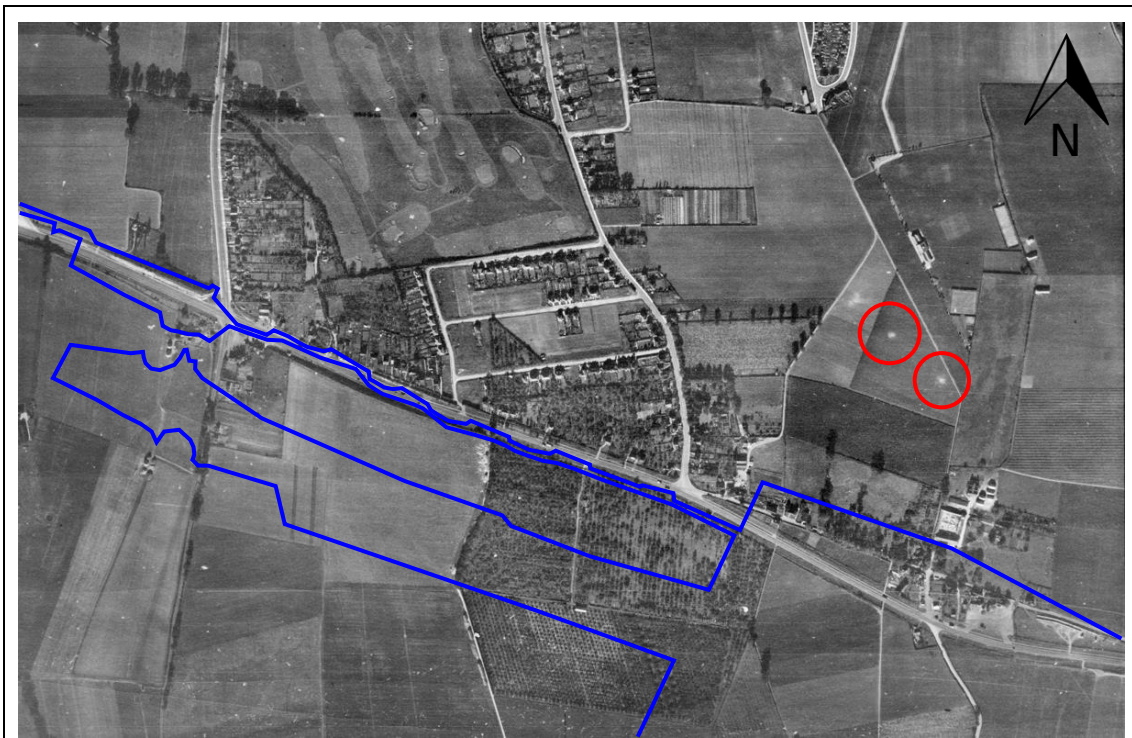
Legend	Site boundary 	Possible bomb damage 
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Plate 31 is an aerial photograph of the area of the Site west of Cobham, dated the 11th October 1946.

No bomb damage has been identified on or in close proximity to the Site. Some possible bomb cratering is visible to the north of the Site.

Plate 31 Aerial photograph, 11th October 1946 (west of Cobham)



Source: Historic England

Not to Scale



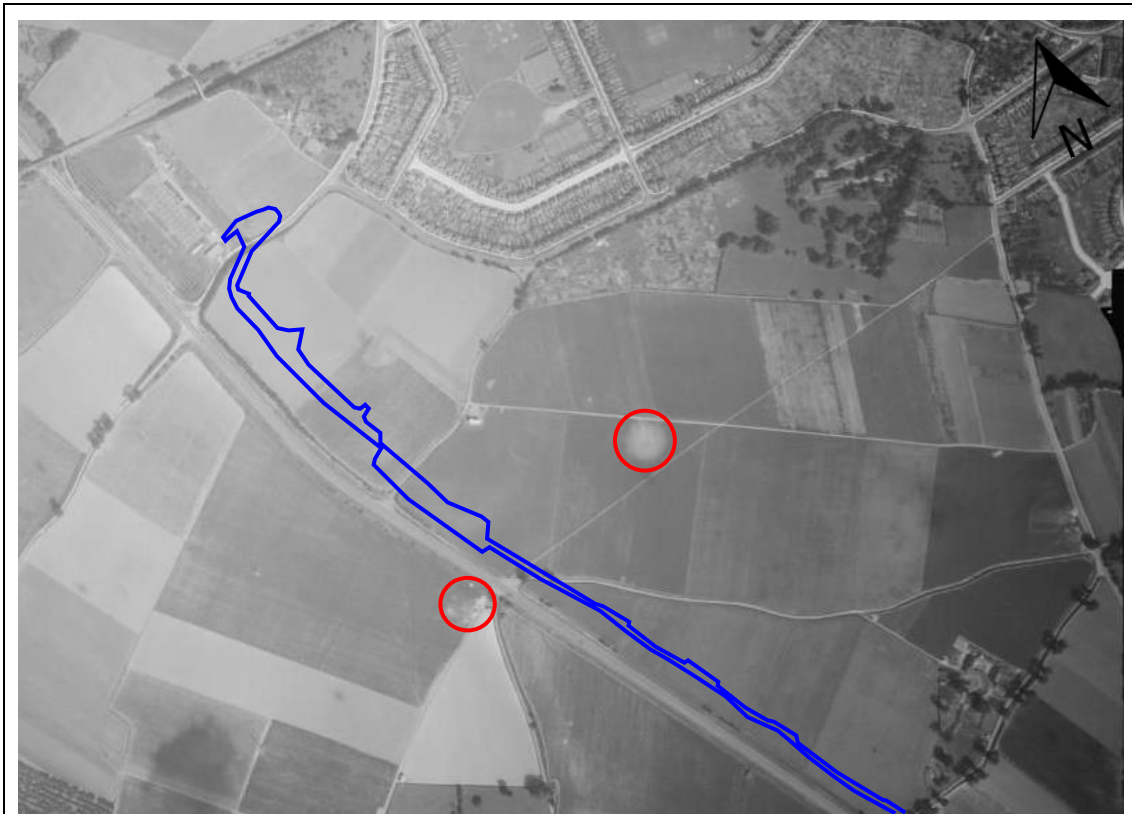
Legend	Site boundary 	Possible bomb damage 
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Plate 32 is an aerial photograph of the area of the Site south of Northfleet Green, dated the 11th October 1946.

No bomb damage has been identified on the Site. Some possible bomb cratering is visible to the north and south of the Site.

Plate 32 Aerial photograph, 18th July 1944 (south of Northfleet Green)



Source: Historic England

Not to Scale



Legend	Site boundary 	Possible bomb cratering 
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Plate 33 is an aerial photograph of the Shorne area of the Site, dated the 11th October 1946.

Some possible isolated bomb cratering has been identified on the Site.

Plate 33 Aerial photograph, 11th October 1946 (Shorne)

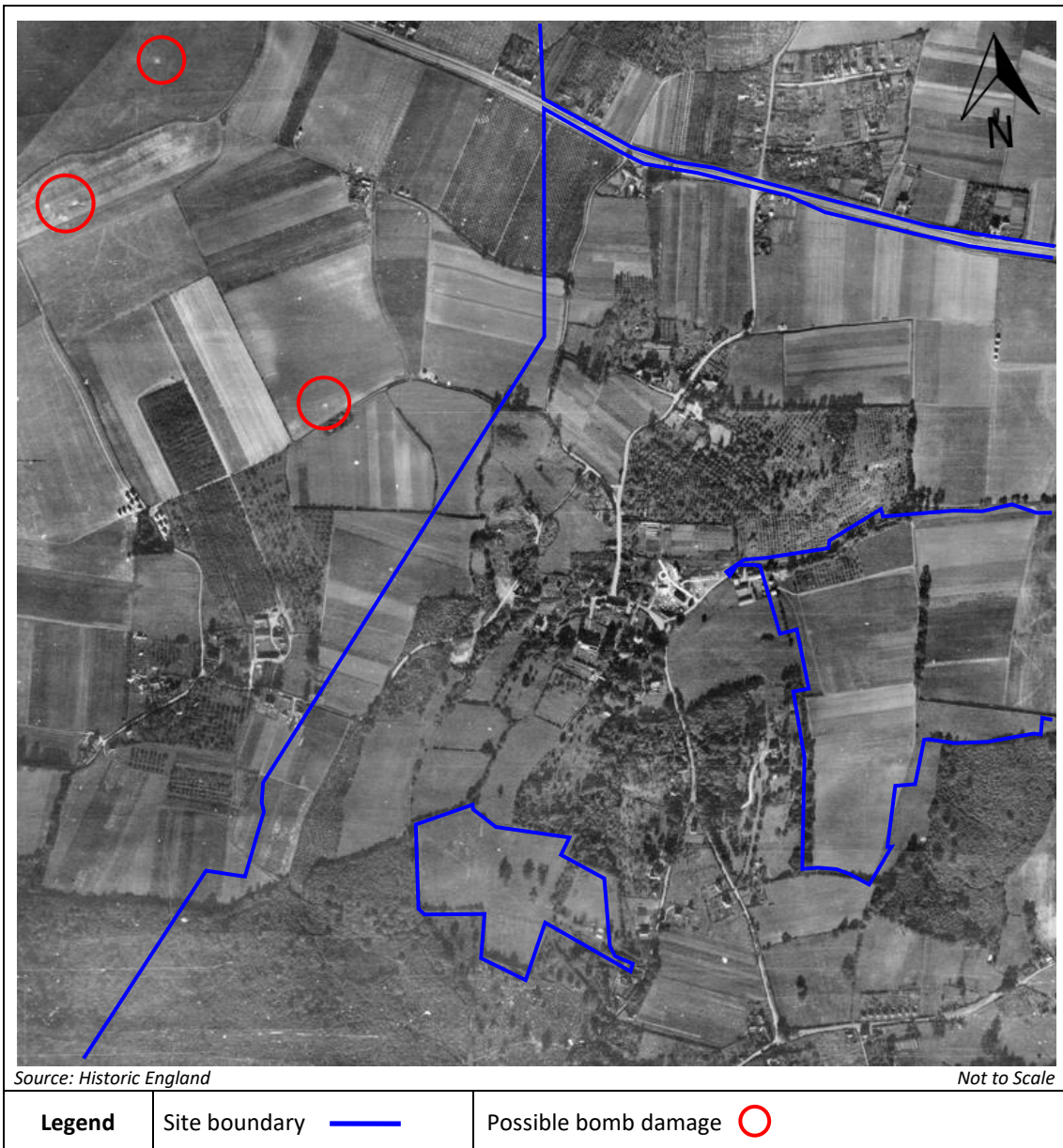
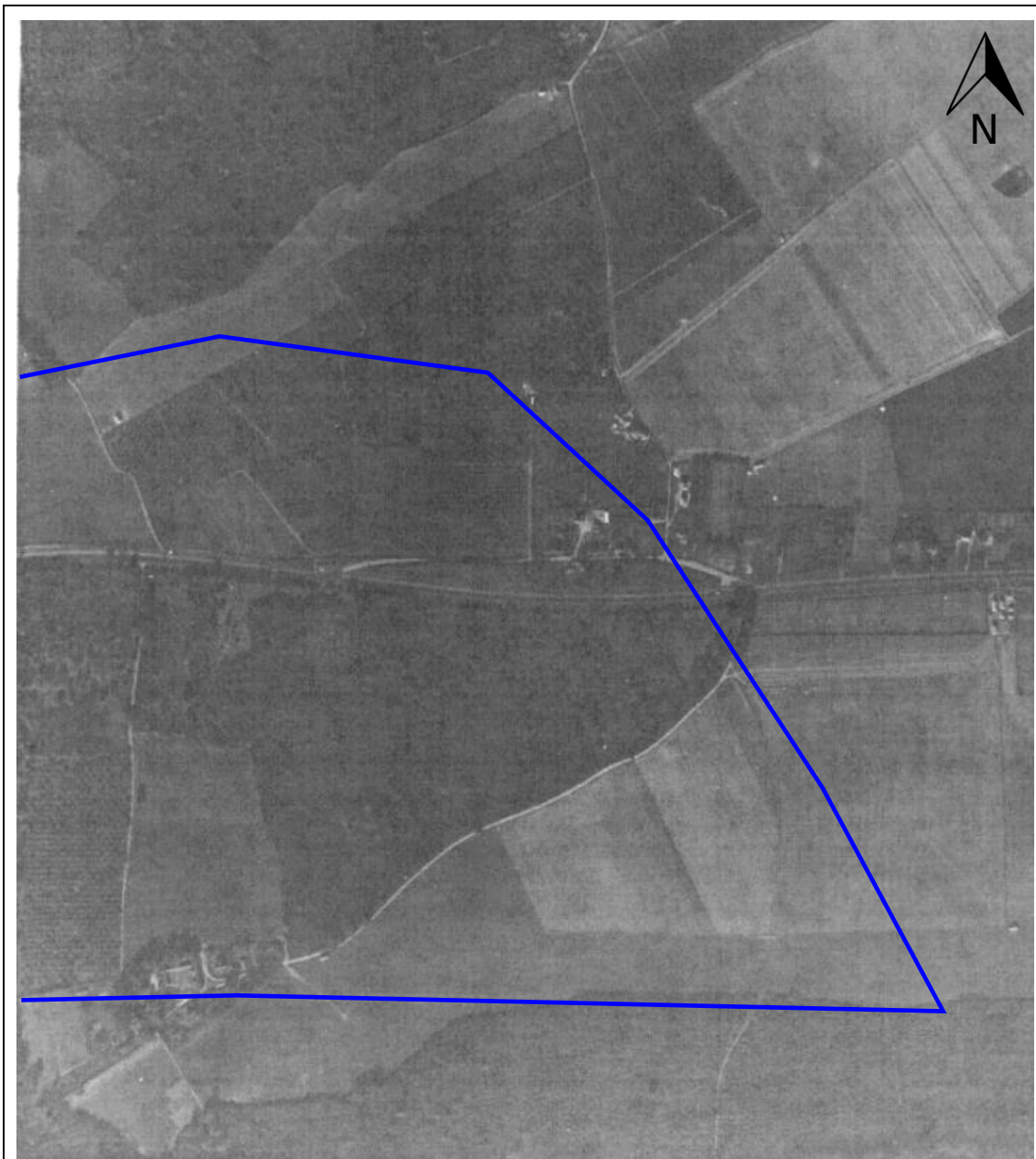


Plate 34 is an aerial photograph of the area of the Site south of Higham, dated the 11th October 1946.

No bomb damage or cratering has been identified on or in close proximity to the Site.

Plate 34 Aerial photograph, 11th October 1946 (south of Higham)



Source: Historic England

Not to Scale


Legend	Site boundary 
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Figure 15 is a compiled bomb impact map for the Westfield Sole area of the southern part of the Site.

The bombing densities for the rural areas to the south of Chatham were generally far lower than their urban counterparts, with the majority of bombing raids in the vicinity of the Site comprising opportunistic ‘tip and run’ raids.

Figure 15 Compiled bomb impact map for the southern part of the Site (Westfield Sole)

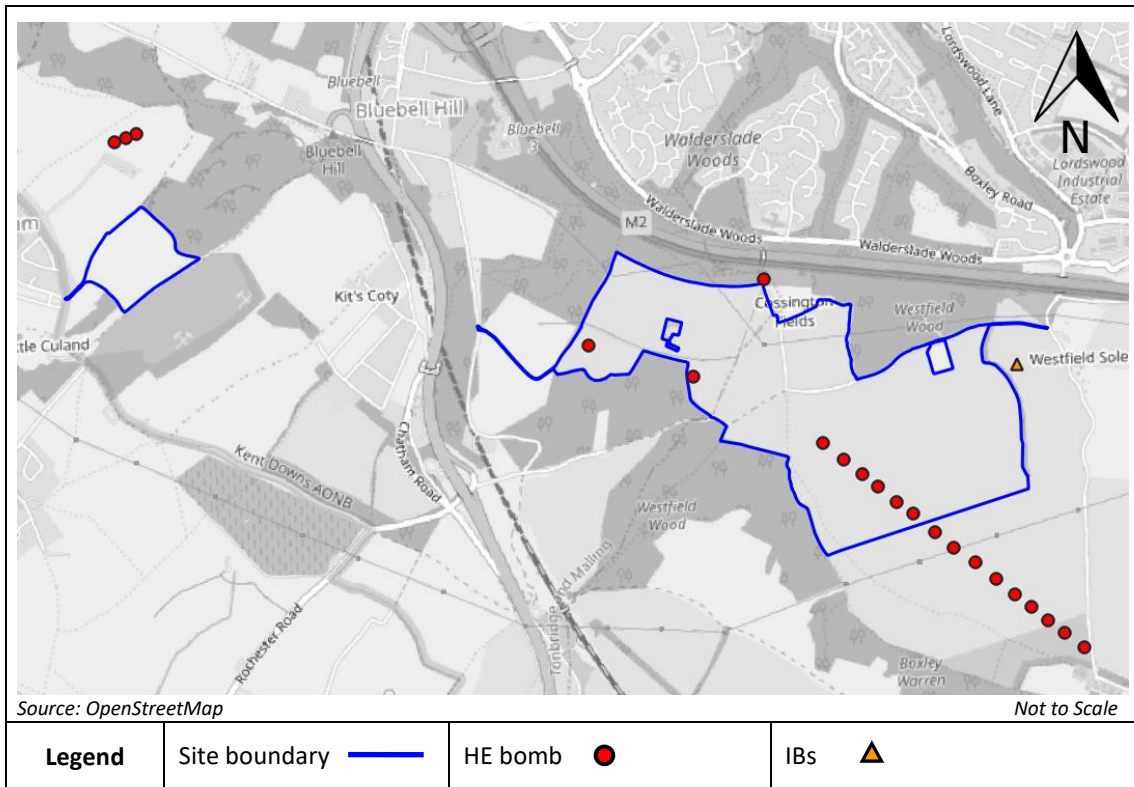


Plate 35 is an aerial photograph of the Westfield Sole area of the Site, dated the 20th December 1945.

No bomb damage or cratering has been identified on or in close proximity to the Site.

Plate 35 Aerial photograph, 20th December 1945 (Westfield Sole)

Source: Historic England

Not to Scale

Legend	Site boundary 
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Potential UXO Hazard**Filborough Marshes**

Filborough Marshes sustained bombing by both HE bombs and IBs. From the 7No. HE bombs recorded on on this part of the Site, 6No. were recorded as UXB.

Given the high UXB rate, and that bombs falling on uninhabited marshland were not always noticed and recorded, WWII bombing is considered to provide a possible source of UXO hazard to this part of the Site.

This area is identified as M1 on **Figure 24** and shown on HE540039-ZET-GEN-GEN-MAP-GEO-00001-P05.

Wrotham Road

Records indicate that during WWII at least 20No. HE bombs fell across Watling Street near the junction with Wrotham Road. Additionally, several attacks against Northumberland Bottom AA battery, approximately 0.2km southwest of the Site, were recorded. 1No. UXB was recovered from the Site on the 10th March 1945.

Given the elevated localised bombing density, it is considered possible that a UXB could have fallen on the Site unnoticed.

This area is identified as M1 on **Figure 24** and shown on HE540039-ZET-GEN-GEN-MAP-GEO-00001-P05.

Remainder of the southern part of the Site

On the remainder of the southern part of the Site, bombing densities were generally lower and no records have been found of any extensive air raids on this part of the Site.

It should be noted that during WWII areas of the southern part of the Site comprised marshland and open fields and it possible that bomb and shell impacts may have been missed and gone unrecorded in uninhabited areas.

As such, the potential for encountering a UXB on any part of the Site cannot be discounted.

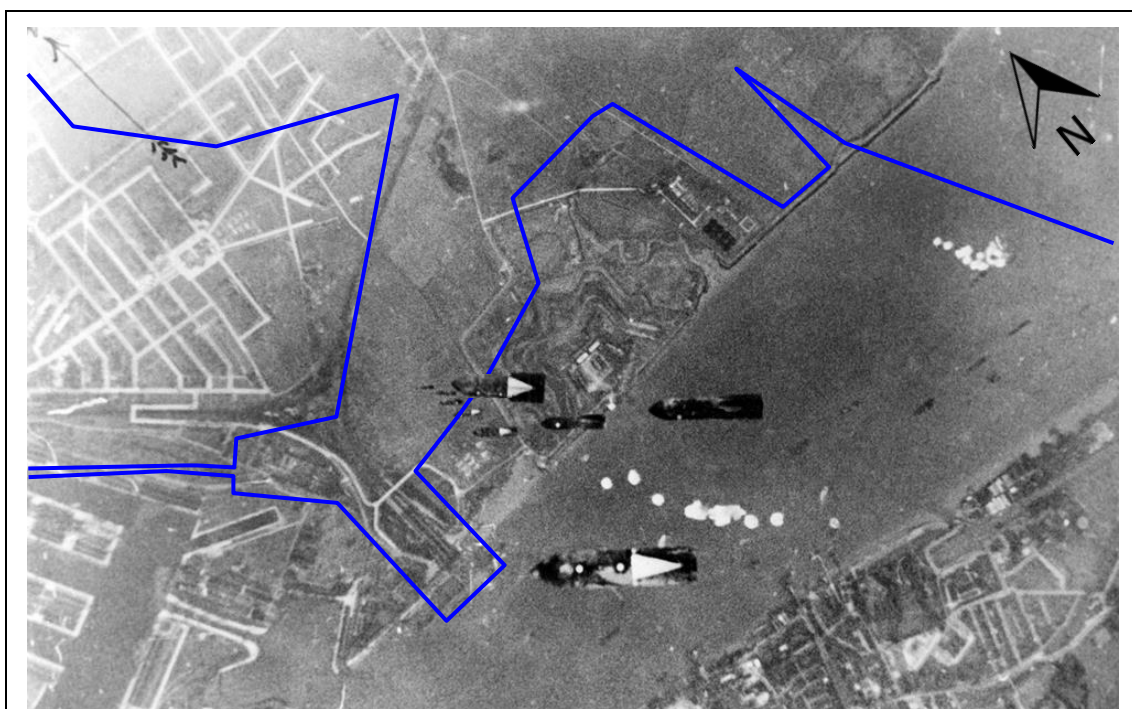
4.2.7 The River Thames part of the Site

The Thames Estuary south of Tilbury was an important navigational aid for the Luftwaffe when bombing London and numerous bombs were jettisoned in the river by aircraft coming under AA fire or attacks by fighter aircraft.

Opportunistic attacks against merchant shipping in the river, in addition to industrial and military targets along its banks, increased the bombing density in this area.

Plate 36 is an aerial photograph of Tilbury, dating from October 1940. This shows an air raid taking place against Tilbury Fort and shipping in the River Thames.

Plate 36 Aerial photograph of Tilbury, October 1940



Source: Historic England

Not to Scale

Legend

Site boundary 

Potential UXO Hazard

There were a number of strategic targets along the River Thames in the vicinity of the Site that were bombed, and UXB falling in the river were less likely to have been accurately recorded or retrieved.

Several ARP records simply state that bombs fell 'in the river' without specifying exactly where.

Therefore it is considered that there is an elevated probability that a UXB fell unnoticed on the Site within the River Thames and remained in situ.

This area is identified as M2 on **Figure 24** and shown on HE540039-ZET-GEN-GEN-MAP-GEO-00001-P05.

Further details on UXO in the marine environment are presented in Section 5.

4.2.8 Geology and Bomb Penetration Depths

It is important to consider the geological materials present at the time that a bomb was dropped in order to establish its maximum penetration depth.

British Geological Survey (BGS) 1:50,000 Sheets 257, Romford (Solid & Drift), 271 Dartford (Solid & Drift), 272 Chatham (Drift) and Special Sheet Inner Thames Estuary (Pre-Quaternary and Quaternary Geology), based on parts of Sheets 257, 258, 259, 271, 272 & 273, as well as BGS borehole records from nearby investigations were consulted to get an indicative overview of the Site geology.

Table 4 illustrates the estimated average maximum bomb penetration depths with the assumed WWII ground conditions for areas of the Site identified as having a moderate UXO hazard.

Note that the actual depth of the bomb may be anywhere between the WWII ground surface and these indicative maximum depths due to both the 'J' curve effect (see below) and localised changes in geomaterial strength and pore water pressures.

Table 4 Estimated average maximum bomb penetration depths

Approximate Location		Bomb Weight			Summary Geology	
From	To	50kg	500kg	1,000kg	Thickness (m)	Indicative Lithology
Warley Street TQ 593850	Saint Mary's Lane TQ 602875	5.0m	11.0m	13.5m	~1.0m	Head Deposits
					> 20.0m	London Clay
Dennises Lane TQ 574842	West Road TQ 584828	2.5m	9.0m	11.0m	4.0m	Lynch Hill Gravel
					> 20.0m	London Clay
South of Fen Lane TQ 610845	North of Mollands Lane TQ 602830	7.0m	14.0m	15.5m	~4.0m	Alluvium
					> 20.0m	London Clay
Mardyke Way TQ 622826	Baker Street TQ 629814	5.0m	12.0m	14.0m	~3.0m	Head Deposits
					> 20.0m	London Clay
Baker Street TQ 629814	North of Whitmore Avenue TQ 620807	2.5m	6.0m	8.0m	~6.0m	Boyn Hill Gravel
					> 5.0m	Lambeth Group
South of	North of	2.5m	7.0m	8.0m	~3.0m	Boyn Hill Gravel

Standford Road TQ 645808	Halton Road TQ 650794				> 5.0m	Thanet Formation
St Andrew's Road TQ 633764	Tilbury Landing Stage TQ 643750	3.5m	11.5	14.0m	~1.5m	Made Ground
					>20.0m	Alluvium
South of Gloucester Avenue TQ 682782	Princess Margaret Road TQ 686770	3.0m	6.0m	7.5m	~4.0m	Lynch Hill Gravel
					> 20.0m	Thanet Formation
Princess Margaret Road TQ 686770	North of River Thames TQ 691763	7.5m	17.0m	18.5m	~15.0m	Alluvium
					> 20.0m	Lewes Nodular Chalk, Seaford Chalk & Newhaven Chalk Formations
Riverbank (North) TQ 684780	Riverbank (South) TQ 690747	7.5m	17.0m	18.5m	~15.0m	Alluvial, Intertidal and Marine Deposits (Mud)
					> 20.0m	Lewes Nodular Chalk, Seaford Chalk & Newhaven Chalk Formations
East Court Marshes TQ 686746	North of Lower Higham Road TQ 699727	7.5m	14.0m	15.0m	~10.0m	Alluvium
					> 20.0m	Lewes Nodular Chalk, Seaford Chalk & Newhaven Chalk Formations
Walting Street TQ 645708	East of Hall Road TQ 621723	4.5m	8.5m	9.5m	~0.3m	Head Deposits
					> 20.0m	Lewes Nodular Chalk, Seaford Chalk & Newhaven Chalk Formations

These calculations can be refined on receipt of Site-specific information.

The estimated bomb penetration depths given in Table 4 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.

The average offset is one third of the penetration depth, i.e. an offset of 2m may be expected for a 50kg bomb in dry silts and clays. If hard standings or Made Ground were present during WWII, bomb penetration depths would have been significantly reduced but offset distances may have been up to four times greater.

5 UXO IN THE MARINE ENVIRONMENT

Both wartime and peace time military and naval activities provide numerous sources of UXO within the marine environment. The principal sources of UXO hazards are from ordnance disposal at sea, WWII aerial laid mines, mines laid as beach defences, crashed aircraft and wrecks containing ordnance.

Clearance certification for UXO within a marine environment may be valid only for a limited period as storms, tides and general current movement can cause UXO to migrate into an area that may have been cleared of UXO only hours before. This also makes it very difficult to accurately predict where UXO may be found.

UXO is most likely to be concentrated on and immediately around the principal sources of the UXO hazard. These are typically ordnance disposal sites at sea, WWII mines, marine ranges and wrecks containing ordnance.

Potential sources of UXO hazard in the marine environment in the vicinity of the Site are described below.

5.1 AA Defences

During WWII extensive HAA and LAA defences were established in the vicinity of the Site, forming part of the GDA (see Section 3.1.1).

These are likely to have contributed UXAA shells to the marine environment in the vicinity of the Site. The potential for UXAA shells falling on the Site cannot be totally discounted.

This forms part of the low background risk for any similar site in the UK.

5.2 Coastal Defences

During WWII the approaches to the Thames Estuary were heavily defended by a series of coastal batteries.

Table 5 lists the recorded coastal batteries in the vicinity of the Site. Those on the north bank of the River Thames were manned by units of the East Tilbury Home Guard from 1943 (see Section 3.1.10).

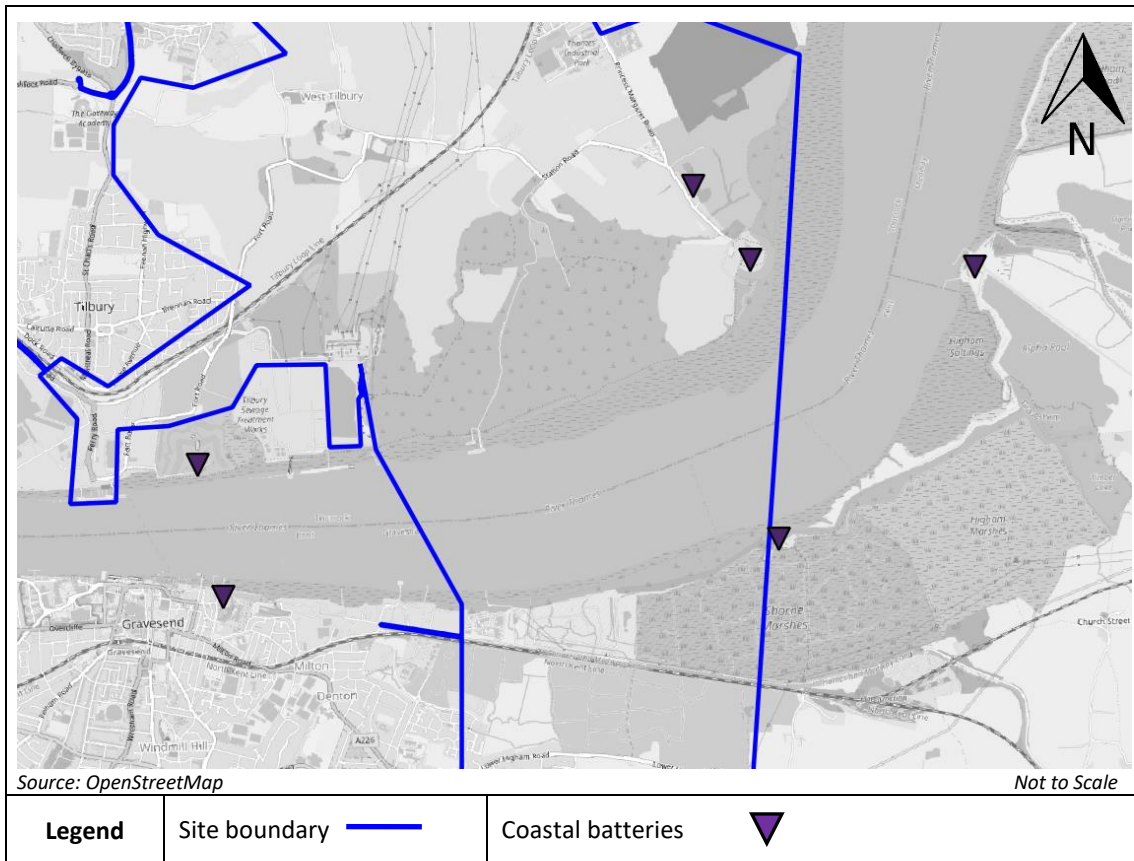
Table 5 Coastal batteries in the vicinity of the Site

Grid Reference	Location	Armament	Approximate Distance from Site
TQ 687774	East Tilbury Battery	4No. 12-pdr guns	On the Site
TQ 691768	Coalhouse Fort	2No. 5.5" naval guns	On the Site
TQ 693748	Shornemead Fort	2No. 5.5" naval guns	On the Site
TQ 652755	Tilbury Fort	2No. 6" guns and 4No. 12-pdr guns	0.2km S
TQ 653742	New Tavern Fort	2No. 6" naval guns	1.1km SE
TQ 707768	Cliffe Fort	Unknown	1.3km E

Coastal batteries often had associated searchlight emplacements. This included Coalhouse Fort and Shornemead Fort (see Sections 3.6.5 and 3.6.6), which were equipped with Defence Electric Lights (DEL) during the early 1900s. These were originally used for lighting the boom defences across the River Thames.

Figure 16 is a map showing the locations of the coastal batteries in the vicinity of the Site.

Figure 16 Map of coastal batteries in the vicinity of the Site



Potential UXO Hazard

As with AA gun batteries (see Section 5.1), the potential for misfired or unexploded shells from coastal batteries falling on the Site cannot be totally discounted

This forms part of the low background risk for any similar site in the UK.

It should also be noted that the coastal batteries are likely to have contributed to UXO in the marine environment in the vicinity of the Site.

5.3 Marine Ranges

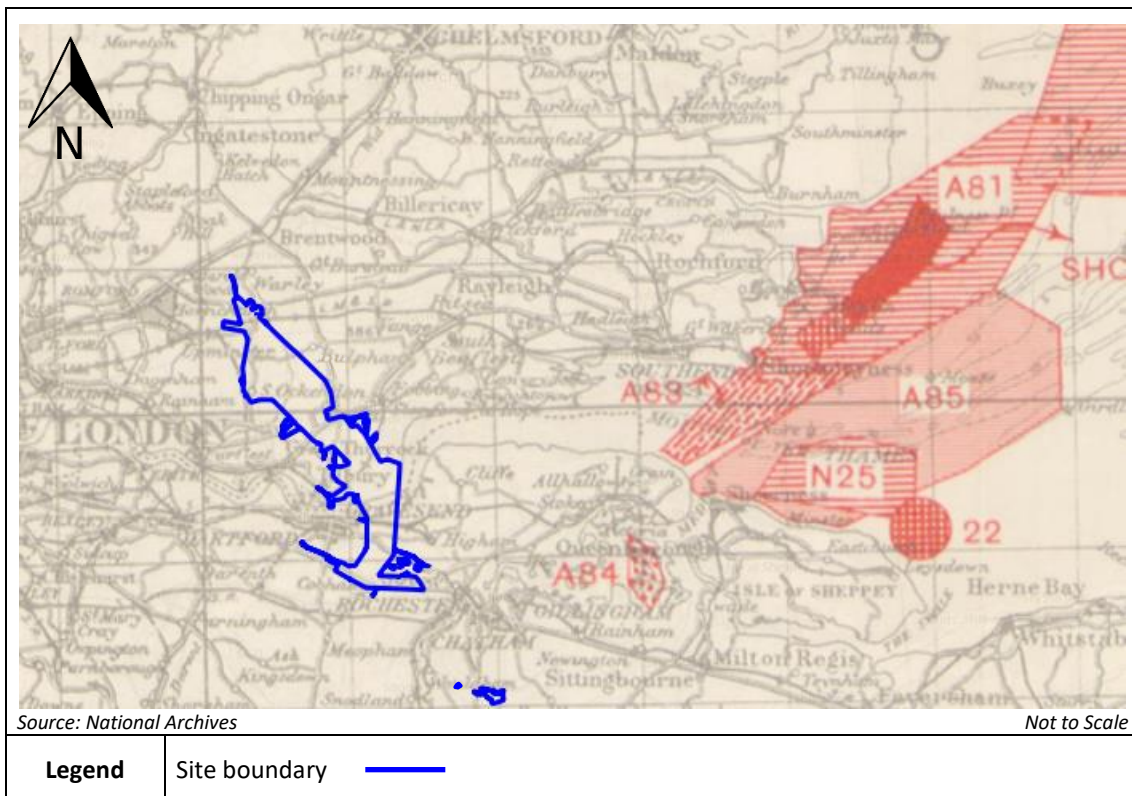
No records of marine ranges or coastal batteries on or in close proximity to the Site have been found.

The nearest marine range to the Site was Range N25, approximately 17km east of the Site. This was used for HAA and LAA gunnery practice by the Chatham Military School during WWII. It was also used for practice by Defensively Equipped Merchant Ships (DEMS).

This is shown in Figure 17, an extract from a plan of marine ranges in the vicinity of the Site, dating from 1945.

The Leysdown Fighter Bombing Range (22), Shoeburyness Artillery Test Range (A81), Yanlett Zone Coast Artillery Range (A83) and Sheerness and Grain Coast Artillery Range (A85) have also been identified.

Figure 17 Plan of marine ranges in the vicinity of the Site, 1945



Given their distance from the Site and the tidal patterns in the area, marine ranges are not considered to provide a source of UXO hazard to the Site.

5.4 Marine Mines

No records have been found indicating that marine mines were laid on the Site.

Records indicate that marine mines were laid in the River Thames during at least 25No. Luftwaffe raids between November 1939 and November 1941. These were effective in sinking vessels in the Thames Estuary on a number of occasions.

Marine mines are not considered to provide a source of UXO hazard to the Site with the possible, albeit very unlikely, exception of buoyant marine mines migrating onto the Site.

5.5 Attacks on Shipping

Evidence has been found indicating that enemy air raids on shipping took place in close proximity to the Site (see Section 4.2).

Further examples of offshore bombing incidents in the vicinity of the Site are given below.

2nd November 1940

His Majesty's Trawler (HMT) Deanbrook was sunk by aerial bombing involving influence mines at Tilbury, within approximately 1.5km west of the central part of the Site.

HMT Lea was sunk by aerial bombing involving influence mines at Tilbury, within approximately 1.5km west of the central part of the Site.

Aerial bombing is considered to provide a possible source of UXO hazard to the River Thames part of the Site (see Section 4.2.7).

5.6 Wrecks Containing UXO

No records have been found indicating that any live wrecks likely to contain a source of UXO hazard are located on the Site.

4No. lighter barges on the Site, typically used to transport goods and people, are shown as live wrecks on Figure 18 below.

The nearest military wreck to the Site is detailed below.

Wreck No. 69972

On the 6th July 1942, the 19th century three-masted training ship *HMS Cornwall* was bombed and sunk at its moorings near Clubbs Jetty, approximately 0.2km west of the central part of the Site.

Records indicate that it was broken up and removed during the 1970s, with the remnants moved onshore, approximately 0.1km west of the central part of the Site.

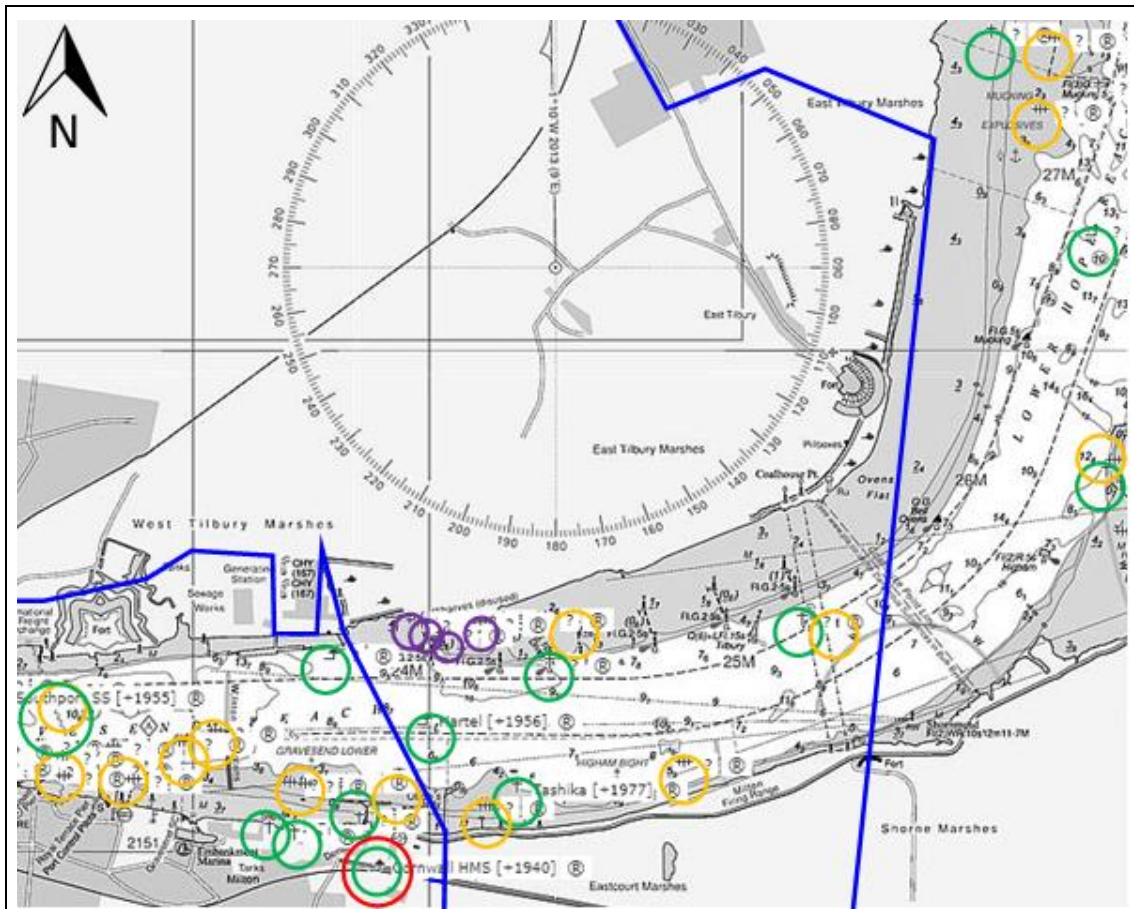
The nearest wreck to the Site known to have contained explosives is detailed below.

Wreck No. 12908

The wreck of a powder hulk is recorded off Mucking Flats, approximately 2.2km northeast of the central part of the Site.

Figure 18 is an extract from the Admiralty chart showing the wrecks and obstructions in the vicinity of the Site. *HMS Cornwall* is circled in red and the live wrecks (lighter barges) on the Site are circled in purple.

Figure 18 Admiralty chart of wrecks in the vicinity of the Site



Source: UKHO

Not to Scale

Legend	Site boundary		Dead or lifted wrecks		Other obstructions ³	
	HMS Cornwall		Lighter barges			

No wrecks likely to contain explosives have been identified on the Site and wrecks are not considered to provide a source of UXO hazard to the Site.

5.7 Offshore Munitions Disposal

No records have been found indicating that offshore munitions disposal occurred on or in close proximity to the Site.

5.8 UXO Migration in the Marine and Estuarine Environment

There are several identified potential sources of UXO hazard in the marine and estuarine environment in the vicinity of the Site.

The factors controlling UXO migration in the marine and estuarine environment surrounding the Site are discussed below.

Tidal Currents

The Thames Estuary in the vicinity of the Site has a tidal range exceeding 6m during spring tides, with correspondingly strong offshore tidal currents. Tidal water levels are enhanced by a storm surge component, which may raise the tide levels by as much as 4m at high water.

³ Marked as 'foul' - ground tackle remaining on the riverbed following the removal of PLA marine services mooring buoys.

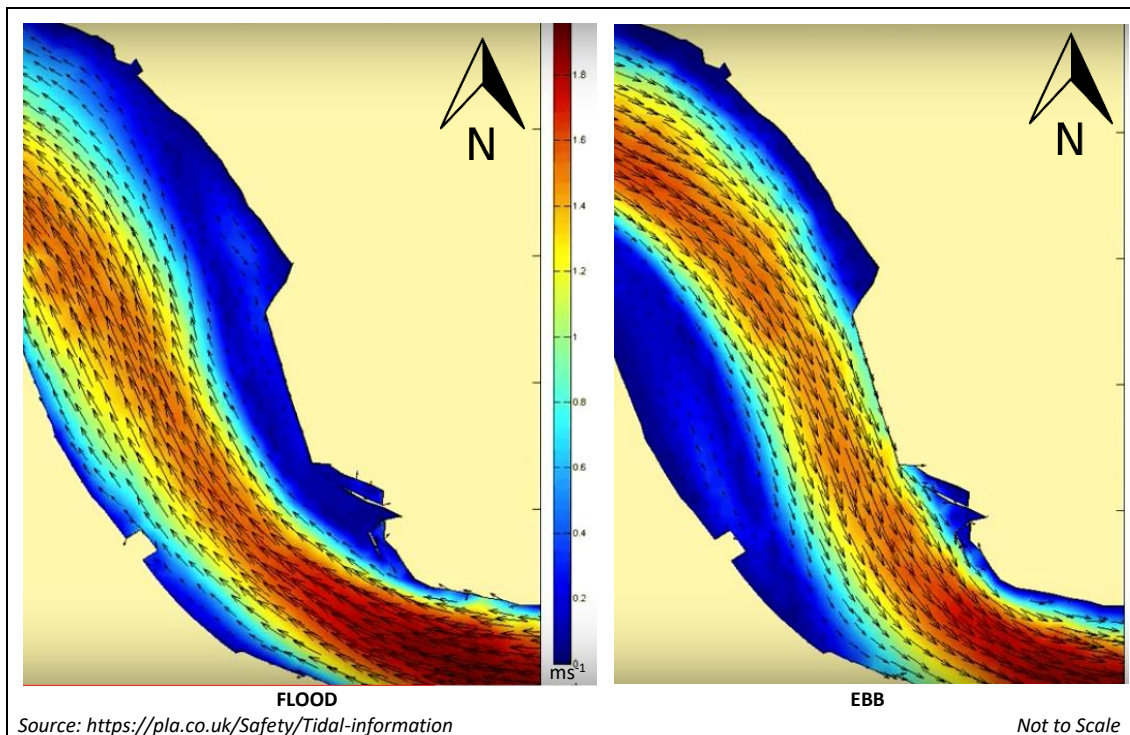
There is an increasing tidal range upstream due to the funnelling effect of the estuary. The tidal current pattern is controlled by the funnelling effect. Tidal currents become increasingly flood-dominated in an upstream direction.

Between Sheerness and Gravesend, maximum ebb current velocities are in excess of the flood, upstream of Gravesend the flood current velocities are in excess of the ebb.

The main freshwater input to the Thames Estuary has an average flow rate of $90 \text{ m}^3\text{s}^{-1}$. Major fluvial events occurred in 1947 ($714 \text{ m}^3\text{s}^{-1}$) and 2003 ($461 \text{ m}^3\text{s}^{-1}$). Average freshwater inputs are small compared to tidal discharge in the estuary. Tidal discharges of up to $15,000 \text{ m}^3\text{s}^{-1}$ on both flood and ebb tides have been recorded.

Typical tidal streams in the vicinity of the Site with maximum velocities of up to 2 m/s are shown in Figure 19.

Figure 19 Typical tidal streams in the vicinity of the Site



Tidal streams may exceed 2.5 m/s in the central channel. Elsewhere the currents are controlled mostly by channel geomorphology and water depth. Peak near and offshore velocities are highest in deeper water, but for spring tides they are generally less than 2 m/s .

Bed stresses created by these tidal currents may sweep the deeper channel clean of finer sediments.⁴

Near shore, in the vicinity of the Site, they are insufficient to entrain anything more than fine sediments, but they act in conjunction with waves to transport other material both onshore and offshore, as described in the following sections.

Wave Action

Wave data demonstrates that the wave environment within the estuary is predominantly wind driven. The prevailing wave direction offshore is from the east and southeast, but fetches are

⁴ Soulsby R & Clark S, Bed shear-stresses under combined waves and currents on smooth and rough beds, HR Wallingford Report TR137, 2006

dramatically reduced within the estuary in the vicinity of the Site, where intertidal areas and river bends protect the foreshores.

In the Lower Gravesend Reach, significant wave heights are 1.5m for 1 in 50 year winds and under 0.7m for 10 times a year winds.

The passage of large vessels also generates significant waves, which may influence sediment mobilisation and net direction of transport.

Strong flood and ebb flows also interact with waves, leading to wave blocking in some locations and at some states of tide.

The generally low energy wave action dominates the near shore and intertidal sediment transport on the mudflats and shoals in the vicinity of the Site.

Sediment Pathways

The tidal current ebb- or flood-dominance has implications for sediment, and therefore UXO, transport in the Thames Estuary. Flood-dominance will tend to favour net movement of sediment into the estuary, whereas ebb-dominance will favour net export of sediment. The combined influences of wave action and tidal currents create a dynamic environment which continually moves fine sediments around the estuary.

The River Thames carries some 300,000 tonnes of sediment a year, much of which goes to build up the mud flats and sand banks in the estuary.⁵ Approximately 20,000 tonnes of sediment is carried per tide but much of it is carried back on the following tide, so the net effect is small.⁶

The riverbed material is generally dominated by fine-medium gravel, overlain by alluvium.

Channel dredging in the River Thames and flood prevention schemes have influenced sediment supply to the estuarine parts of the system, including in the vicinity of the Site.

Maintenance dredging since 1928 has periodically removed shoals or sediments from existing navigational channels, berths and moorings to maintain an appropriate safe depth of water for navigation, construction or operational purposes.⁷

Annual dredging returns for the River Thames for the period 1928 to 1956 were 1,860,000m³. Approximately 50% of this dredging originated in the Mud, Gravesend and Lower Hope Reaches.

Located upstream of Coalhouse Point, Diver Shoal (Sandbank), on the Site, has historically provided the limiting depth for the river as it impinges on the deep water channel.

From 1965 there has been a significant reduction in maintenance dredging from the Gravesend Reach/Diver Shoal. Within the vicinity of the Site, dredging was approximately in balance with annual rates of sedimentation between 1977 and 1997, suggesting a sedimentation rate of 37,000 tonnes per annum.

Groynes and training works implemented on the northern side of the channel in 1995 successfully generated higher currents in the channel itself, while allowing accretion on the northern foreshore. This considerably reduced, although did not eliminate, the shoal's maintenance dredging requirements. Maintenance of depth was undertaken by water injection dredging and, less frequently, mechanical dredging to remove coarser materials.

⁵ <https://www.pla.co.uk/Safety/PLA-Hydrographic-Service-Published-Surveys>

⁶ Tomes I M, Harmar O P & Thorne C R, Sediment Impact Analysis for the Lower Thames Flood Strategy, 2006

⁷ <https://www.pla.co.uk/Environment/Historic-Dredging>.

Although approximately 75% of the granular bed load is transient and does not accumulate on the riverbed, since 1997 bed elevations have increased slightly in response to the lack of dredging.

More recently the navigable depth, approximately 9.1m CD, of the Diver Shoal which impinges on the deep water channel in the vicinity of the Site, has been maintained by dredging every three to six months.

Approximately 6,000 m³ of fine sand and silt, with little gravel but some debris, is regularly moved by water injection dredging. The debris accumulating on the riverbed is removed by mechanical plant. The excavated material comprises coarser gravels, with additional waste materials such as tyres and steel debris.

UXO Migration

Given the river flow, tidal streams, wave action, pattern of sediment movement and dredging in the vicinity of the Site, as detailed above, it is considered that large UXO items in the marine environment are unlikely to be transported on to the Site.⁸

More likely is for larger UXO (such as UXB and AA shells) to have fallen directly on the Site and penetrated the riverbed at an estimated maximum depth of 19m for UXB and 2.5m for 4.5" UXAA shells.

It is considered that buoyant UXO (as may be the case with some marine mines), smaller, lighter items of UXO (such as small and medium sized shells) and SAA could roll as bed load particles during high river flow, flood, storm or tidal surge conditions.

Such conditions may provide a pathway for UXO migration onto the Site. This is considered to present no more than a low background risk (as in any other such offshore environment in the UK).

⁸ CIRIA C754, Assessment and Management of Unexploded Ordnance Risk in the Marine Environment, 2016, p.27

6 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 27th February 1946 upwards of 45,000No. UXBs were disposed of.

On average 8.5% of 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.

6.1 Abandoned Bombs

For further information on abandoned bombs, and the potential UXO hazard associated with them, follow the link below:

- [Abandoned Bombs](#)

Zetica holds the following record of a previously abandoned bomb on the Site.

15th September 1945

1No. 1,000kg bomb was abandoned at East Tilbury (TQ 688770), on the central part of the Site. This bomb was removed at 20 feet (ft), approximately 6.1m bgl, on the 10th October 1950.

No other officially recorded abandoned bombs are on the Site.

6.2 EOC Tasks

Records held by Zetica Ltd show that the following post-WWII EOC tasks have taken place in the vicinity of the Site.

Undated

Anecdotal evidence has been found to suggest that several pipe mine casings were discovered in a chalk pit near Thong Lane, on the southern part of the Site. They were removed.

It should be noted that no records have been found to support this claim.

For further details on Pipe Mines and their associated UXO hazard, see Section 3.2.3.

Several WWII-hand grenades were found during vegetation clearance at Goshams Landfill, north bank of the River Thames, on the central part of the Site. They were removed.

1No. 250kg HE bomb was discovered at an electricity sub-station in Wychelm, Hornchurch, approximately 1.1km west of the northern part of the Site. It was removed.

1st May 1952

1No. 250kg HE bomb was discovered in a sandpit in Meesons Lane, Grays, approximately 1.6km southwest of the central part of the Site. It was destroyed in situ.

8th September 1955

1No. 50kg UXB was found on a beach at Tilbury, within approximately 0.4km south of the central part of the Site. It was destroyed in situ.

10th January 1956

1No. UXIB was found in Great Crabbles Wood, Shorne, approximately 0.2km east of the southern part of the Site. It was removed.

19th April 1962

1No. 250kg HE bomb was discovered in a sandpit in Meesons Lane, Grays, approximately 1.6km southwest of the central part of the Site. It was destroyed in situ.

1966

Live WWII ammunition was found in Laughing Water Lake, Cobham, on the southern part of the Site. It was removed. This area was previously used to station troops from RAF Gravesend (see Section 3.6.4).

23rd September 1973

1No. 50kg UXB was discovered on the foreshore of the River Thames at Chadwell St Mary, within approximately 0.5km west of the central part Site. It was removed.

10th June 1984

28No. 105mm MI HE shells (US), 21No. Schermuly Flares, 3No. 37mm AP rounds (US), were discovered at Columbia Wharf, Tilbury Docks, approximately 3km southwest of the central part of the Site. They were removed.

26th June 1984

9,830No. 2lb shells, 19,176No. 20mm shells, 10No. 105mm MI High Explosive (HE) Shells (US), 1No. 6" shell, 1No. 25lb carrier, 2No. 4.2" mortar shells, 1No. No. 36 Mills grenade, 5No. 57mm ammunition, 416No. 37mm ammunition and 1No. Mortar (unknown), were discovered at Columbia Wharf, Tilbury Docks, approximately 1.3km west-northwest of the central part of the Site. They were removed.

18th January 2001

1No. hand grenade was found on rail track near Stanbrook Road bridge, approximately 1.6km west of the southern part of the Site. It was removed.

31st January 2007

1No. unexploded hand grenade was discovered in a rubbish bin in Thurrock, within approximately 0.5km southwest of the central part of the Site. It was removed.

29th April 2008

1No. hand grenade was found at Salisbury Avenue, Stanford-le-Hope, approximately 2.5km northeast of the central part of the Site. It was removed and subsequently destroyed.

4th September 2009

WWII-era .303" live rounds and cartridges together with live 9mm rounds were discovered at Bramble Tree Wharf, Borstal, Rochester, approximately 2.1km south-southeast of the southern part of the Site. They were removed.

20th March 2012

22No. shells was discovered at Sacred Heart of Mary School, Upminster, approximately 2.4km west of the northern part of the Site. They were removed.

10th April 2012

1No. shell was discovered at Sacred Heart of Mary School, Upminster, approximately 2.4km west of the northern part of the Site. It was removed.

26th February 2013

1No. empty shell case was discovered at the Waste Recycling Centre, Buckingham Hill Road, Thurrock, approximately 0.6km northeast of the central part of the Site. It was removed.

7th May 2015

1No. artillery shell was found near Gordon Promenade, Gravesend, between the cafe and Gravesend Sailing Club, approximately 1.8km west of the southern part of the Site.

17th May 2016

1No. UXAA shell was found on Trinity Road, Gravesend, approximately 1.8km west of the southern part of the Site.

27th May 2016

1No. UX WWII item was found in the back of a car parked in St. Mary's Close, Gravesend, approximately 1.7km west of the southern part of the Site.

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

7 UXO HAZARD ASSESSMENT

7.1 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 or 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.

The following potential sources of UXO hazard have been identified on the Site:

WWII Bombing (M1)

Records indicate that during WWII in excess of 512No. HE bombs fell on the Site. At least 183No. of these were recorded as UXB.

It is considered prudent to assign a moderate UXO hazard level to 10No. parts of the Site where an elevated bombing density and high percentage of UXB were recorded.

Estimated bomb penetration depths in these areas vary between 2.5m and 18.5m depending on the weight of the bomb and the underlying geological materials (see **Table 4**).

River Thames (M2)

Several potential sources of UXO hazard have been identified on the part of the Site encompassing the River Thames.

The main anticipated ordnance hazard is from air-dropped UXB due to the heavy WWII raids in the region and UXAA shells fired from the numerous gun batteries in the vicinity of the Site.

This part of the Site is therefore assigned a moderate UXO hazard level.

Milton Range (M3)

Part of the Site encompasses Milton Range, which has been in use from the 19th century until the present day.

In addition to training with SAA, records indicate that the range was used for mortar practice during WWII, providing a potentially significant hazard.

This part of the Site is assigned a moderate UXO hazard level due to the potential presence of mortars (and other Close Combat Munitions such as hand grenades) at shallow depths.

Pipe Mines at RAF Gravesend (M4)

Canadian Pipe Mines were laid under the runways and perimeter track at RAF Gravesend at the beginning of WWII so that the airfield could be destroyed in the event of a German invasion.

Part of the Site encroached upon the area that was pipe mined and records suggest that not all of the mines were removed during WWII and post-WWII clearances.

Therefore, it is considered prudent to assign this part of the Site a moderate UXO hazard level to account for the possibility that pipe mines remain in situ.

Bomber aircraft crashes (M5)

There are records of 2No. WWII bomber aircraft crashes on the Site at Botany Farm, near Orsett, and at Clay Tye Hill, near North Ockendon. No records have been found to indicate whether the bombs being carried by these aircraft had already been dropped, exploded on impact, or were retrieved from the crash site.

It is therefore considered prudent to assign these parts of the Site a moderate UXO hazard level at shallow depths to account for the possibility that UXB are present.

Remainder of the Site

No records of any significant bombing or other sources of UXO hazard have been identified on the remainder of the Site, which is assigned a low UXO hazard level.

It should be noted that during WWII the Site was located in an area subjected to heavy bombing due to its proximity to Continental Europe and being on the flightpath to important strategic targets. Numerous AA batteries were established on the Site and in the surrounding area to defend against air raids.

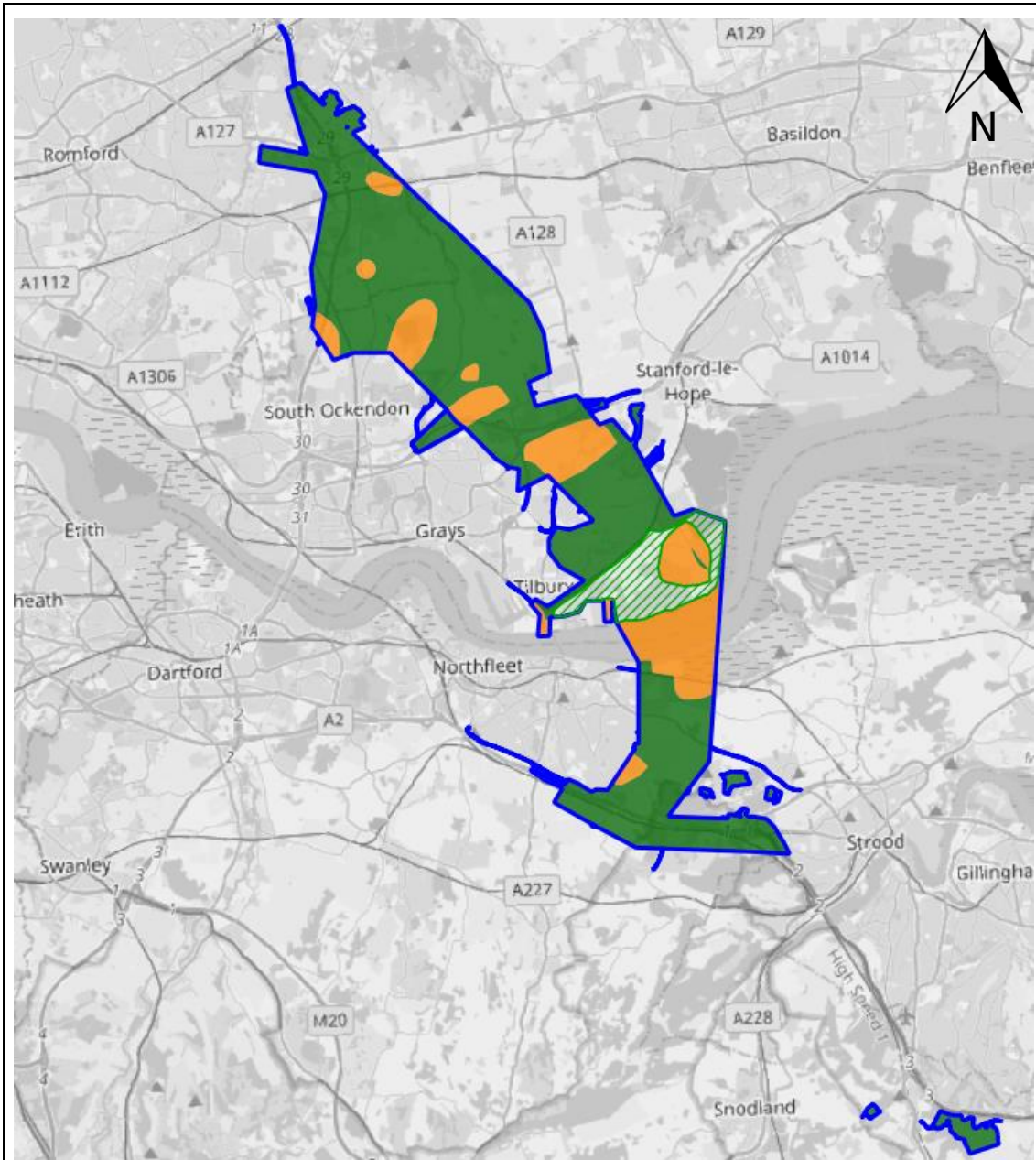
Large parts of the Site comprised marshland and open fields during WWII and it possible that bomb and shell impacts may have been missed and gone unrecorded in uninhabited areas.

As such, the potential for encountering a UXB or UXAA shell anywhere on the Site cannot be discounted.

Given this, it is considered that the UXO hazard level on the Site can be zoned from low to moderate, as shown in **Figure 20** below.

The UXO hazard zone plan of the Site is also given in the accompanying HE540039-ZET-GEN-GEN-MAP-GEO-00001-P05.

Figure 20 UXO hazard zone plan of the Site



Source: OpenStreetMap

Not to Scale

Legend	Very Low		Low		Moderate	
	High		Very High		Low (Tilbury Marsh)	
	Site boundary					

Figures 21 to 25 below, provide more detailed extracts of the moderate UXO hazard level zones on the Site.

Figure 21 UXO hazard zone plan of the Site (Great Warley to Upminster)

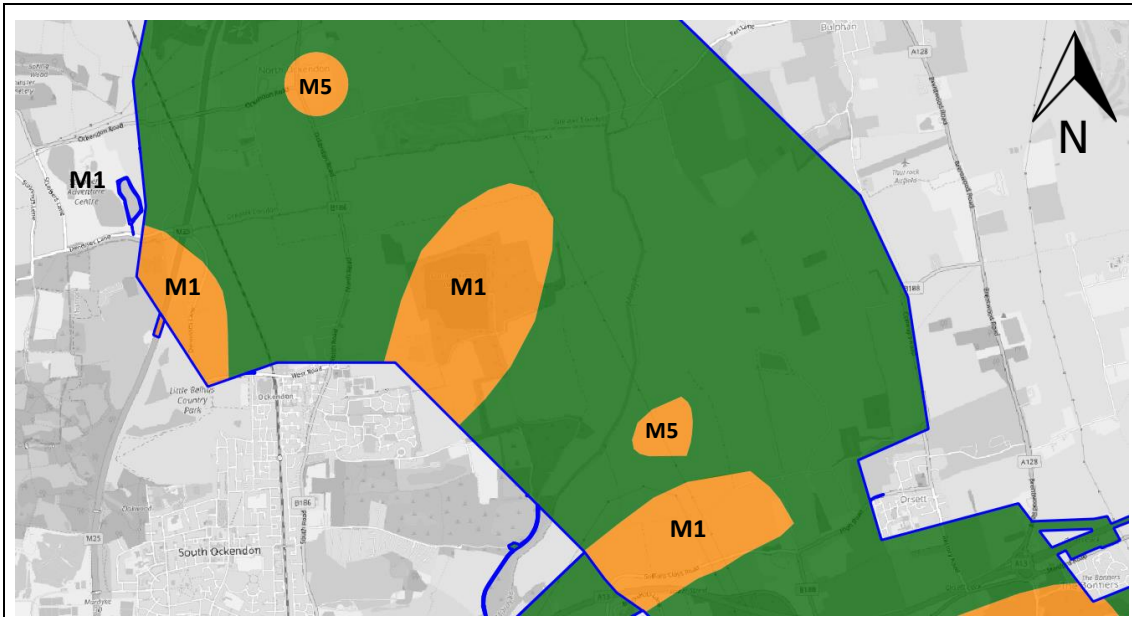


Source: OpenStreetMap

Not to Scale

Legend	Very Low		Low		Moderate	
	High		Very High		Site boundary	

Figure 22 UXO hazard zone plan of the Site (North Ockendon to Baker Street)

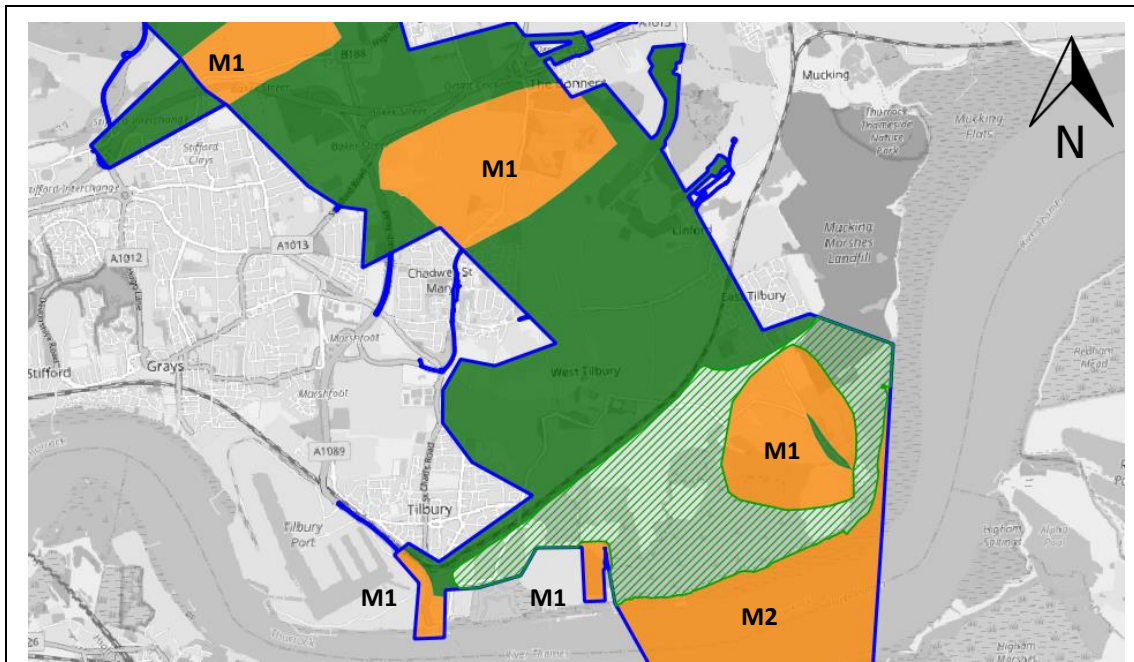


Source: OpenStreetMap

Not to Scale

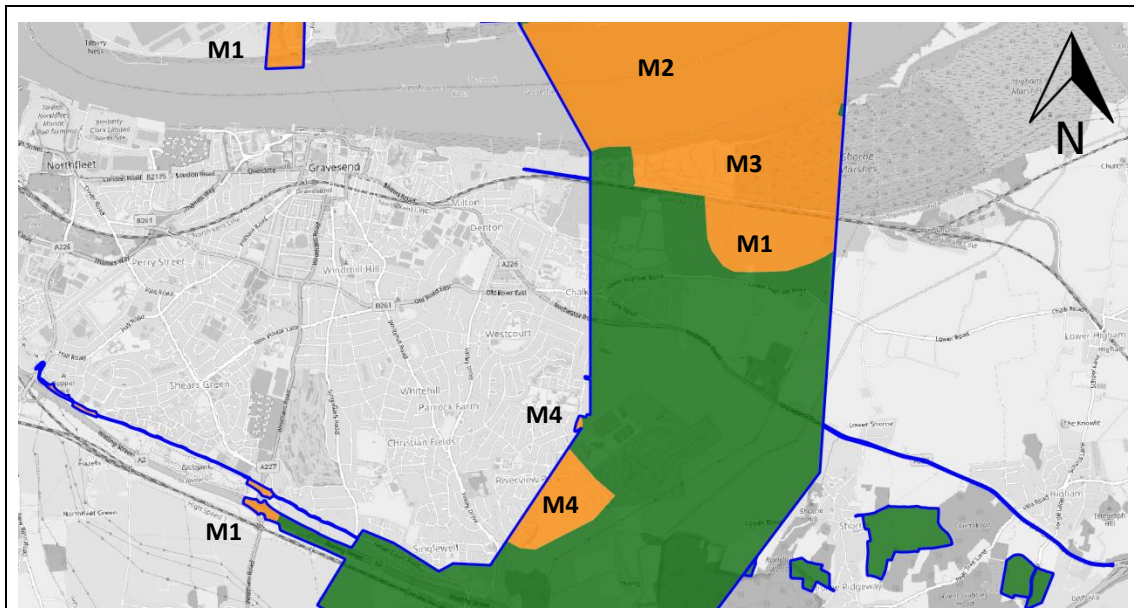
Legend	Very Low		Low		Moderate	
	High		Very High		Site boundary	

Figure 23 UXO hazard zone plan of the Site (Baker Street to Tilbury)



Legend	Very Low		Low		Moderate	
	High		Very High		Low (Tilbury Marsh)	
	Site boundary					

Figure 24 UXO hazard zone plan of the Site (River Thames to Cobham)

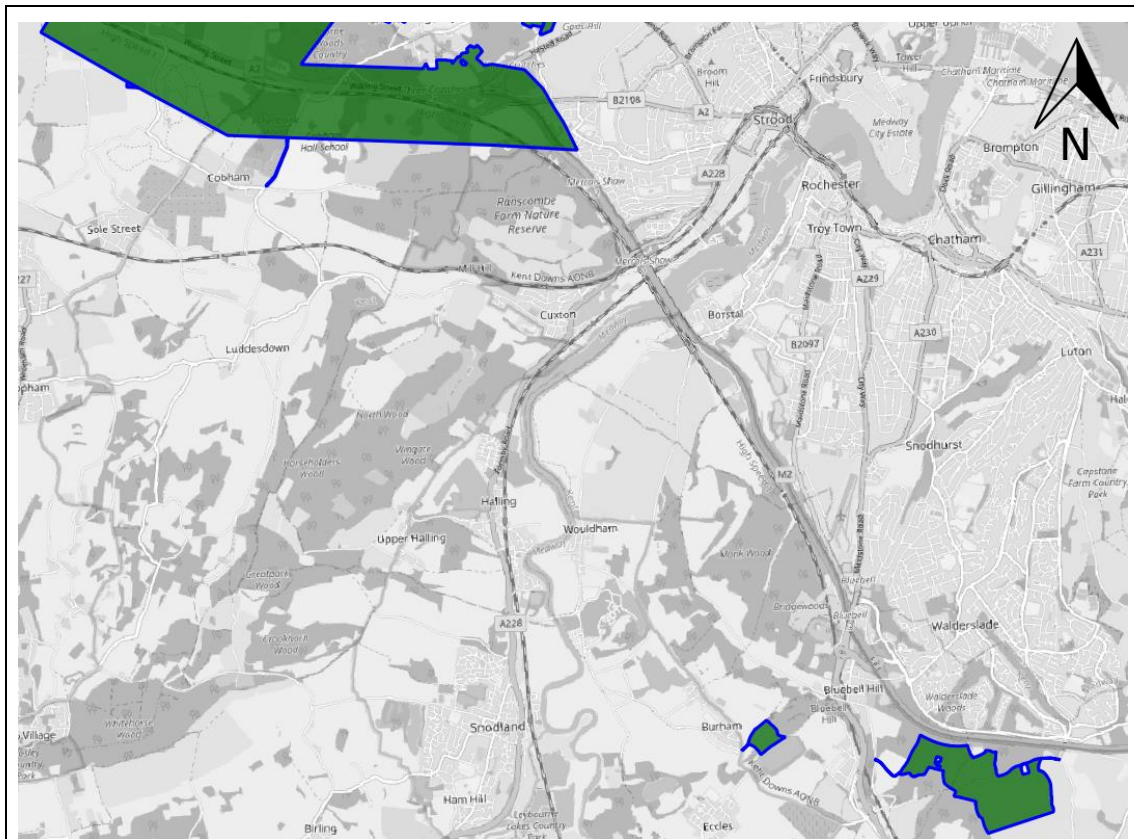


Source: OpenStreetMap

Not to Scale

Legend	Very Low		Low		Moderate	
	High		Very High		Site boundary	

Figure 25 UXO hazard zone plan of the Site (Cobham and Westfield Sole)



Source: *OpenStreetMap*

Not to Scale

Legend	Very Low		Low		Moderate	
	High		Very High		Site boundary	

Note that the UXO hazard will have been mitigated within the depth and extents of any post-WWII intrusive works.

8 UXO RISK ASSESSMENT

8.1 Proposed Works

It is understood that works on the Site associated with a proposed road tunnel crossing of the Thames estuary. Initial works on the Site will comprise the following intrusive ground investigations, including cable percussion boreholes with wireline rotary drilling following on at designated locations, dynamic and windowless sampling boreholes, trial pits and CPT.

Subsequent works on the Site will involve the construction of a twin bore tunnel under the River Thames between Tilbury and Milton. The final construction design is yet to be formalised.

8.2 Risk Assessment Methodology

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 x 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							
		SEVERITY (S)					
LIKELIHOOD (P)		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

8.3 UXO Risk Level

The UXO risk assessment for proposed works on the Site is given in Table 6.

Table 6 UXO risk assessment for the Site

Hazard Zone	Potential UXO Hazard	Anticipated Works	PE	PD	P = PE x PD	Likelihood	Severity	Risk Rating	UXO Risk
M1	UXB	Shallow Excavations	2	3	6	3	5	15	Moderate
		Deep Excavations	3	3	9	3	5	15	Moderate
		Boreholes/CPT/Pilling	2	4	8	3	4	12	Moderate
	UXAA Shells	Shallow Excavations	1	1	1	1	4	4	Low
		Deep Excavations	1	1	1	1	4	4	Low
		Boreholes/CPT/Pilling	1	1	1	1	3	3	Low
	Close Combat Munitions	Shallow Excavations	1	1	1	1	4	4	Low
		Deep Excavations	1	1	1	1	4	4	Low
		Boreholes/CPT/Pilling	1	1	1	1	3	3	Low
	SAA	Shallow Excavations	2	1	2	2	2	4	Low
		Deep Excavations	2	1	2	2	2	4	Low
		Boreholes/CPT/Pilling	1	1	1	1	2	2	Low
M2	UXB	Boreholes/CPT/Pilling	3	4	12	3	4	12	Moderate
	UXAA Shells	Boreholes/CPT/Pilling	2	4	8	3	3	9	Moderate
	Close Combat Munitions	Boreholes/CPT/Pilling	1	1	1	1	3	3	Low
	SAA	Boreholes/CPT/Pilling	2	1	2	1	2	4	Low
M3	UXB	Shallow Excavations	1	1	1	1	5	5	Low
		Deep Excavations	1	1	1	1	5	5	Low
		Boreholes/CPT/Pilling	1	1	1	1	4	4	Low
	UXAA Shells	Shallow Excavations	1	1	1	1	4	4	Low
		Deep Excavations	1	1	1	1	4	4	Low
		Boreholes/CPT/Pilling	1	1	1	1	3	3	Low
	Close Combat Munitions	Shallow Excavations	3	3	9	3	4	12	Moderate
		Deep Excavations	3	3	9	3	4	12	Moderate
		Boreholes/CPT/Pilling	2	4	8	3	3	9	Moderate
	SAA	Shallow Excavations	4	1	4	2	2	4	Low
		Deep Excavations	4	1	4	2	2	4	Low
		Boreholes/CPT/Pilling	2	1	2	2	2	2	Low
UXB	Shallow Excavations	1	1	1	1	5	5	Low	

M4		Deep Excavations	1	1	1	1	5	5	Low	
		Boreholes/CPT/Pilling	1	1	1	1	4	4	Low	
	UXAA Shells	Shallow Excavations	1	1	1	1	4	4	Low	
		Deep Excavations	1	1	1	1	4	4	Low	
		Boreholes/CPT/Pilling	1	1	1	1	3	3	Low	
	SAA	Shallow Excavations	2	1	2	2	2	4	Low	
		Deep Excavations	2	1	2	2	2	4	Low	
		Boreholes/CPT/Pilling	1	1	1	1	2	2	Low	
	Pipe Mines	Shallow Excavations	2	5	10	3	4	12	Moderate	
		Deep Excavations	3	2	6	3	4	12	Moderate	
		Boreholes/CPT/Pilling	2	3	6	3	3	9	Moderate	
	M5	UXB	Shallow Excavations	2	3	6	3	5	15	Moderate
Deep Excavations			2	3	6	3	5	15	Moderate	
Boreholes/CPT/Pilling			2	4	8	3	4	12	Moderate	
UXAA Shells		Shallow Excavations	1	1	1	1	4	4	Low	
		Deep Excavations	1	1	1	1	4	4	Low	
		Boreholes/CPT/Pilling	1	1	1	1	3	3	Low	
Close Combat Munitions		Shallow Excavations	1	1	1	1	4	4	Low	
		Deep Excavations	1	1	1	1	4	4	Low	
		Boreholes/CPT/Pilling	1	1	1	1	3	3	Low	
SAA		Shallow Excavations	2	1	2	2	2	4	Low	
		Deep Excavations	2	1	2	2	2	4	Low	
		Boreholes/CPT/Pilling	1	1	1	1	2	2	Low	
Low		UXB	Shallow Excavations	1	1	1	1	5	5	Low
			Deep Excavations	1	1	1	1	5	5	Low
			Boreholes/CPT/Pilling	1	1	1	1	4	4	Low
	UXAA Shells	Shallow Excavations	1	1	1	1	4	4	Low	
		Deep Excavations	1	1	1	1	4	4	Low	
		Boreholes/CPT/Pilling	1	1	1	1	3	3	Low	
	Close Combat Munitions	Shallow Excavations	1	1	1	1	4	4	Low	
		Deep Excavations	1	1	1	1	4	4	Low	
		Boreholes/CPT/Pilling	1	1	1	1	3	3	Low	
	SAA	Shallow Excavations	1	1	1	1	2	2	Low	
		Deep Excavations	1	1	1	1	2	2	Low	
		Boreholes/CPT/Pilling	1	1	1	1	2	2	Low	
	PE (Probability of Encounter), PD (Probability of Detonation), P (Overall Probability)									
	Shallow Excavations defined as <1.0m bgl.									

9 RISK MITIGATION ASSESSMENT

Key findings: Potential sources of UXO hazard have been identified on parts of the Site. These comprise hazards from deep-buried UXB and shallow-buried UXO from military activity.

Key actions: In moderate hazard zones, non-intrusive UXO surveys are recommended in advance of intrusive works. Where piling or boreholes/CPTs are proposed in an area with a UXB hazard, deep UXB detection is recommended.

When the construction design is finalised, it is recommended that a detailed UXO risk mitigation strategy is commissioned.

Figures 26 and 27 outlines the recommended steps to reduce the UXO risk to ALARP.

Figure 26 Recommended risk mitigation plan for the Site (Landward Areas)

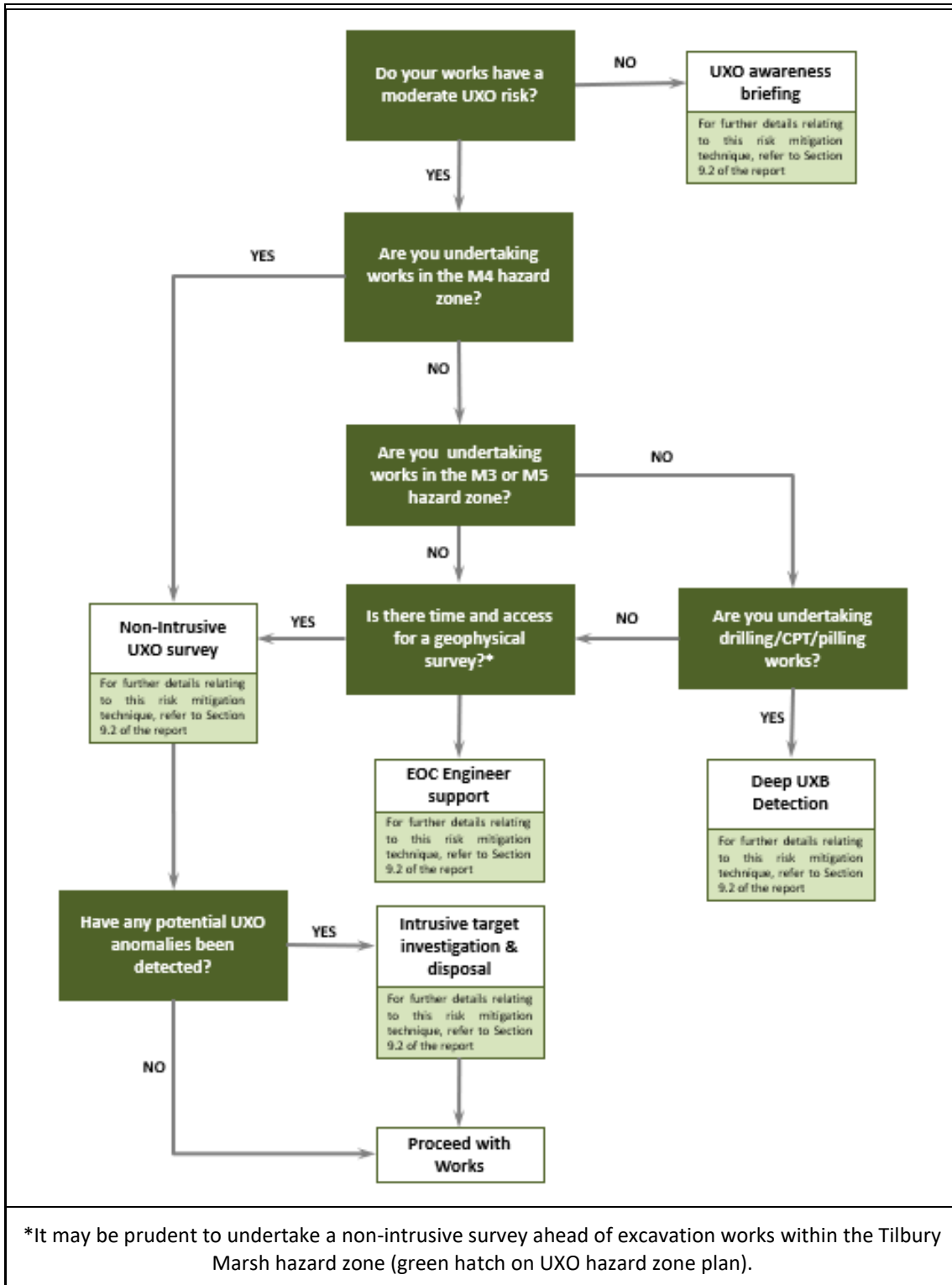
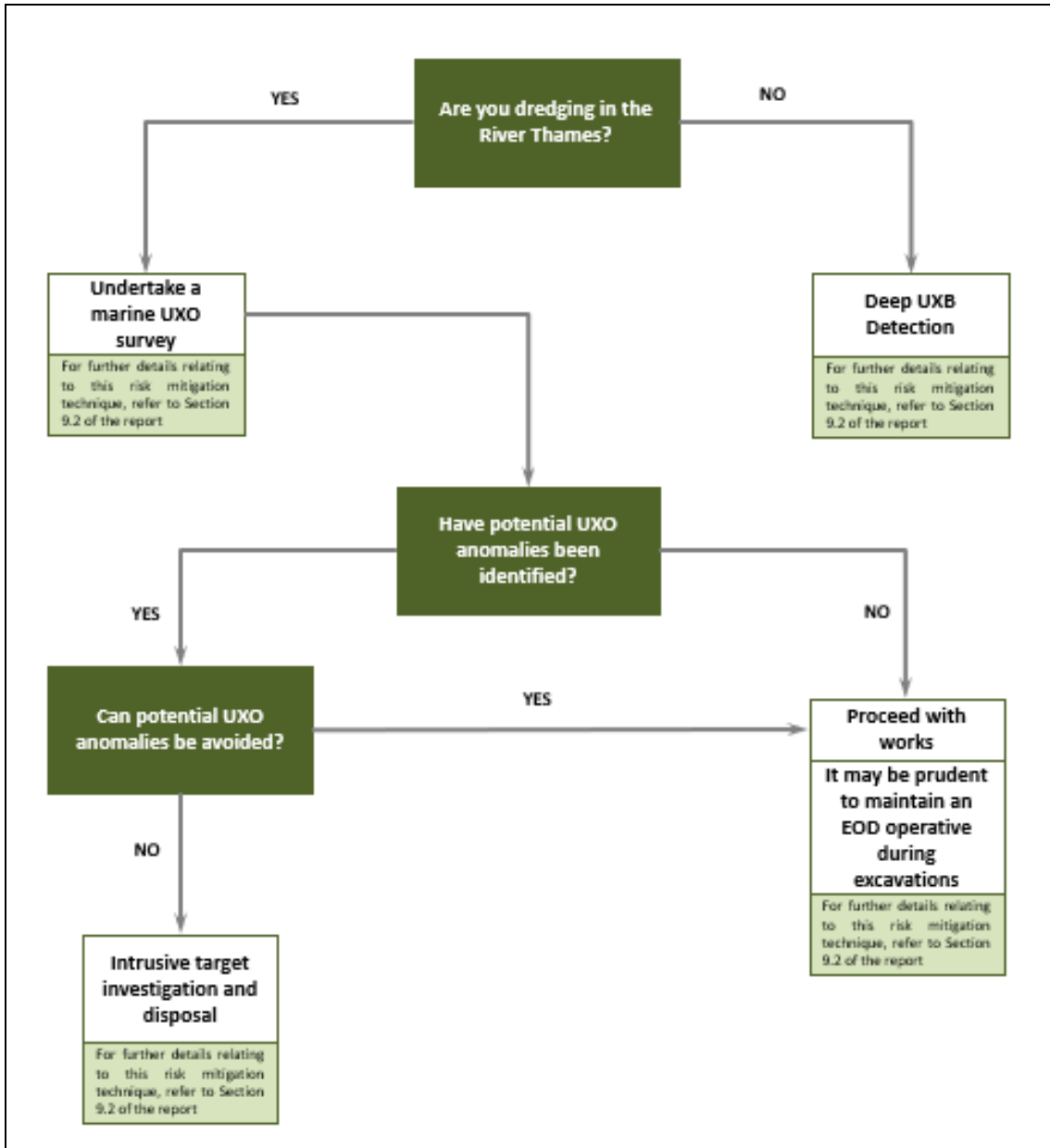









Figure 27 Recommended risk mitigation plan for the Site (River Thames)



9.1 UXO Risk Summary

Table 7 summarises the most appropriate risk mitigation recommendations for the proposed works on the Site.

Table 7 Summary of UXO risk and mitigation recommendations

Proposed Works	UXO Risk	Recommended Mitigation
Excavations		UXO awareness briefing – Given the Site’s military history it is recommended that a formal UXO awareness briefing is provided to staff involved in excavation.
Excavations (In hatched areas)		UXO awareness briefing – As above It may be prudent to undertake a non-intrusive UXO survey in advance of excavations on Tilbury Marshes where there is a lower confidence in the assessed UXO hazard level.
Boreholes/CPT		Proceed with works
Excavations		Non-intrusive survey – where practical, a non-intrusive UXO survey should be undertaken in advance of intrusive ground investigations to detect potential shallow-buried UXO. Potential UXO targets detected can either be avoided or intrusively investigated and removed.
Boreholes/CPT/Piling		Deep UXB detection – to clear borehole and CPT locations of potential UXB, an intrusive magnetometer survey should be undertaken until either the maximum bomb penetration or maximum drilling/CPT/piling depth is reached.
Jack-up barge installation		Deep UXB detection – as above, deep UXB detection to be undertaken at jack-up barge leg positions to ensure that they are clear of UXB.
Dredging		Marine UXO survey – A non-intrusive magnetometer survey should be undertaken in advance of dredging to detect potentially hazardous UXO.

In summary, it is recommended that a detailed risk mitigation plan is devised to outline the recommended risk mitigation techniques in relation to the identified UXO hazards, proposed construction methods, and intended phase of works.

9.2 Risk Mitigation Techniques

The section below provides further details of the recommended techniques for mitigating the UXO risk on the Site.

9.2.1 UXO Awareness Briefing

Typically ~1hour in duration, these briefings will be expected to provide site workers with:-

- Background to the potential UXO hazards that could be encountered.
- Awareness of how the UXO hazard could present a risk.
- Knowledge of what to do in the event that a suspect item is encountered.

The briefing is to be provided along with back-up materials such as UXO awareness posters, emergency contact numbers and other background information to assist site workers in becoming familiar with what potential UXO can look like.

The materials can also be used by key staff to pass on the relevant points of the induction to others who visit or work on the Sites.

By providing the UXO awareness briefing, it ensures that in the unlikely event that UXO is encountered:-

- All site staff take appropriate action.
- A support mechanism and points of contact are established.
- The likelihood of harm to people or property is reduced.
- Significant delays to site work are prevented.

9.2.2 Non-intrusive survey

A non-intrusive geophysical survey is recommended to detect shallow-buried UXO.

A magnetometer survey should be undertaken to detect ferrous ordnance such as UXB.

Where close combat munitions and pipe mines are anticipated a complementary Electromagnetic (EM) technique is recommended.

Analysis of the survey data should be undertaken in the office by a suitably trained and qualified geophysics specialist to determine the limits of detection and enable effective target selection. From this, a priority ranking can be established for those targets most likely to be UXO.

Potential UXO targets can be avoided (where practical) or investigated and removed by an Explosive Ordnance Clearance (EOC) team.

Any hazardous UXO uncovered can be made safe in an Explosive Ordnance Disposal (EOD) operation.

It should be noted that non-intrusive surveys can typically detect the smaller 50kg UXB up to ~2.5m (depending on site conditions). If works deeper than the maximum detection depth are proposed, then a reduced-level dig may be required, depending on the anticipated hazard depth.

This will involve the non-intrusive survey being undertaken in ~2.5m layers (depending on detectability) with any potential UXO targets investigated and removed as required.

Further details on an appropriate survey technique can be provided on request.

9.2.3 Marine UXO survey

A non-intrusive marine magnetometer survey is recommended to map potential UXB and other ferrous ordnance that may provide a risk to ground investigation and dredging works. Side-Scan Sonar (SSS) may also be deployed to further characterise objects on the riverbed.

Zetica can provide further details of a suitable survey design if required. In essence the design would consider:

- Survey altitudes are sufficiently low for the anticipated targets (<2m).
- Survey resolution is sufficiently close for the anticipated targets (<1m).
- A detection method using a vertical gradient magnetic technique.

Any design will include a requirement for geophysical survey verification by use of a surrogate item trial (SIT) survey.

Any analysis of the survey data would be undertaken as a back-office exercise by a suitably trained and qualified geophysics specialist. This will determine the limits of detection and enable effective target selection. From this, a ranking of potential UXO targets can be established, identifying geophysical anomalies most likely to be UXO-related.

On completion of the survey, these potential UXO targets can either be avoided (where practical) or investigated and removed by an Explosive Ordnance Disposal (EOD) diving team.

9.2.4 EOC Engineer Supervision

Where time or access do not allow for a non-intrusive survey to be undertaken, it may be considered more practical for an EOC engineer to attend site and supervise during excavation works if required.

The EOC engineer will carry out a visual assessment on any suspect items uncovered during the excavation works and classify them as potential UXO or other material.

If an item of UXO is uncovered, the EOC engineer will liaise with the authorities and arrange for its disposal as appropriate.

9.2.5 Deep UXB Detection

To clear piling, borehole and CPT positions, in addition to jack-up barge legs, of potential UXB, an intrusive magnetometer survey should be undertaken if practical.

Any piling, borehole or CPT locations should be positioned to avoid potential UXO targets identified by the marine magnetometer survey.

The survey should be carried out to either the maximum bomb penetration depth or maximum drilling/piling/installation depth, whichever is shallower.

There are two main systems available:

MagDrill (Boreholes) – this is a system that is suitable for working with ground investigation drillers.

It allows a magnetometer to be lowered into the borehole to ensure the route is clear of potential UXB.

MagCone (CPT, piles and jack-up barge legs) – this is a CPT-based system that facilitates the pushing of a magnetometer into the ground at the proposed location of a pile or jack-up barge leg.

MagCone is suitable for cohesive/loose soils and has a much higher speed of operation compared to MagDrill.

Detection - Typical radius of detection should be assumed as approximately 1.0m for a 50kg UXB until site conditions are confirmed.

Assuming no objects comparable to the UXB detection range are identified, then the position can be considered clear of UXB.

If any ferrous anomalies are identified at the borehole, pile, CPT or jack-up barge leg position, then they may need to be relocated or the anomaly investigated.

It should be noted that in Made Ground or close to buried/adjacent structures, effective UXB detection is compromised due to geophysical noise.

A clearance report should be issued on completion of the site works.

9.2.6 Risk Mitigation Plan

It is recommended that a detailed risk mitigation plan is devised based on the information provided in this desk study and risk assessment, the proposed construction methodology, and the requirements of any planning conditions.

This should outline the recommended risk mitigation techniques in relation to the identified UXO hazards, proposed construction methods, and intended phase of works.

These risk mitigation measures are to be discussed and confirmed with the client to ensure that the level of proposed mitigation is appropriate for the intended use and the client's risk tolerance, and carefully addresses the often emotive issue surrounding UXO and development.

Outline EOD proposals are also to be detailed to account for the type of UXO anticipated.

The contents and structure of any risk mitigation plan can be discussed with Zetica prior to compilation.

9.3 What Do I Do Next?

If you wish to proceed with UXO risk mitigation, Zetica would be happy to assist. Just contact us via phone (01993 886682) or email (uxo@zetica.com) and we can provide a proposal with options and prices.

If you have requirements to identify other buried hazards (such as mapping utilities or obstructions) we can provide these surveys.

If proposed works on the Site change, or additional works are planned, contact Zetica for a re-assessment of the UXO risk and the risk mitigation requirements.

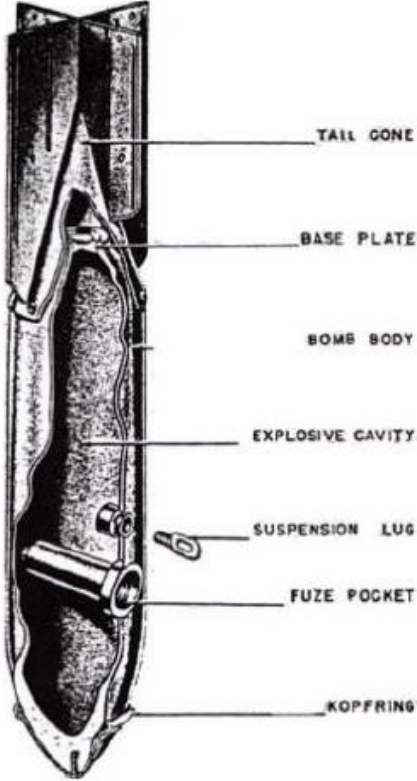
APPENDICES



Appendix 1 Anticipated Ordnance Types

The most likely ordnance types to be encountered on the Site are detailed below. For a more comprehensive set of ordnance data sheets, see <http://zeticauxo.com/downloads-and-resources/ordnance-data-sheets/>.

Information Data Sheet

Category	Bomb (Luftwaffe)
Type	Sprengbombe-Cylindrisch (SC) 50kg
Variants	8
Body Dimensions	762 x 200mm (30" x 7.9")
Weight	55kg (122lbs)
Charge Weight	25kg (54lbs)
Fuze	Single electric impact fuze. Some have short time delay
Composition	Sheet steel
Description	Thick nose welded to a steel body. Nose may be attached to Kopfring (a triangular section steel ring) or spike. Suspension bolt in eye/body and sheet metal tail attached to body with rivets/screws. Originally painted green-grey with a yellow stripe on the tail. Cast TNT, Amatol or Trialen filling.
Function	Designed to maximise shock waves through air, water and earth and for general demolition. Used against easily damageable targets, including roads, aircraft hangars, rolling stock and small buildings. Spike bombs/ 'Stabo' (SC 50 with spikes attached to nose) were used against rail lines and country roads, with Kopfring used against naval targets.



Information Data Sheet

Category Bomb
Type Sprengbombe-Cylindrisch (SC) 250kg

Variants 8

Body Dimensions 1194mm x 368mm (47" x 14.5")

Weight 249-264 kg (548-582lbs)

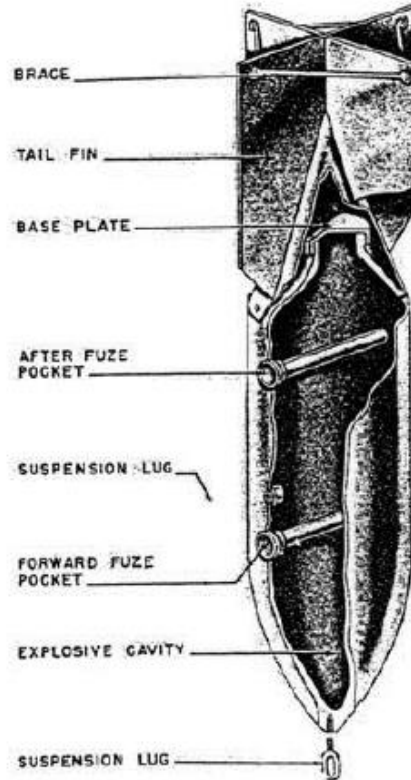
Charge Weight 130-145 kg (287-320lbs)

Fuze Electric impact fuze/electric clockwork time fuse & electric anti-disturbance fuze

Composition Sheet steel with stays

Description Thick nose welded to steel body. Nose may be attached to Kopfring (triangular section steel ring) or spike. Sheet metal tail attached to body with rivets/ screws. Suspension eye bolt in the nose/body. Originally painted green-grey with a yellow stripe on the tail. TNT; amatol; TNT and aluminium powder, naphthalene, ammonium nitrate and wax/ wood meal filling.

Function Designed to maximise shock waves through air, water and earth and general demolition. Used against railway installations, large buildings, ammunition depots and below-ground installations (to 8m). Spike bombs/ 'Stabo' (SC 50 with spikes attached to nose) used against rail lines and country roads.



Information Data Sheet

Category Bomb
Type Sprengbombe-Cylindrisch (SC) 500kg

Variants -

Body Dimensions 1414-1486mm x 470mm (55.7-58.5' x 18.5')

Weight 500kg (1,100lbs)

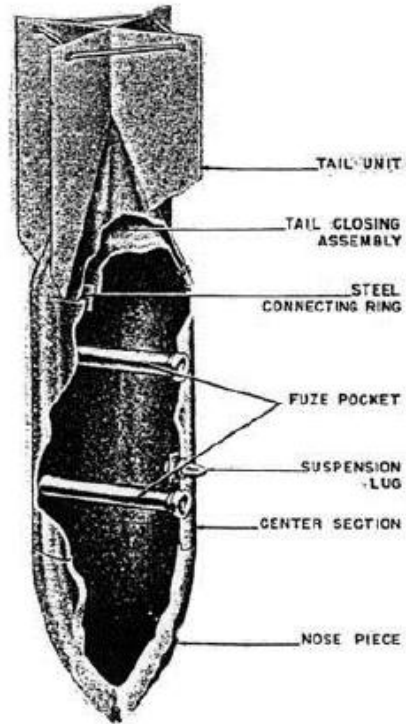
Charge Weight 220kg (484lbs)

Fuze Electric impact fuze/electric clockwork time fuze & electric anti-disturbance fuze.

Composition Sheet steel with stays or drum

Description Thick nose welded to steel body. Nose may be attached to Kopfring (triangular section steel ring). Tail either steel sheet or drum-shaped. Suspension band. Originally painted green-grey/ buff (some later versions sky blue) with yellow stripe on tail. Filled with amatol, TNT or trialen.

Function Designed to maximise shock waves through air, water and earth and for general demolition. Used against railway property, large buildings, shipping and below-ground installations.



Information Data Sheet

Category Bomb
Type Sprengbombe-Cylindrisch (SC) 1,000kg (HERMANN)

Variants 3

Body Dimensions 1742-1905mm x 648-660mm (68.6-75" x 25.5-26")

Weight 1,000-1,088kg (2,204-2,398lbs)

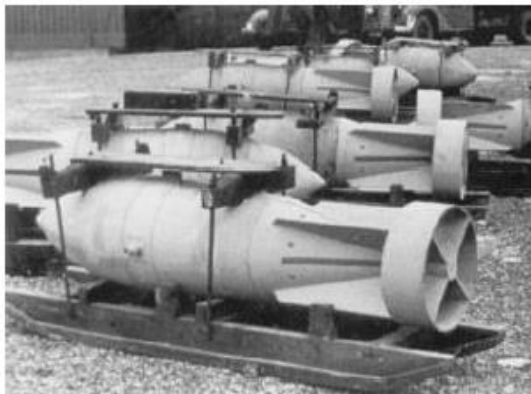
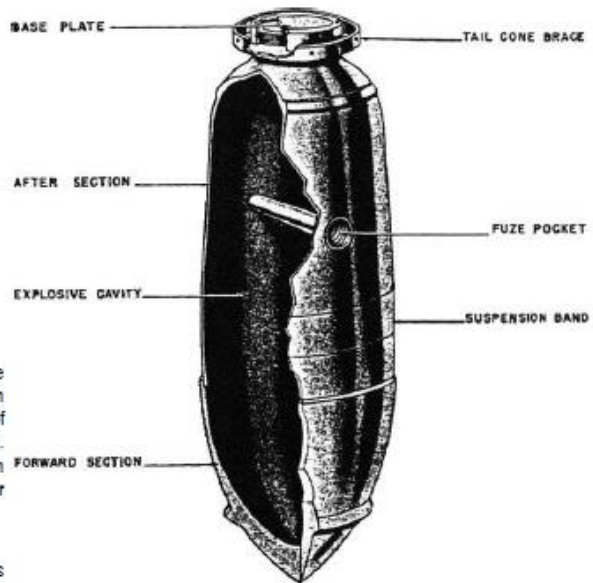
Charge Weight 529-619kg (1,166-1,364lbs)

Fuze Electric impact fuze/ electric clockwork time fuze & electric anti-disturbance fuze

Composition Magnesium alloy with drum

Description Thick nose welded to steel body. Nose attached to Kopfring (triangular section steel ring). Drum-shaped tail made of magnesium alloy. Suspension band. Originally painted sky-blue. Filled with amatol, TNT/aluminium/wood meal or trialen.

Function Designed to maximise shock waves through air, water and earth and for general demolition.



Information Data Sheet

Category Bomb (Luftwaffe)
Type Brandbombe (Incendiary Bomb) 1kg

Variants 6

Body Dimensions 350mm x 50mm (13.8" x 1.97")

Weight 1kg & 1.3kg (2.2lbs & 2.86lbs)

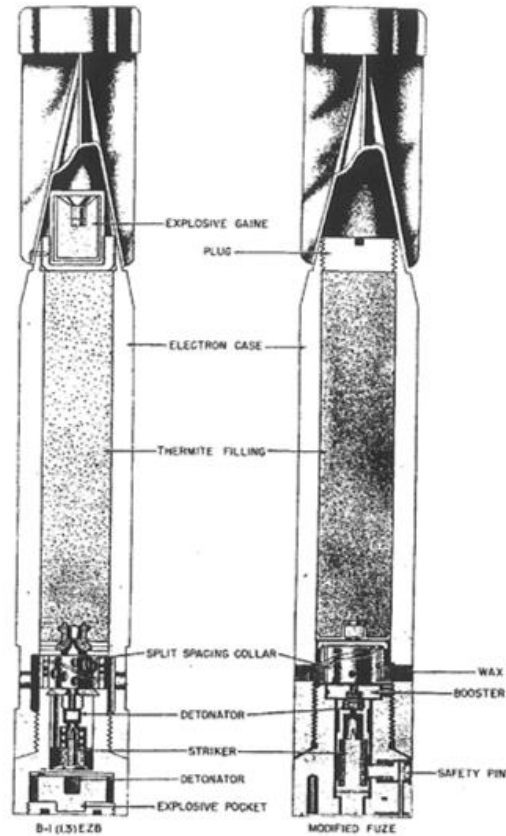
Charge Weight 8 -15 gm (0.28 – 0.53 oz) in models with Nitropenta explosive. No charge in B-1 & B-1.3 E types.

Fuze Impact fuze with safety plug

Composition Sheet steel

Description The body is a cylindrical alloy casting threaded internally at the nose to receive the fuze holder and fuze. The after body is tapered to receive the sheet metal, three-fined drum-shrouded tail assembly. The bomb is unpainted magnesium; the tail is dark green.

Function Dropped in clusters against industrial and commercial targets to start conflagrations.



Information Data Sheet

Category Bomb (Luftwaffe)
Type Brandbombe (Incendiary Bomb) 2kg

Variants 2

Body Dimensions 525mm x 50mm (20.67" x 1.97")

Weight 2kg & 2.2kg (4.4lbs & 4.85lbs)

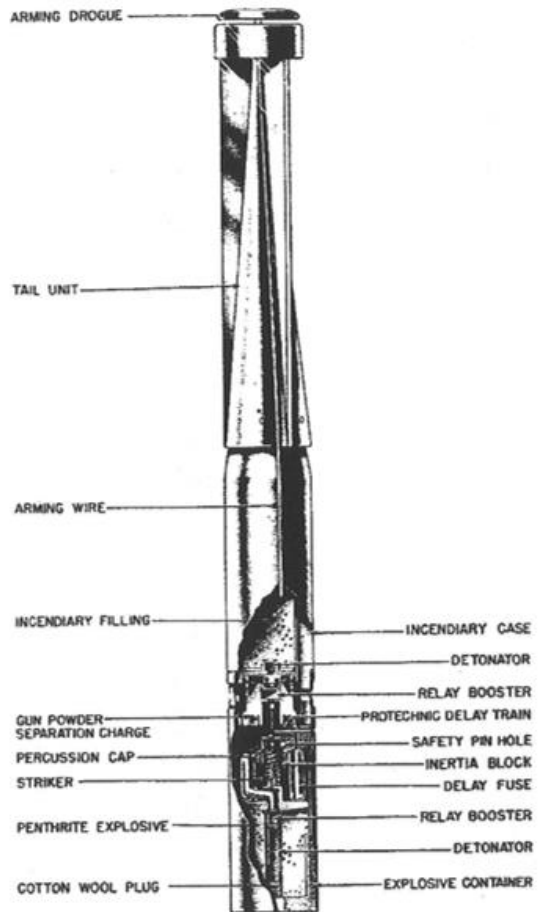
Charge Weight 60g (0.13lbs)

Fuze Impact fuze with screw impact

Composition Sheet steel

Description Steel cylinder. Body originally painted green with black explosive section and grey tail.

Function Dropped in clusters against industrial and commercial targets to start conflagrations. When dropped from 2000m could penetrate iron-concrete roofing.



Information Data Sheet

Category Projectile
Type 3.7" Anti-Aircraft Shell

Variants 6

Body Dimensions 94mm x 360mm (3.7 x 14.7")

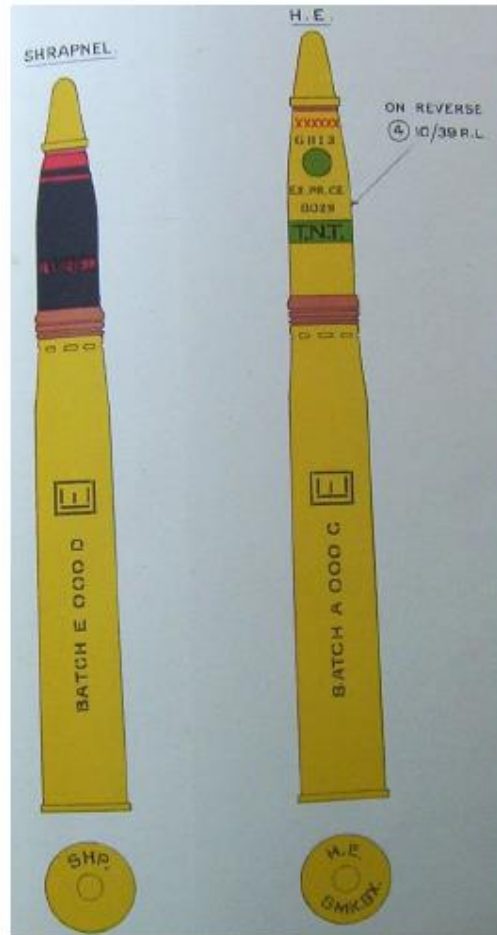
Weight 12.7kg (28lb)

Fuze Mechanical time fuze

Composition Cast steel

Description Brass cartridge case. Square-based shell with tapered nose, filled with Amatol, TNT or RDX/TNT. MK6 had forward centring bands and a wider driving band.

Function Used as a defence against enemy aircraft, fired from fixed batteries and mobile mountings. Could fire approximately 20 rounds per minute with a maximum ceiling of 41,000ft and horizontal range of 20,600 yards.



Information Data Sheet

Category Projectile
Type 4.5" Shell (Mark II – Anti-Aircraft)

Variants -

Body Dimensions 114mm x 566mm (4.5" x 21.9")

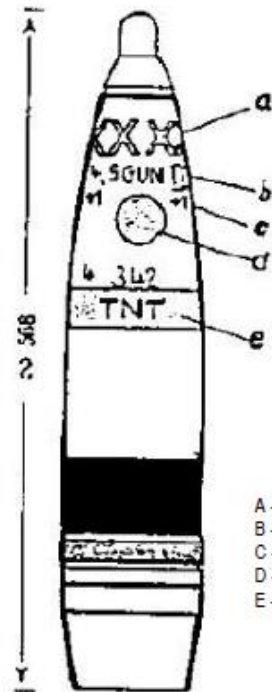
Weight 24.9kg (55lb)

Fuze Mechanical time fuze

Composition Cast steel

Description Square-based, tapered-nosed shell filled with TNT or Amatol. Steel casing, rotating band of either copper or gilding metal located 3.5" in front of the base end with single groove.

Function Used as field artillery and adapted for use in anti-aircraft defence from fixed batteries. Rate of fire of 8 rounds per minute, maximum ceiling of 44,000ft and horizontal range of 22,800 yards.



Information Data Sheet

Category Small Arms Ammunition
Type Various



Description: 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.

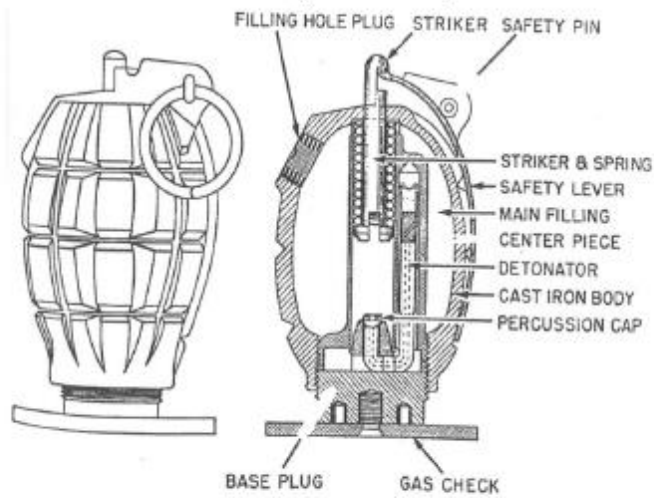
Generally small arms ordnance has a relatively low risk as UXO, although the larger calibre categories may have the same detonation risk as larger high explosive ordnance.

SAA is often associated with discarded ammunition boxes around firing practice ranges and training areas and is often found scattered across former military airfields as a result of aircraft crashes and localised disposal.



Information Data Sheet

Category Grenades (British)
Type No. 36 Hand Grenade ('Mills Bomb')



Variants - **Dimensions** 101.6mm x 61mm (4" x 2.4")

Weight 2 lbs **Delay** 4 seconds

Filling Baratol **Material** Cast Iron

Description Lemon-shaped, cast-iron body filled with high explosive. Three holes in the body; one in the base for priming, one near the top for filling; one on the top holding striker.

Function Used as a defence against enemy personnel.



Information Data Sheet

Category Grenades (British)
Type No. 76 Self-Igniting Phosphorus Grenade

Variants -

Dimensions 152.4mm x 63.5mm (6" x 2.5")

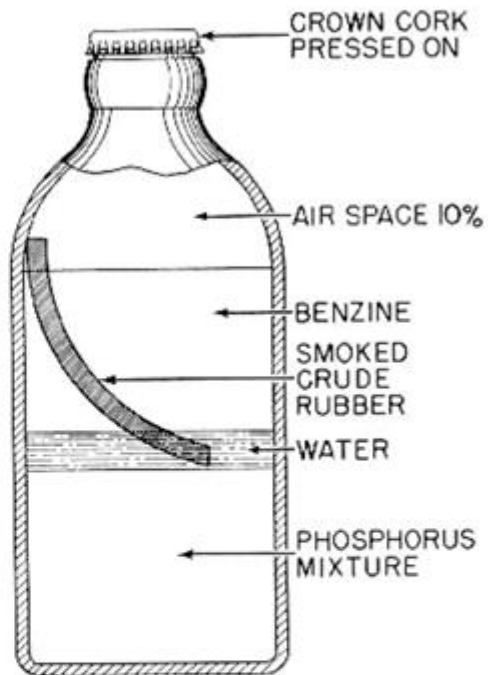
Weight 1lb

Fuze Self-igniting upon breakage

Material Glass

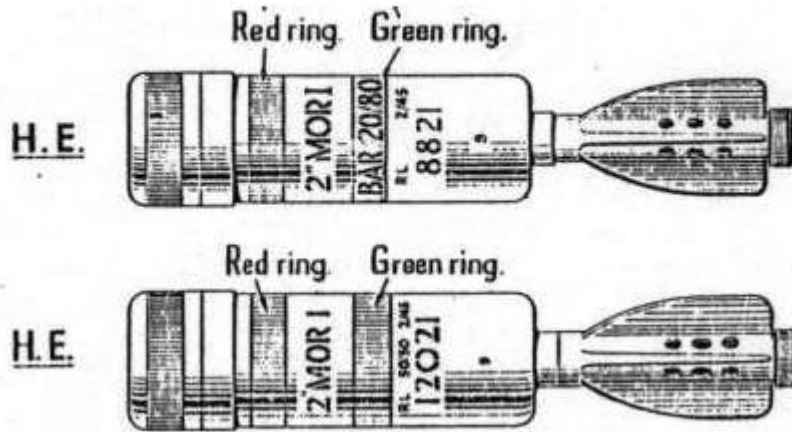
Description Glass bottle filled with white phosphorus, benzene, water and crude rubber.

Function Introduced as an emergency anti-tank measure for the Home Guard early in WWII. Intended to ignite the engine compartment of advancing tanks.



Information Data Sheet

Category Mortar (British)
Type 2-Inch Mortar Bomb



Variants	14	Length	11.4" x 2"
Weight	2.5lbs	Firing Mechanism	Trip (small trigger)
Calibre	50.8mm (2.0 inches)	Rate of Fire	8 rounds per minute

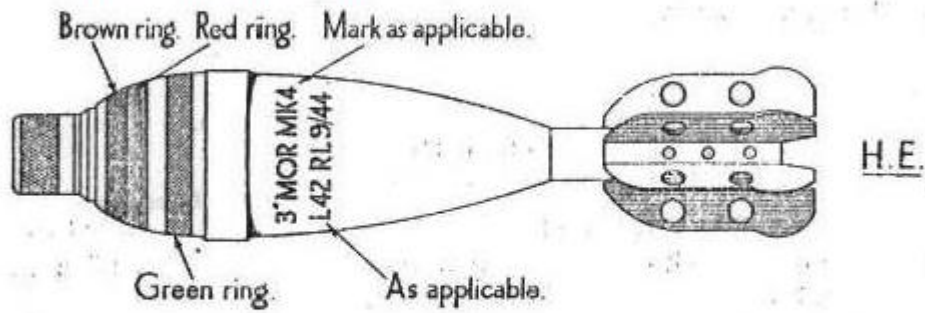
Description Pear-shaped steel body with 6 or 8 vanes. Originally painted buff yellow or dark grey. Filled with c. TNT, granular TNT or powdered Amatol. Also smoke, illumination and practice versions.

Function Small enough to be carried by one man, with a range limited to 500 yards, the 2" mortar was used an anti-personnel role.



Information Data Sheet

Category Mortar (British)
Type 3-Inch Mortar Bomb



Variants 2	Dimensions 19.3" x 3"
Weight 10lbs	Firing Mechanism Trip (small trigger)
Calibre 76.2mm (3.0 inches)	Rate of Fire 12 rounds per minute

Description Pear-shaped steel body with vaned tail fin for stability in flight. Typically filled with high explosive or white phosphorus, the latter dispersing on detonation.

Function Range of up to 1,600 yards, the 3" mortar was used in an anti-personnel role.



Information Data Sheet

Category Projectiles (British)
Type 20mm Shell

Variants Numerous

Body Dimensions 20mm x 310mm (0.8" x 7.19")

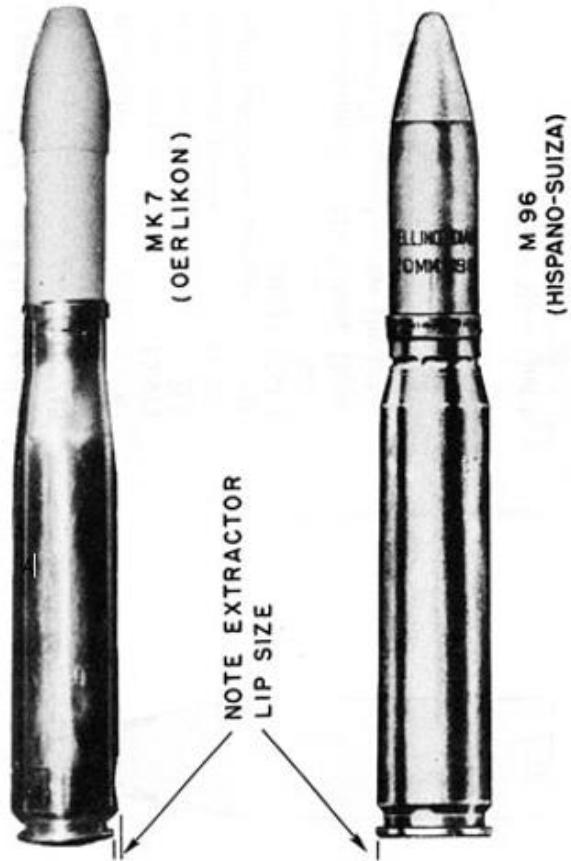
Weight 0.57lb (0.3lb for projectile)

Fuze Point-detonating fuze.

Composition Steel casing

Description Steel casing and projectile with disintegrating belt links at centre and end. Typically a tetryl filling, with some incendiary versions.

Function Automatic cannon shell for use against ground targets and aircraft.



Information Data Sheet

Category Projectiles (British)
Type 40mm Shell

Variants -

Body Dimensions 40mm x 310mm (1.6" x 12.2")

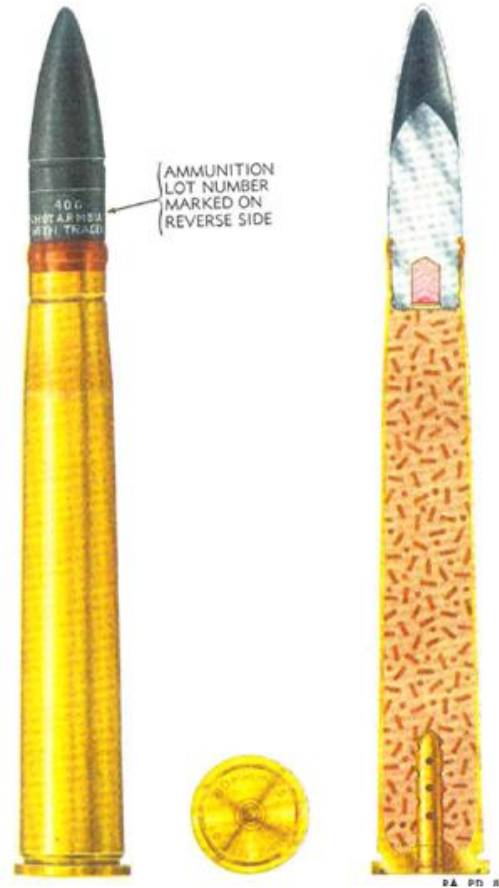
Weight 4.57lb (1.96lb for projectile)

Fuze Point-detonating fuze

Composition Steel casing

Description Steel-cased cartridge and projectile with copper expansion ring around base of projectile to allow release on firing.

Function Used as a rapid-fire defence against enemy aircraft, fired from fixed batteries and mobile mountings.



Information Data Sheet

Category Mines

Type Canadian Pipe Mine / McNaughton Tube

Variants 1

Body Dimensions 2.5" / 3" / 4" diameter x lengths between 20' and 180'

Weight 1kg per ft

Fuze No. 3 Tube Fuze, pencil timer fuze or No. 27 detonator and cordtex

Composition Steel

Filling Nitro-glycerine / Polar Blasting Gelignite

Description Often crudely made, pipe mines were bored, drilled or placed near-horizontally beneath critical infrastructure, such as airfield runways or roads. Usually in a grid pattern. The pipes were filled with nitro-glycerine or Polar Blasting Gelignite (PBG), over time these devices can become increasingly unstable. It is estimated that some 40,000 feet of pipe mines were installed across southern England alone.

Function Designed as an anti-tank weapon, but mainly saw use as a weapon to deny airfields to the enemy and to defend invasion pinch points.



Information Data Sheet

Category Bomb Components
Type Fuzes, Gains and Detonators



Description Bomb components such as detonators, gaines, primers and fuzes typically contain some type of explosive charge to initiate the detonation of a munition. These components have numerous types, appearance and function depending on their intended use. They were stored in quantity at ammunition depots and operational airfields and are also likely to be found anywhere where munitions have been used or were intended to be used.

An indicative cross-section of components is pictured below, with some typical WWII fuzes above.



Information Data Sheet

Category Mine (British)
Type Mark XVII; Moored Contact Mine

Variants 1

Body Dimensions 1,020mm x 1,220mm

Weight 105-225kg (320-500lbs)

Fuze Contact

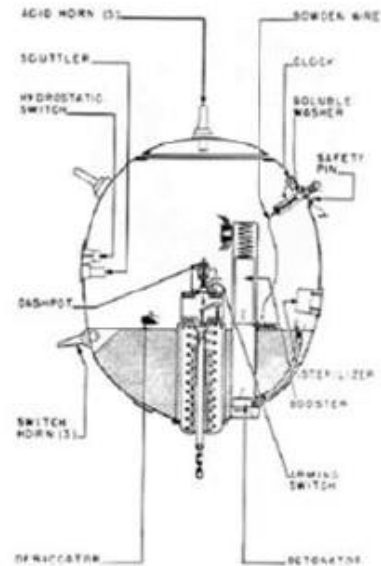
Composition Steel

Description Spherical in shape and typically painted black with a coloured band around the lower section. Could be equipped with up to 11 switch horns, protruding from the body at all angles. Top and bottom have fixtures for a detonator and mooring chain respectively.

Function

The MK XVII was the most commonly used British naval mine, and could be moored in waters up to 915m depth.

It was a moored contact mine which was frequently used in defensive minefields within UK territorial waters.



Appendix 2 Sources of UXO Hazard

The sections below provide background information on the most likely sources of UXO hazard affecting the Site. For a more comprehensive set of UXO information sheets, see <http://zeticauxo.com/downloads-and-resources/uxo-information-sheets/>.

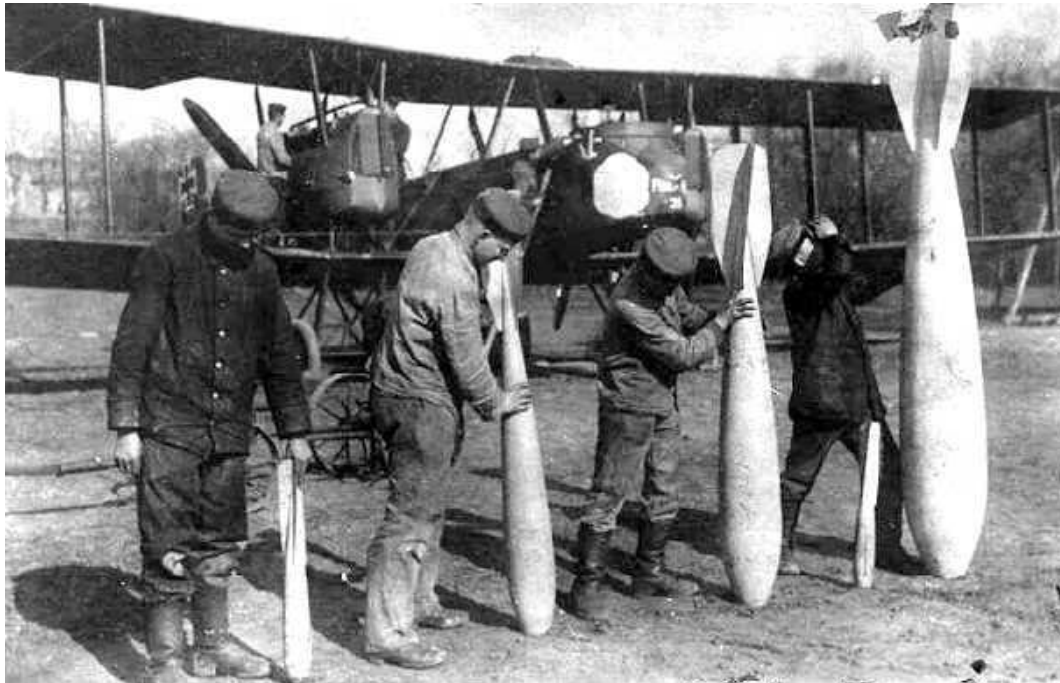
Appendix 2.1 WWI Bombing

It is not generally realised that during World War One (WWI) significant bombing took place across some areas of the UK. An estimated 9,000No. German bombs were dropped on Britain during the course of 51No. airship and 52No. aircraft raids. It was the first time that strategic aerial bombardment had been used. More than 1,400No. people were killed during these raids.

Most air raids were carried out on London and Southeast England. Areas along the East Coast were also targeted regularly due to their proximity to the European continent. Bombing raids further inland were rare and West England and Wales were out of reach for German aircraft of the time.

Aerial bombing during WWI initially relied on visual aiming, with bombsights not developed until later in the war. The inaccuracy inherent in this method meant that bombs often fell some way from their intended targets.

The first recorded raid against England occurred on the 21st December 1914 when 2No. high explosive bombs fell near the Admiralty Pier at Dover. Zeppelin raids intensified during 1915 and 1916, with aircraft raids becoming more frequent after 1917. The last raid of WWI took place on the 19th May 1918, when 38 Gotha and 3 Giant aircraft bombed London and surrounding districts, dropping a total of more than 2,500lbs of bombs.



The potential of coming across an Unexploded Bomb (UXB) from WWI is far less likely than a WWII UXB given the lower bombing densities during raids in the Great War.

Some areas which were subjected to sustained bombing raids, such as parts of London and coastal towns, recorded a higher number of UXB. In these areas, where there has been no significant development for the last century, the potential of a UXB remaining from WWI cannot be totally discounted.

Appendix 2.2 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, harbours, industrial premises, power stations and airfields. In addition to London, industrial cities and ports, including Birmingham, Coventry, Southampton, Liverpool, Hull and Glasgow, were heavily targeted, as well as seaside towns such as Eastbourne and cathedral cities such as Canterbury.

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 Incendiary Bombs (IBs) 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. 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.

In 1944, the Germans introduced new weapons; the V1, a 'flying bomb' and guided missile, and the V2, a ballistic missile rocket that travelled at such speed that no one could see or hear its approach. London was the main target for these attacks.

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 Unexploded Bombs (UXB) or other UXO. In more rural areas, fewer bombing raids occurred. It is known that Air Raid Precaution (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 and coastal areas often went unrecorded or entered as 'fell in open country' or 'fell in the sea'. The Luftwaffe are thought to have dropped approximately 75,000 tons of bombs on Britain throughout the Second World War and an estimated 11% of all bombs dropped during the war failed to detonate.

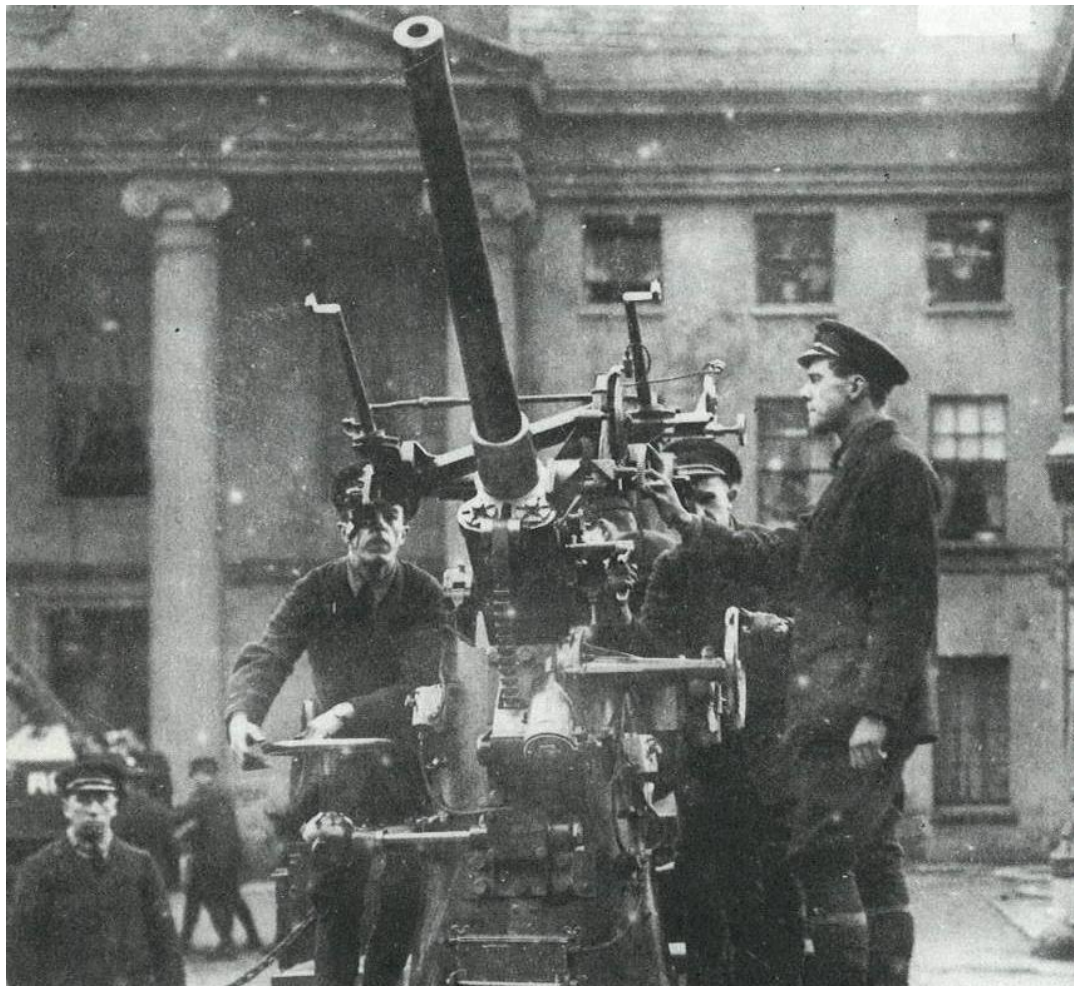
The potential for a UXB hazard to exist on a site depends on a variety of factors. Were there strategic targets in the surrounding area? Was the site bombed? Could a UXB impact have been missed? Even in rural areas, the potential for UXB cannot be totally discounted and therefore it is essential that detailed local bombing records are obtained when assessing the UXB hazard on any site.

Appendix 2.3 Anti-Aircraft Guns

As aerial bombardment first began during WWI, Anti-Aircraft (AA) gun batteries were established and gradually established throughout much of England to counter German bombing raids. By June 1916, there were approximately 271 No. AA guns and 258 No. searchlight installations defending London alone.

Common AA defences during WWI included 3-inch, 75 millimetre, 6-pounder and 1-pounder guns. Many of these guns were mobile, being mounted on lorry chassis. They were driven about following the course of an airship and fired from any area of open land.

During WWI, Unexploded AA (UXAA) shells, could land up to 13km from the firing point, although more typically fell within 10km.



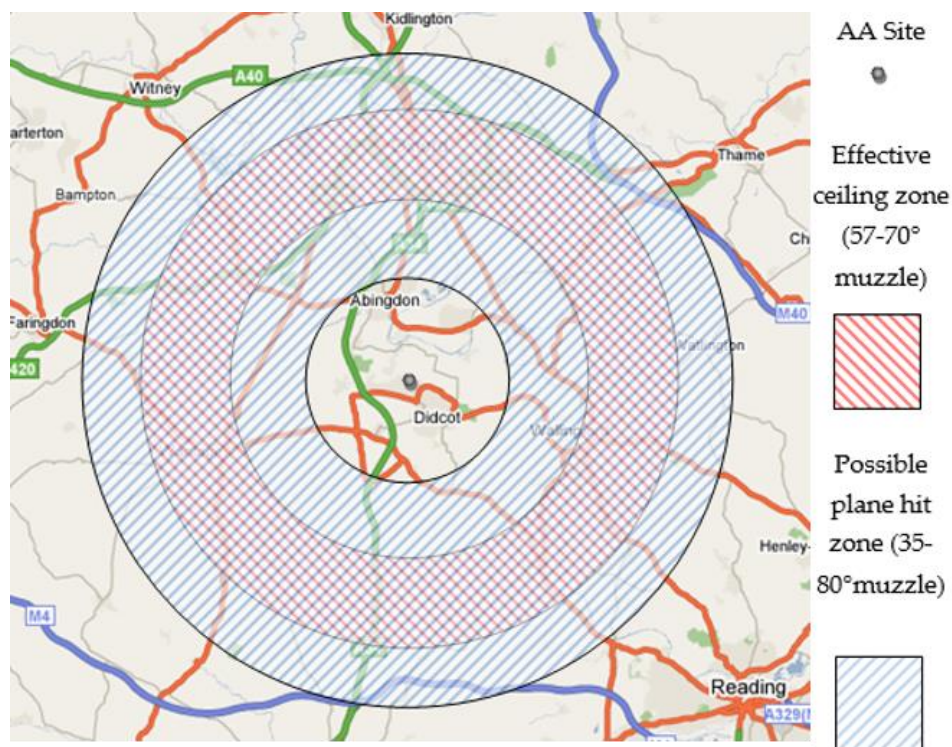
AA gun batteries were used extensively during WWII to counter the threat posed by enemy aircraft. In many instances, AA shells caused damage to Allied territory and in some areas caused significant numbers of civilian fatalities.

During WWII, AA shells could land up to 27km from the firing point, although more typically fell within 15km. These could be distributed over a wide area.

3 No. types of AA batteries existed:

- **Heavy Anti-Aircraft (HAA)** batteries of large guns (typically 3.7", 4.5" and 5.25" calibre) 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. They typically fired 40mm shells and machine gun ammunition.
- **Rocket batteries (ZAA)** firing 3" or 3.7" AA rockets with a maximum altitude of 5,800m and a ground range of 9km were typically permanent emplacements.

Unexploded AA (UXAA) shells were a common occurrence during WWII. As the figure below demonstrates, shells were unlikely to fall in the immediate vicinity of a gun battery but in the surrounding area. This would be dependent upon the angle of fire and the flight height of the attacking aircraft.



AA batteries were deliberately targeted by the Luftwaffe and therefore areas surrounding a gun battery may have a greater risk of UXB being present.

Munitions stores were also established around AA batteries. These stored the shells for the batteries and small arms ammunition for troops manning the position. Such stores were typically removed at the end of WWII, although some disposal may have occurred in the immediate vicinity of the gun battery.

Appendix 2.4 Military Training Areas

In September 1939, the area of land occupied by the army for all purposes, including training, was 235,000 acres. By February 1944, this had risen to 9,800,000 acres for training alone. Land was required for infantry and tank training, for beach assault, and for weapon practice.

Coastal sites involved not only use of the land but also the seabed designated by navigational exclusion zones. Where the land was selected, often requiring the civilian population to leave, camps for the incoming troops had then to be built.

Official training areas tend to have clearly delineated boundaries within which training is to take place. During wartime, however, many areas of open fields and woodland were requisitioned under Defence Regulation 52 by military units stationed in the area. Training in these areas was often not subject to any official rules and regulations, or detailed records.

Some training areas had associated firing ranges and others had provisions for armoured vehicle and tank training. In addition to the surrounding camps, the training areas required firing points, stop butts and observation and range control bunkers.

In the build-up to D-Day, marshalling areas for British and American troops were established in park and woodland near to the coast and these areas were commonly used for training exercises using live munitions.



Testing flamethrowers at a WWII Battle Training Area

The types of UXO that could be present at former military training areas varies depending on their operational history. Ordnance used during exercises ranged from small arms ammunition to grenades, defensive mines, mortars and shells, and unconventional weapons such as flamethrowers.

'Dry' training areas will have primarily used blank ammunition, although even these are likely to have used live munitions at some stage.

Appendix 2.5 Small Arms Ranges

Small arms ranges (such as rifle ranges) can provide a source of UXO, explosive and metallic contamination, depending on their operational history and length of use.

Rifle ranges were a common feature in the open countryside during the 19th century, with local volunteer and militia forces using them extensively for practice.

By the beginning of the 20th century, many of the rifle ranges had fallen into disuse, although some were retained for training purposes by the regular army.

Small arms ranges vary considerably in length, from 25yd machine gun ranges (typically found at airfields, barracks and in urban areas) to 1,000yd shooting galleries. On the larger ranges, medium-calibre and close combat munitions, such as grenades and mortars, were occasionally used, particularly during wartime.

Most of the larger small arms ranges still in use are under MoD control and access is carefully managed. They often have extensive danger areas within which live firing may occur.



Generally, small arms ammunition does not provide a significant UXO hazard and, whilst some live ammunition is likely to be found at former small arms ranges, it does not typically have a high explosive charge.

It should be noted that some larger calibre smalls arms ammunition does have high explosive filling and, at airfield sites, machine gun ranges were used to test cannon shells in addition to small arms. The possibility that some of the larger rifle ranges were used for close combat practice, using grenades and mortars, can also not be discounted.

A significant hazard arising from small arms ranges is metallic contamination associated with spent ammunition. This contamination is usually from lead, although antimony and zinc may also be present. These substances are potentially toxic to humans and the environment.

Appendix 2.6 Military Airfields

During WWII, there was an urgent need for an increasing number of military airfields in the UK. This requirement grew further as the war progressed, particularly after the arrival of American troops in 1942. Airfields were constructed for a variety of purposes, including training, as fighter and bomber stations, and for maintenance units (Mus).

Many former airfield sites have not been significantly redeveloped in the post-WWII period. As such, a number of potential sources of UXO relating to former airfield activity still remain. The types of UXO that may be present depends on the operational history of the airfield. Almost all military airfields had a similar set of features, including ordnance storage and disposal areas, alongside offensive and defensive weapons.

Pipe Mines: Pipe mines were laid beneath critical infrastructure such as runways and designed to be detonated in the event of an invasion to prevent enemy use of the airfield. Airfields that were most likely to have been equipped with pipe mines were those considered vulnerable to invasion, particularly along the South and East Coast. Airfields further inland, and those built after the main threat of German invasion had passed, are unlikely to have had pipe mines installed.

Whilst the majority of the pipe mines at airfields were removed at the end of WWII, it is known that some were left in situ or were not detected during post-WWII clearance operations. Pipe mines are periodically found during development at former airfields.

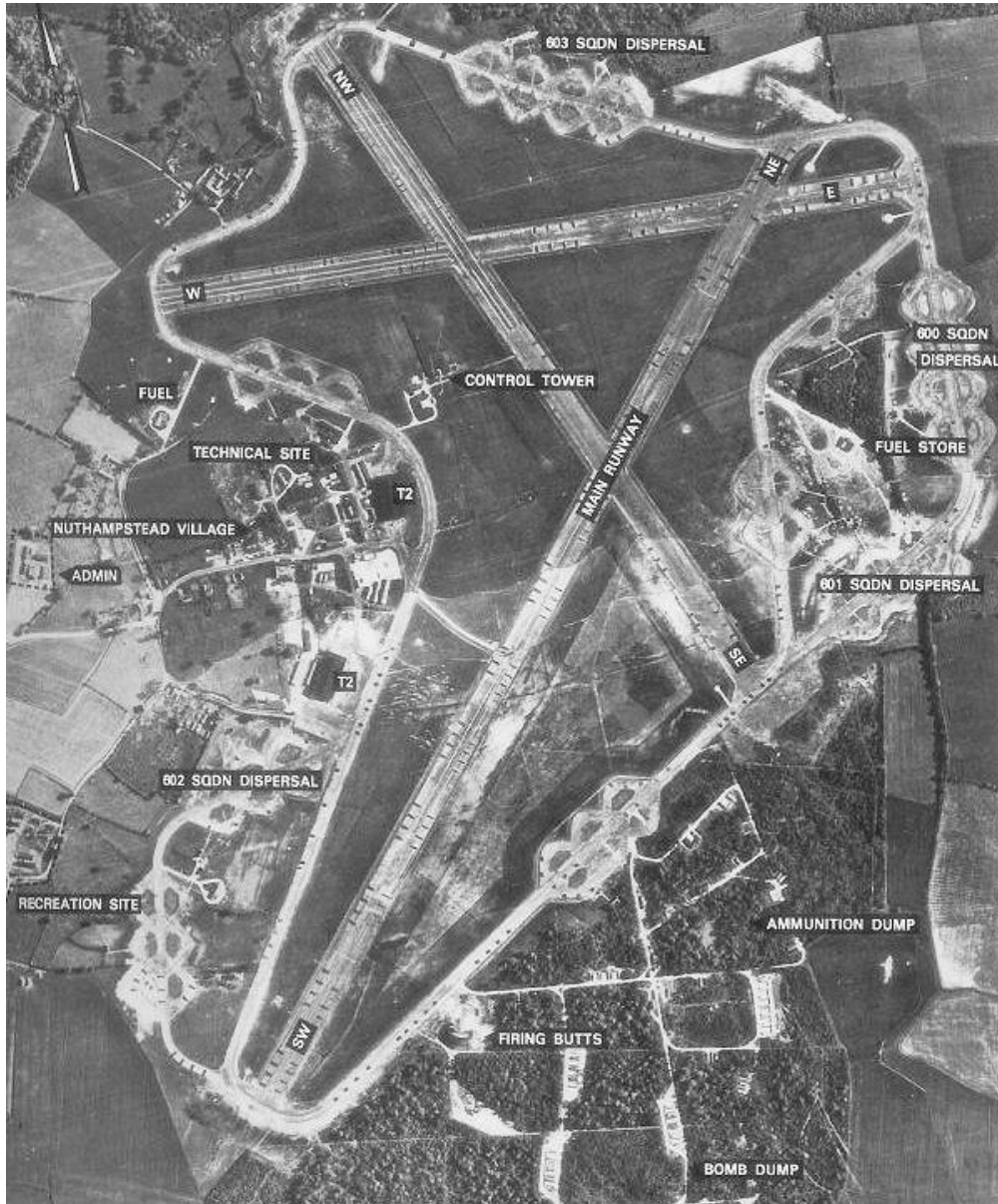
Bomb and Munitions Stores: These were typically constructed in a remote area of an airfield, linked to the perimeter track by a service road. Bomb stores often contained a combination of both practice and live ordnance, in addition to components such as fuzes, detonators and gaines.

Munitions stores also often held close combat ordnance (such as grenades and mortars) and small arms ammunition for airfield defence.

Whilst the bomb stores at airfields were typically subjected to ordnance clearance operations during decommissioning, the sophistication and thoroughness of the clearance was often insufficient to ensure confidence that most of the potential UXO were removed. Incidents of ordnance burial and the accidental spillage of smaller munitions components in the vicinity of the bomb stores is known to have occurred, although such disposal usually occurred in designated areas away from the storage area.

Machine Gun Test Butts: On an airfield, the butts were a designated area where aircraft tested their guns. The butts were often located at the end of access runways or dispersals and incorporated a mound of Made Ground, sand or soil into which firing took place. Whilst machine gun rounds were typically tested at the butts, some aircraft fired cannon shells into the butts.

Small Arms Ranges: Small arms ranges (such as rifle ranges) and close combat ranges (such as mortar and grenade ranges) were provided for training the troops involved in ground defence of the airfield. (See the small arms ranges information sheet for further information on these sites).



Munitions Disposal Areas: For any operational military airfield, an ordnance disposal facility is required. During wartime, this typically took the form of a burning or burial pit and commonly took place in areas around the perimeter of an airfield, away from aircraft operations and buildings.

The most likely disposal operations at airfields during WWII involved the burial or burning of aircraft ammunition and close combat munitions related to airfield defence. Larger munitions, such as bombs, were usually returned to regional ordnance depots, for reuse or for disposal. It is known, however, that the buried disposal of HE bombs occurred at some airfields and UXBs relating to such practices are occasionally found.

Aircraft Breaking: Specialist Maintenance Units (MU) were responsible for the modification, maintenance and repair of damaged aircraft. Those aircraft considered beyond all repair were stripped of useful and salvageable parts and disposed of in a pit or 'aircraft graveyard', usually in areas around the perimeter of an airfield. Waste from aircraft disposal should be considered hazardous. It contains a range of conventional contaminants and potentially radioactive materials (such as radium from luminescent dials).

Appendix 2.7 Aircraft Crashes

These were a common occurrence during the exigencies of wartime. Collisions, damage sustained during operational duty, pilot error and adverse weather conditions were all causes for crashes.

The nature of aircraft crashes means that debris was often scattered over a wide area around the crash site, sometimes up to a distance of two miles.



Aircraft crash sites provide a potential source of UXO hazard, largely depending on the type of aircraft that crashed, its operational status, its ordnance load and any efforts made to clear up the crash site. 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.

The most common source of ordnance associated with aircraft crash sites is small arms ammunition. This may be scattered over a wide area but does not typically constitute a significant UXO hazard. Some later aircraft designs were armed with cannons, the shells of which contain a higher explosive content.

Bomber aircraft crashing with full or partial bomb loads provide a further potential hazard. If the crash site was inaccessible or remote it would commonly be left during wartime. As such, UXBs may still be present around bomber aircraft crash sites.

It is generally the case that post-WWII crash sites are more thoroughly cleared of debris and residues than those which occurred during wartime.

It should be noted that in some cases where a fatal crash site is located, the disturbance of the site may be prohibited due to its status as a war grave.

Appendix 2.8 UXO in the Marine Environment

Both wartime and peace time military and naval activities provide numerous sources of UXO within the marine environment. In addition to coastal and offshore artillery and bombing ranges, the principal sources of marine UXO hazards are from ordnance disposal at sea; aerial or ship laid mines, depth charges and torpedoes; projectiles, shells and bombs left in battle conflict zones; mines laid as beach defences; crashed aircraft and wrecks containing ordnance.



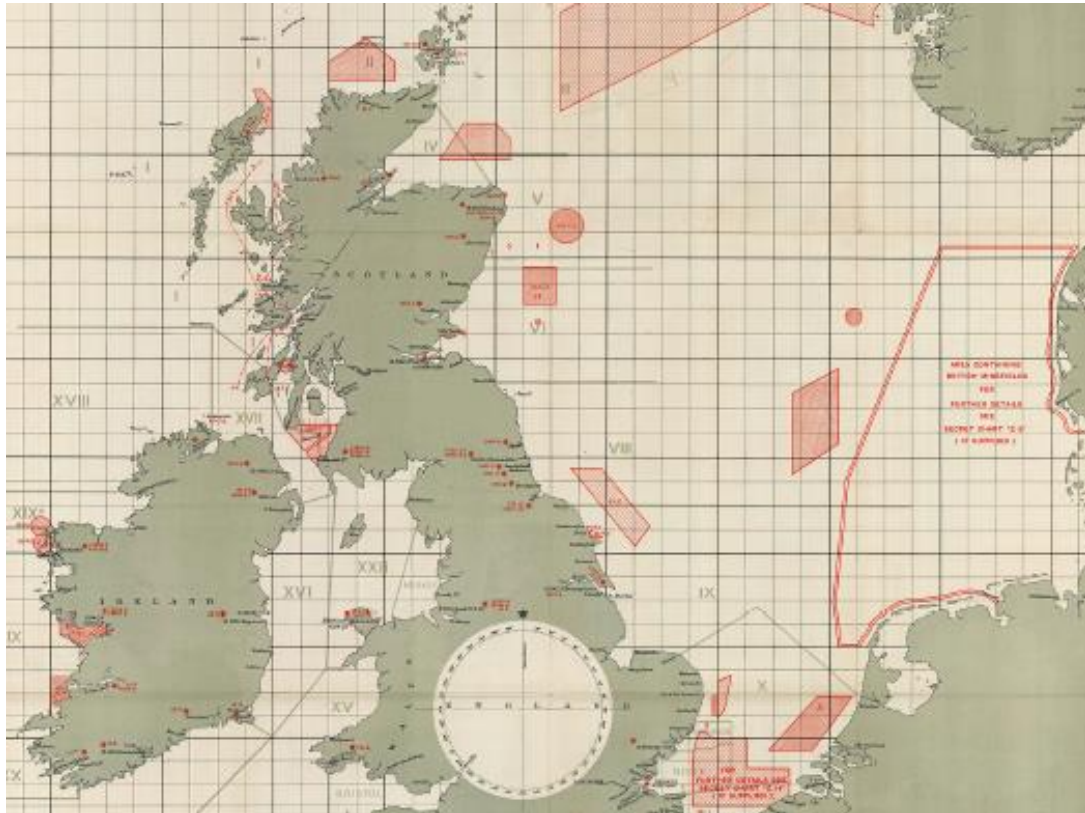
Clearance certification for UXO within a marine environment may be valid only for a limited period as storms, tides and general current movements can cause UXO to migrate into an area that may have been cleared of UXO only hours before. This also makes it very difficult to accurately predict where UXO may be found.

UXO is most likely to be concentrated on and immediately around the principal sources of the UXO hazard but, given sufficiently high energy events over long time periods, migration from source can never be entirely discounted.

Appendix 2.9 Marine Mines and Minefields

During WWI, approximately 128,000No. mines were laid in the sea around the coast of the UK.

At the beginning of WWII the Admiralty ordered the laying of further extensive minefields around the coast of England. This included both defensive mines on beaches in order to prevent enemy landings, as well as approximately 100,000No. marine mines laid at sea to destroy enemy ships.



Buoyant mines, designed to drift free, float or sit just below the surface, were the most commonly deployed marine mines. They were typically moored, or tethered to the seabed with an anchor or wire.

After deployment, cables or anchor systems designed to keep the mine at predetermined depths often failed, allowing previously moored mines to be moved from their original locations by currents. They could also be moved by later fishing activity such as trawling.

Generally spherical in shape, the mines were comprised of 2No. hemispheres connected with a cylindrical mid-section.

Marine mines typically carried 100 to 500lbs (50 to 250kg) of explosive. They were detonated by contact (being struck) or by influence (a vessel interfering with the mine's electromagnetic field).

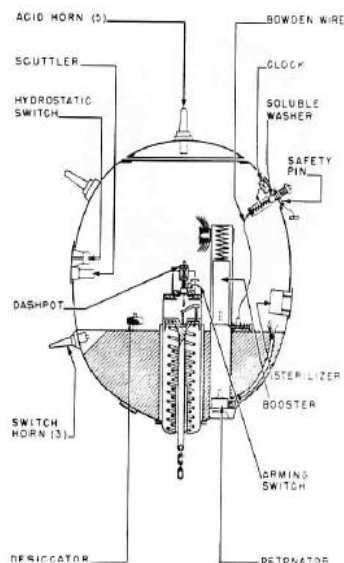
Marine mines deployed during WWI were mostly activated by contact mechanisms, those during WWII were activated by either contact or influence mechanisms, or a combination of both.



German ground mines (Luftmine) were air-deployed naval mines which were also modified for deployment from submarines and surface craft. Although primarily designed to lie on the seabed, many were also moored or buoyant. Designed as an anti-shipping weapon, the WWII Luftmine was also often used on land based targets.

Luftmines typically comprised a cylindrical body with a hemispherical nose and tapered tail, with charges weighing between 675lbs and 1,500lbs (305 to 680kg).

Some German marine mines were composed of aluminium or manganese steel depending on the variant, whereas British mines were typically made of steel



It is generally accepted that less than 30% of the total number of marine mines laid during WWII were recovered due to migration from their initial locations in tidal currents. The recovery rate for anchored submerged mines is likely to be higher but accurate records regarding the clearance of these minefields is not readily available.

As a result there is a possibility that some remain in the marine environment and a mine can be washed up on a beach or found drifting in the water around any part of the UK's coastline.

Air-dropped German mines that did not detonate may remain unexploded in coastal areas around the UK, in addition to in lakes and reservoirs, and rivers.

Appendix 3 Recent UXO Finds

UXO finds in the UK are a regular occurrence, although they almost never result in an accidental detonation.

It is still important to note that explosives rarely lose effectiveness with age. In some instances, mechanisms such as fuzes and gaines can become more sensitive and 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 an accidental UXO detonation are usually extremely fast, often catastrophic and invariably traumatic to any personnel involved. Such occurrences are largely restricted to current theatres of war and overseas minefields, with occasional events in mainland Europe.

Zetica, and other commercial EOD companies, uncover and make safe thousands of items of UXO each year, though details are rarely made public knowledge.

Publicly-recorded discoveries do also occur regularly, as demonstrated by the list of recent significant UXO finds in the UK below. To keep up to date with the latest UXO finds, visit <http://zeticauxo.com/news/>.

On the 3rd February 2020, a 500kg German UXB was found on a building site in Soho, London. It was removed by an EOD team.

On the 18th April 2020, a 500lb British UXB was discovered by a farmer near Drayton in Oxfordshire. The area had been used as an RAF practice bombing range during WWII and after an in-situ disposal was completed the item was found to have contained no explosives.

On the 4th May 2020, a UXB was discovered by builders at Kings Hill on the former RAF West Malling airfield, the fourth found since 2017. It was destroyed in a controlled explosion.

On the 1st December 2020, a research vessel discovered an unexploded marine mine containing 350kg of explosives in Wemyss Bay in the Firth of Clyde. RN divers investigated the item and destroyed it.

On the 4th February, 2No. anti-tank mines were discovered on Slapton Sands in Devon. They had been uncovered by recent storms and were destroyed.

On the 26th February 2021, a 1,000kg German "Hermann" UXB was discovered by builders at Exeter University campus (see plate below). It was investigated and detonated in-situ following the evacuation of nearby properties and University halls of residence.



On the 29th March 2021, 1No. 250lb UXB was discovered on the seabed near Hinkley Point C harbour, Bristol. A maritime exclusion was imposed while the item was investigated and then destroyed in a controlled explosion.

On the 10th May 2021, 1No. Anti-Aircraft shell dating from WWII was found by a member of the public in Horsham, Surrey. It was destroyed in-situ by a bomb disposal unit.

On the 17th May 2021, 1No. Sea Wolf missile was brought onboard a fishing vessel near Brixham in Devon. A Royal Navy EOC team destroyed the missile in a controlled explosion.

On the 1st June 2021, a cache of approximately 100No. hand grenades dating from WWII were found in a Nottinghamshire forest, a possible relic from nearby wartime camps. They were destroyed.

On the 23rd July 2021, 1No. 18lb artillery shell dating from WWI was discovered in a private garden in Bloxham, Oxfordshire. It was transported to a nearby field where it was destroyed in a controlled explosion.

On the 24th July 2021, 1No. 500lb British UXB was uncovered during construction works in Goole, East Yorkshire. Reports indicated that the UXB had been jettisoned by a Lancaster bomber aircraft prior to crashing nearby in WWII. The item was investigated and destroyed.

On the 18th August 2021, 1No. UXB was found by construction workers on a Site in Earl Sterndale, Derbyshire. Upon inspection the UXB was deemed to be dangerous and a controlled detonation was undertaken.

On the 10th September 2021, EOD teams destroyed 25No. mortars which had been washed up onto beaches around Nairn and Ardersier in Morayshire. These beaches had been used during WWII for training prior to the D-Day landings in Normandy.

On the 18th October, 1No. 18.5lb artillery shell was discovered during the clearing-out of a farmyard barn near Aberfeldy in Perthshire. The shell dated from WWI and was removed.

On the 12th November 2021, 1No. unexploded artillery shell was found on a housing development site in Wrexham, Wales. It was destroyed in controlled explosion.

On the 15th December 2021, approximately 200No. artillery shells were discovered at a construction site located within the former Royal Ordnance Factory at Swynnerton in Staffordshire. The shells were removed and destroyed.

On the 15th December 2021, 1No. apparent UXB was snagged by a fishing trawler off the Norfolk Coast and then detonated, causing significant damage to the vessel. Upon further investigation, it was concluded that the UXB had been dropped in the water during WWII.

On the 2nd January 2022, 1No. heavily deteriorated 105mm artillery shell was discovered by dogwalkers on a beach in Cumbria. This may have originated on one of the several offshore ranges which have been operational along the nearby coastline since WWII.

Between the 24th and 27th January 2022, 5No. empty artillery shells were uncovered at a construction site in Manchester. These were likely linked to a shell-production factory which had been active on the site during WWII.

On the 17th February 2022, 1No. WWI-era Mk1 Mills hand grenade was found in the River Frome in Dorset by magnet fishermen. This was the third grenade to be pulled from the same stretch of the river over the past year. It was inspected by local police and destroyed.

Appendix 4 Glossary and Definitions

Abandoned Explosive Ordnance (AXO)	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.
Close Combat Munitions	Items of ordnance thrown, propelled or placed during land warfare, to include grenades, mortars, projectiles, rockets and land mines.
Demil	Derived from the term ‘Demilitarisation’, it refers to the break down and the recycling or disposal of ordnance components.
Detonation	The high-speed chemical breakdown of an energetic material producing heat, pressure, flame and a shock wave.
Device	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.
Explosive	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.
Explosive Ordnance (EO)	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.
Explosive Ordnance Clearance (EOC)	Explosive Ordnance Clearance is a term used to describe the operation of ordnance detection, investigation, identification and removal, with EOD being a separate operation.
Explosive Ordnance Disposal (EOD)	Explosive Ordnance Disposal is the detection, identification, on-site evaluation, rendering safe, recovery and final disposal of unexploded explosive ordnance.
Explosive Ordnance Reconnaissance (EOR)	Explosive Ordnance Reconnaissance is the detection, identification and on-site evaluation of unexploded explosive ordnance before Explosive Ordnance Disposal.
Explosive Remnants of War (ERW)	Explosive Remnants of War are Unexploded Ordnance (UXO) and Abandoned Explosive Ordnance (AXO), excluding landmines.

Explosive Substances and Articles (ESA)	<p>Explosive substances are solid or liquid substances (or a mixture of substances), which are either:</p> <ul style="list-style-type: none">• 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.• 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. <p>Explosive article is an article containing one or more explosive substances.</p>
Fuze	<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>
Gaine	<p>Small explosive charge that is sometimes placed between the detonator and the main charge to ensure ignition.</p>
Geophysical survey	<p>A geophysical survey is essentially a range of methods that can be used to detect objects or identify ground conditions without the need for intrusive methods (such as excavation or drilling). This is particularly suited to ordnance as disturbance of ordnance items is to be avoided where ever possible.</p>
Gold line	<p>This is the estimated limit of blast damage from an explosive storage magazine. It usually means that development within this zone is restricted.</p>
High Explosive	<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>
Munition	<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">• inert - contain no explosives whatsoever.• live - contain explosives and have not been fired.• blind - have fired but failed to function as intended.

Primary Explosive	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.
Propellants	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.
Pyrotechnic	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.
Small Arms Ammunition (SAA)	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.
Unexploded Anti-Aircraft (UXAA) Shell	<p>UXAA shells are army ordnance commonly containing HE, though they can also contain pyrotechnic compounds that produce smoke.</p> <p>Most commonly, these were 3.7" and 4.5" HE shells, although they ranged from 2" to 5.25" calibre.</p>
Unexploded Bomb (UXB)	UXB is a common term for unexploded air-dropped munitions.
Unexploded Ordnance (UXO)	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.
V1	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.
V2	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 man-made object launched into space, during test flights that reached an altitude of 189km (117 miles) in 1944.

Appendix 5 WWII AA Shell Incident List

Northern part of the Site

14th September 1940

1No. AA shell fell 100-yards (yds) southwest of Hall Farm, South Ockendon. It was recorded as a UXAA shell.

22nd September 1940

1No. AA shell was found in a field approximately 500yds east of Berridens.

8th December 1940

3No. UXAA shells were discovered on open ground on Ockendon Road, North Ockendon.

17th December 1940

1No. AA Shell fell 400yds southeast of Broadfields Farm. It was recorded as a UXAA shell.

20th December 1940

1No. AA shell fell 100yds west of the railway between Dennis's corner and Redcrofts. It was recorded as a UXAA shell.

24th February 1941

1No. AA shell fell 200yds north of Dennises Lane and 20yds west of Pea Lane, North Ockendon.

27th February 1941

1No. AA shell fell near Puddle Dock Farm, North Ockendon.

8th September 1941

1No. AA shell fell 600yds east of Hall Farm, South Ockendon. It was recorded as a UXAA shell.

1st April 1943

1No. UXAA shell was discovered east of Pea Lane, North Ockendon.

11th October 1943

1No. AA shell fell on Home Farm, south of St Mary's Lane.

25th October 1943

1No. AA shell fell south of Whitepost Farm, North Ockendon.

17th December 1943

1No. UXAA shell was discovered on Cranham Place Farm.

18th January 1943

2No. AA shells 300yds south of a searchlight post near Broadfields Farm. It was recorded as a UXAA shell.

10th February 1943

1No. AA shell fell near Chapman's Farm, Cranham.

5th March 1943

1No. AA shell fell near Clay Tye Road, North Ockendon.

1No. AA shell fell near Puddle Dock Farm, North Ockendon.

1st April 1943

1No. AA shell fell east of Pea Lane, South of Ockendon Road, North Ockendon.

14th April 1943

1No. AA shell fell northeast of Dennises Lane, North Ockendon.

15th April 1943

1No. UXAA shell was discovered northeast of Mollands Farm, South Ockendon.

19th April 1943

1No. AA shell fell south of Bay Farm, North Ockendon.

7th October 1943

1No. AA shell fell on Kemps Farm, north of West Road, South Ockendon. It was recorded as a UXAA shell.

15th January 1944

1No UXAA shell was found in a meadow, Cranham. It was removed on the 21st January 1944.

31st January 1944

1No. AA shell fell in open ground northeast of Mollands Farm. It was recorded as a UXAA shell.

2nd February 1944

1No. UXAA shell was discovered in Meadowcroft, Cranham.

14th March 1944

1No. AA shell fell on open ground east of the London, Midland and Scottish Railway (LMSR) line. It was recorded as a UXAA shell.

29th March 1944

1No. AA shell fell on open ground south of Grove Farm, South Ockendon. It was recorded as a UXAA shell.

1No. AA shell fell 200yds east of Wagstaff Wood, South Ockendon. It was recorded as a UXAA shell.

6th May 1944

1No. UXAA shell was discovered in Meadowcroft, Cranham.

10th June 1944

1No. UXAA shell was found in a potato field, near Moor Lane, Cranham.

Central part of the Site

31st August 1940

1No. AA shell fell on Grays Corner.

3rd September 1940

1No. UXAA shell was discovered in a field north of Long Lane, 300yds west of Grays Corner.

19th September 1940

1No. AA shell fell on Baker Street, damaging cables.

24th September 1940

1No. UXAA shell was discovered at the Bata Estate.

3rd October 1940

1No. AA shell fell on the Bata Factory, East Tilbury. It was recorded as a UXAA shell.

17th October 1940

1No. UXAA shell was removed from Fen Cottage, Orsett.

24th November 1940

1No. UXAA shell was discovered on Tilbury Marshes.

25th December 1940

1No. AA shell fell on 304 Long Lane, Stifford. It was recorded as a UXAA shell and removed.

15th March 1941

1No. AA shell fell in a field north of Northumberland Road, Linford.

19th March 1941

1No. AA shell fell near Barrington's Farm, Orsett Cock. It was recorded as a UXAA shell.

10th May 1941

1No. UXAA shell was removed from Marsh's Field, Green Lane, Orsett.

14th June 1941

1No. UXAA shell was removed from Heath Place Farm, Orsett Heath.

21st June 1942

1No. UXAA shell was discovered 40yds south of Orsett Cock.

19th August 1942

10No. AA shells were discovered near the east railway signal box, Tilbury.

14th October 1942

1No. AA shell fell approximately 30yds north of Green Lane, Baker Street. It was recorded as a UXAA shell.

18th February 1943

1No. AA shell fell in a field near Turnpike Cottages, West Tilbury.

4th March 1943

2No. AA shells fell west of Elm Farm, Orsett.

5th March 1943

1No. UXAA shell was discovered 200yds west of the Old Rectory, East Tilbury.

9th March 1943

1No. UXAA shell was discovered near the junction of Low Street Lane and Muckingford Road.

6th June 1943

1No. AA shell fell on open ground at Botany Farm. It was recorded as a UXAA shell.

17th November 1943

1No. UXAA shell was discovered on Lower Crescent, Linford.

14th February 1944

1No. AA shell exploded at the foot of the river wall near Marsh Farm, Tilbury.

26th February 1944

1No. UXAA shell was discovered 250yds north of the Thames River, on Tilbury Marshes.

29th February 1944

1No. AA shell fell 200yds north of Heath Place Farm, Orsett. It was recorded as a UXAA shell.

29th March 1944

1No. AA shell fell on open ground south of Grove Farm, South Ockendon, approximately 40m north of the Site. It was recorded as a UXAA shell.

24th August 1944

2No. AA shells fell Tilbury Riverside Railway Station.

17th November 1944

1No. UXAA shell was discovered east of Baker Street.

Southern part of the Site

4th December 1940

1No. AA shell fell near east of Church Lane, Chalk.

23rd January 1944

1No. UXAA shell was discovered on Watling Street, southwest of Claylane Woods.

4th February 1944

1No. UXAA shell was discovered near Lower Higham Road.

12th February 1944

1No. UXAA shell was discovered at Chalk, near Gravesend Road.

Appendix 6 WWII Bombing Incident List

Northern part of the Site

26th July 1940

HE bombs (number unspecified) bombs fell between Brentwood and North Ockendon, including the Site.

1st August 1940

1No. UXB was discovered in a field east of Clay Tye Hill, North Ockendon, on the Site.

24th August 1940

1No. UXB was discovered in a field northwest of the junction of the B186 and the Southend arterial road, on the eastern site boundary.

29th August 1940

6No. HE bombs fell on open fields 400 yds west of South Ockenden Station, between Little Belhus Farm and Kemp Farm, within approximately 0.1km west of the Site.

HE bombs (unspecified number) fell on North Ockendon, on the Site.

4th September 1940

IBs fell on North Ockendon, on the Site.

9th September 1940

HE bombs (unspecified number) fell on North Ockendon, on the Site. These were recorded as UXB.

10th September 1940

1No. HE bomb fell on Poole's Farm, Hall Lane, Upminster, on the Site.

HE bombs (unspecified number) fell on Broadfields Farm, on the Site.

11th September 1940

1No. HE bomb fell on North Ockendon, on the Site. It was recorded as UXB.

16th September 1940

2No. OBs and 100No. IBs fell half a mile east of Ockendon Road, north of Fen Lane, North Ockendon, on the Site.

18th September 1940

1No. HE bomb fell on Ockendon Road, leading to the White House Inn, North Ockendon, on the Site. It was recorded as UXB.

1No. HE bomb fell to the west of the junction of Warley Street and the A127, on the Site.

21st September 1940

1No. HE bomb fell 100yds north of the footpath on Front Lane, Cranham, on the Site. It was removed.

23rd September 1940

9No. HE bombs fell between the LMSR railway line, on the Site, and Dennis's Corner, also on the Site. They were all recorded as UXB.

1No. HE bomb fell on Kemps Farm, on the Site. It was recorded as UXB.

1No. HE bomb fell on the meadow adjacent to Marsh Farm, on the Site. It was recorded as UXB.

25th September 1940

1No. Parachute Mine (PM) fell near Monks Farm, west of Cranham, on the Site.

HE bombs (number unspecified) fell on Harold Wood, Tye Lane and Hornchurch, including the Site.

26th September 1940

HE bombs (number unspecified) fell on Broadfields Farm, on the Site.

4th October 1940

1No. HE bomb fell on open fields at North Ockendon Hall Farm, on the Site.

7th October 1940

1No. Oil Bomb (OB) fell in field near the junction of St Marys Lane and Warley Street, on the Site.

9th October 1940

1No. HE bomb fell on Kemp's Farm, on the Site. It was recorded as UXB.

1No. HE bomb fell 170yds west of Brentwood Road, approximately 0.1km west of the Site. It was recorded as UXB.

13th October 1940

1No. HE bomb fell on the railway line near South Ockendon, on the Site.

14th October 1940

4No. Delayed Action Bombs (DAB) fell north of Dennises Lane, on the Site.

16th October 1940

10No. HE bombs fell between Fairholme Gardens, Moor Lane and the A127, Cranham, on the Site.

1No. HE bomb fell on Brookman's Farm, Front Lane, Cranham, on the Site.

17th October 1940

1No. HE bomb fell 350yds south of Ockendon Road and 20yds west of Pea Lane, on the Site. It was recorded as UXB.

20th October 1940

2No. HE bombs fell north of the junction of Hall Lane and Bird Lane, Cranham, on the Site. They were recorded as UXB and removed. (west of hall lane)

1No. HE bomb fell west of Hall Lane and south of Bird Lane, Cranham, on the Site. It was recorded as UXB and removed.

25th October 1940

3No. HE bombs fell 400yds north of Berry Farm, North Ockendon, on the Site. They were recorded as UXB and removed.

1No. DAB south of Dennis's Cottages, Dennises Lane, on the Site. It exploded during disposal operations.

26th October 1940

1No. HE bomb fell 500yds south of Bird Lane, 50yds east of Hall Lane, Cranham, on the Site. It was recorded as UXB and removed the next day.

28th October 1940

8No. HE bombs fell on open ground at Manor Farm, North Ockendon, in close proximity to the Site.

4th November 1940

2No. HE bombs fell on a field west of Hall Lane, near the junction with Bird Lane, Cranham, on the Site. They were recorded as UXB.

5th November 1940

4No. HE bombs fell near the CWS factory, Warley Street, on the Site. They were recorded as UXB and removed.

23rd November 1940

5No. HE bombs and 1No. DAB fell on fields between Hall Farm and South Ockendon Mental Hospital, including the Site.

24th November 1940

1No. HE bomb fell near Hall Farm, South Ockendon, on the Site. It was recorded as UXB.

27th November 1940

9No. HE bombs and 1No. OB fell on the north side of St Mary's Lane, North Ockendon, on the Site.

29th November 1940

1No. HE bomb fell in a field behind Cranham Place Farm, in close proximity to the Site. It was recorded as UXB.

1No. HE bomb fell on North Ockendon Hall Farm, on the Site.

10th December 1940

1No. HE bomb fell 200yds east of Home Farm Cottages, North Ockendon, on the Site. It was recorded as UXB.

29th December 1940

18No. Unexploded IBs (UXIB) were discovered between Puddledock Wood and Berry Farm, North Ockendon, on the Site.

31st December 1940

1No. HE bomb fell on Pea Lane, on the Site. It was recorded as UXB.

13th January 1941

IBs fell on Great Warley, between Great Warley Street and Moor Lane, on the Site.

19th January 1941

2No. HE bombs fell on Broadfields Farm, on the Site.

23rd January 1941

1No. HE bomb fell 250yds west of Pea Lane and 300yds north of Dennises Lane, on the Site. It was recorded as UXB.

19th March 1941

4No. HE bombs fell east of Wantz Bridge, St Mary's Lane, Cranham, on the Site.

20th March 1941

1No. HE bomb fell 500yds north of South Ockendon and west of North Road, on the Site.

4th April 1941

2No. HE bombs fell east of North Road and south of Groves Farm, on the Site. They were both recorded as UXB.

9th April 1941

1No. UXB was discovered 650yds west of the junction of the B186 and A127, on the Site.

17th April 1941

2No. HE bombs fell between Chapman Hall and Chapman Cottages, Hall Lane, Upminster, on the Site.

19th April 1941

2No. HE bombs fell on Kemps Farm, on the Site. They were both recorded as UXB.

14th August 1941

1No. HE bomb fell 600yds north of The Hall, South Ockendon, on the Site. It was recorded as UXB.

9th September 1941

1No. HE bomb fell 400yds northeast of The Hall, South Ockendon, on the Site. It was recorded as UXB.

4th March 1943

8No. HE bombs fell in a stick from open ground on North Ockendon Hall Farm, to open ground south of Dennises Lane, on the Site. 1No. of these was recorded as UXB.

1No. HE bomb fell south of South Ockendon Hall, on the Site. It was recorded as UXB.

8th March 1943

1No. V1 exploded in the air between Hall Lane and Front Lane, Cranham.

5th May 1943

1No. UXB was removed from a field east of Moor Lane, Upminster, on the Site.

9th October 1943

1No. HE bomb fell on the ALMA factory, Warley Street, on the Site.

21st October 1943

1No. HE bomb fell between St Marys Lane and the arterial road, east of Great Warley Street, on the Site. Damage was recorded at Codham Hall. 16No. additional craters were identified on and adjacent to the eastern boundary of the Site.

23rd October 1943

1No. HE bomb fell near the CWS factory, Warley, on the Site. It was recorded as UXB and removed.

21st January 1944

1No. IB fell on open ground north of Bullen Farm, North Ockendon, on the Site. It was recorded as UXIB and removed.

22nd January 1944

8No. HE bombs fell near Codham Hall, on the Site. It was recorded as UXB.

2No. HE bombs fell near St Mary's Church, North Ockendon, on the Site.

29th January 1944

1No. HE bomb fell on Codham Hall Wood, on the Site. It was recorded as UXB.

1No. Phosphorus IB (PhIB) fell on open ground east of Berry Farm, North Ockendon, on the Site. It was recorded as an Unexploded PhIB (UXPhIB) and removed.

1No. V1 fell south of St Mary's Lane, Cranham, on the Site boundary.

30th January 1944

1No. HE bomb and 1No. PhIB fell on Kemps Farm, on the Site. The HE bomb was recorded as UXB.

20th February 1944

3No. HE bombs fell north of Hall Farm, South Ockendon, on the Site. 2No. of these were recorded as UXB.

2No. HE bombs fell southwest of Middle Farm, on the Site.

1No. HE bomb fell northeast of Hall Farm, South Ockendon, on the Site. It was recorded as UXB.

1No. HE bomb fell 300yds east of Whitestaffs Wood, on the Site.

21st February 1944

8No. HE bombs fell 200yds east of Hall Farm, South Ockendon, on the Site.

18th March 1944

5No. UXB were discovered in woodland near Woodside Cottage, Stoney Hill, on the Site.

22nd March 1944

IBs fell on North Ockendon, in the vicinity of the Site.

17th June 1944

1No. V1 fell 200yds south of St Mary's Lane, on the Site.

3rd August 1944

1No. V1 fell in a field west of Folkes Lane, Cranham, on the Site.

11th October 1944

1No. V1 fell on Fen Lane, North Ockendon, on the Site.

11th November 1944

1No. V1 fell near Codham Hall, on the Site.

26th November 1944

1No. V2 fell on Cranham, on the Site boundary.

Central part of the Site

23rd July 1940

2No. HE bombs fell 500yds west of South Ockendon Railway Station, on the Site.

1st August 1940

At least 2No. HE bombs fell in the River Thames between Coalhouse Fort and Tilbury Fort, in the immediate vicinity of the Site.

3rd August 1940

2No. HE bombs fell northwest of Baker Street, Orsett, on the Site.

Approximately 40No. IBs fell on Anchor Lane and Condovers Farm, on the Site.

18th August 1940

1No. HE bomb fell north of the railway line near London Road, Tilbury, on the Site.

26th August 1940

1No. UXB was discovered near Low Street Station, East Tilbury, on the Site.

29th August 1940

IBs fell between Low Street Station and Tilbury Station, on the Site.

31st August 1940

IBs fell on the dust chute at Tilbury, on the Site.

1st September 1940

1No. HE bomb fell on Tilbury Dock Railway Station, on the Site.

2nd September 1940

1No. HE bomb fell 150yds from Grove Road, on the Site. It was recorded as UXB.

3rd September 1940

2No. HE bombs fell southwest of Coalhouse Fort, on the Site. They were recorded as UXB.

1No. UXB was discovered on Ferry Road, Tilbury, on the Site.

5th September 1940

6No. HE bombs fell near Buckland Farm, on the Site.

6No. HE bombs fell on marshland east of Tilbury Fort, on the Site.

3No. HE bombs fell on Grove Farm, South Ockendon, on the Site. They were all recorded as UXB.

1No. HE bomb fell near the sea wall, Tilbury, on the Site.

1No. HE bomb fell near the Railway Cottages, Tilbury, on the Site. It was recorded as UXB.

1No. HE bomb fell on the Co-operative Laundry, Tilbury, on the Site.

200No. IBs fell across Heath Place Farm, Orsett Heath, on the Site.

A large number of IBs fell between the Orsett and Buckles Farm AA gun sites, on the Site.

IBs fell on Dock Road, approximately 0.1km north of the Site.

IBs fell on Tilbury Marshes, on the Site.

IBs fell on Tilbury Dock Station, in close proximity to the Site.

IBs fell on Tilbury, in the immediate vicinity of the Site.

1No. IB fell on a playing field near Cock Inn, Orsett, on the Site.

6th September 1940

6No. HE bombs fell near the gun battery, Chadwell St Mary, on the Site.

6No. HE bombs fell on Biggins Hill, Chadwell St Mary, on the Site

1No. HE bomb fell at Bull Hall Cottages, Chadwell St Mary, in close proximity to the Site. It was recorded as UXB.

8th September 1940

HE bombs (number unspecified) fell on Orsett and Orsett Heath, on the Site.

IBs fell on South Ockendon and Orsett, on the Site.

10th September 1940

1No. HE bomb fell on Botany Farm, on the Site. It was recorded as UXB.

1No. HE bomb fell on Surridges Dust Chute, East Tilbury Marshes, on the Site.

1No. HE bomb fell near the road between Orsett and Baker Street, on the Site.

IBs fell on Fielding Avenue, on and adjacent to the Site.

13th September 1940

4No. HE bombs fell near the barrack wall of Coalhouse Fort, on the Site. These were recorded as UXB and removed.

2No. HE bombs fell to the southwest of Coalhouse Fort, on the Site. They were removed as UXB and removed.

2No. HE bombs fell southeast of Heath Place Farm, Orsett Heath, on the Site. They were recorded as UXB.

2No. HE bombs fell on Orsett Golf Course, encroaching on the Site. They were recorded as UXB.

1No. HE bomb fell 350yds southeast of Heath Place Farm, Orsett Heath, on the Site.

1No. HE bomb fell on Seaborough Hall, on the Site. It was recorded as UXB.

1No. HE bomb fell 250yds of Bucklands Farm, on the Site.

1No. HE bomb fell north of the junction of Northumberland Road and Stanford Road, on the Site. It was recorded as UXB.

HE bombs (number unspecified) fell on Lower Crescent, Linford, on the Site.

HE bombs (number unspecified) fell on Lower Crescent, Linford, on the Site.

HE bombs (number unspecified) fell on Somerset Crescent, Linford, on the Site.

IBs and HE bombs (number unspecified) fell on Orsett Heath and Baker Street, including the Site.

IBs fell in the vicinity of Linford, on the Site.

14th September 1940

1No. HE bomb fell on the front lawn of the Rectory, Orsett, on the Site. It was recorded as UXB.

1No. HE bomb fell near the sea wall at Tilbury, on the Site.

Approximately 40No. IBs fell near the gun battery, Chadwell St Mary, on the Site.

15th September 1940

2No. HE bombs fell on East Tilbury, near Coalhouse Point, on the Site.

1No. HE bomb fell 200yds east of Seaborough Hall, on the Site. It was recorded as UXB.

16th September 1940

4No. HE bombs fell on Tilbury Marshes (precise location unspecified), on the Site.

1No. OB and 1No. HE bomb fell on East Tilbury, on the Site.

17th September 1940

2No. HE bombs fell on the dust chute at East Tilbury.

1No. HE bomb fell on Hill House Farm, Orsett. It was recorded as UXB.

1No. HE bomb fell 200yds south of the farmhouse at Poplars Farm, Orsett. It was recorded as UXB.

18th September 1940

Enemy action caused widespread damage across Essex, including the Site.

4No. HE bombs fell on Tilbury Marshes (precise location unspecified), on the Site.

2No. HE bombs fell near the gun battery, Chadwell St Mary, on the Site.

1No. HE bomb fell in a field near Parker's Avenue, Tilbury, on the Site. It was recorded as UXB and removed the same day.

1No. HE bomb fell near the east signal box, Tilbury, on the Site. It was recorded as UXB and removed the same day.

1No. HE bomb fell on the Convent, Malta Road, within approximately 90m north of the Site.

1No. HE bomb fell on fields 140yds west of the junction of the A127 and Warley Street, approximately 0.1km west of the Site.

1No. DAB fell on Chadwell House, approximately 10m east of the Site.

IBs fell on West Tilbury, on the Site.

19th September 1940

4No. HE bombs fell on Tilbury Marsh, on the Site.

3No. HE bombs fell on open ground at Tilbury Docks, in close proximity to the Site.

1No. HE bomb fell on Baker Street, on the Site.

1No. HE bomb fell on the Laundry at Tilbury, on the Site.

1No. HE bomb fell in a field near Mill House, Baker Street, on the Site. It was recorded as UXB.

HE bombs (number unspecified) fell on the Railway Cottages, Tilbury, on the Site.

IBs fell on West Tilbury, on the Site.

20th September 1940

14No. HE bombs fell on the saltings at East Tilbury, on the Site.

3No. HE bombs fell near Heath Place Farm, Orsett Heath, on the Site. They were recorded as UXB.

1No. HE bomb fell near hairpin Bridge, between Ferry Road and Dock Road, Tilbury, on the Site.

21st September 1940

1No. HE bomb fell near High House Farm, Chadwell St Mary, on the Site. It was recorded as UXB.

1No. HE bomb fell on field adjoining the junction of Buckingham Hill Road and Northumberland Road, Lindford, on the Site. This was recorded as UXB.

23rd September 1940

Damage was recorded on the railway at Dennis' Corner, South Ockendon, on the Site.

24th September 1940

1No. HE bomb fell 300yds east of Marsh Farm Bungalow on Tilbury Marshes, on the Site.

1No. HE bomb fell on West Tilbury, on the Site.

25th September 1940

2No. HE bombs fell on Hall Farm, South Ockendon, on the Site. They were recorded as UXB.

1No. HE bomb fell east of Hall Farm, South Ockendon, on the Site.

1No. UXB was removed south of Fen Lane Corner, Bulphan, on the Site.

HE bombs and DABs (number unspecified) fell near Tilbury Docks, in close proximity to the Site.

26th September 1940

IBs fell on South Ockendon, including the Site.

28th September 1940

1No. PM fell on Orsett Golf Course, on the Site.

29th September 1940

1No. HE bomb fell 300yds east of Seaborough Hall, on the Site. It was recorded as UXB.

1No. HE bomb fell near Potash Hill, Orsett Heath Place, on the Site. It was recorded as UXB.

1No. PM fell 100yds south of the club house, Orsett Golf Course, on the Site.

2nd October 1940

1No. HE bomb fell on Brentwood Road, Chadwell St Mary, on the Site.

4th October 1940

1No. HE bomb fell on Low Street Station, East Tilbury, on the Site.

5th October 1940

1No. HE bomb fell on Barrington's Farm, Orsett on the Site. It was recorded as UXB.

1No. HE bomb fell on Hall Farm, South Ockendon, on the Site. It was recorded as UXB and removed.

1No. HE bomb fell southwest of Bull Hall Cottages, Sandy lane, Chadwell, on the Site. It was recorded as UXB and removed.

IBs fell on East Tilbury, on the Site.

6th October 1940

1No. HE bomb fell on Hall Farm, on the Site. It was recorded as UXB.

9th October 1940

HE bombs (unspecified number) and IBs fell on South Ockendon, within approximately 2km of the Site.

100No. IBs fell near the gun battery, Chadwell St Mary, on the Site.

IBs fell on Orsett Heath, on the Site.

13th October 1940

HE bombs (unspecified number) fell on South Ockendon near the railway line to Upminster, in close proximity to the Site.

15th October 1940

1No. HE bomb fell 200yds east of the Bata Shoe Factory, East Tilbury, on the Site.

1No. HE bomb fell near Sandy Lane, within approximately 0.1km east of the Site. This was recorded as UXB.

15th-16th October 1940

Widespread bombing was reported at Orsett, South Ockendon and West Tilbury, on the Site.

1No. HE bomb fell on Sandy Lane, Chadwell St Mary, on the Site. It was recorded as UXB and removed.

1No. HE bomb fell to the north of the allotments near Gun Hill, West Tilbury, on the Site. It was recorded as UXB.

1No. HE bomb fell at Brookmans Farm, on the Site.

17th October 1940

1No. HE bomb fell near the road between West Tilbury and Low Street, on the Site. It was recorded as UXB and removed.

18th October 1940

1No. HE bomb fell on the northern end of Blackshots Lane, Grays, on the Site.

HE bombs (number unspecified) fell on West Tilbury, on the Site.

20th October 1940

1No. HE bomb fell on Barrington's Farm, Orsett, on the Site.

1No. HE bomb fell southeast of Parker Avenue, West Tilbury, on the Site. It was recorded as UXB and removed.

23rd October 1940

1No. HE bomb fell on West Tilbury, on the Site.

24th October 1940

3No. HE bombs fell southwest of Middle Farm, South Ockendon, on the Site.

25th October 1940

1No. DAB fell on south of Dennis Cottages, on the Site.

1st November 1940

3No. HE bombs fell near Castle Farm, Bulphan, on the Site. They were recorded as UXB.

2nd November 1940

1No. HE bomb fell in Battery Field, East Tilbury, on the Site. It was recorded as UXB.

4th November 1940

1No. HE bomb fell in open ground near Chadwell St Mary, on the Site.

1No. HE bomb fell east of Brentwood Road, near Alexandra Cottage, Chadwell St Mary, on the Site. It was recorded as UXB and removed.

5th November 1940

HE bombs (unspecified number) and IBs fell on East Tilbury, on the Site.

IBs fell on Orsett Heath, on the Site.

7th November 1940

HE bombs (unspecified number) fell on South Ockendon near Hall Lane, on the Site.

8th November 1940

8No. HE bombs and 1No. OB fell on Heathfields Farm, Buckingham Hill, Muckingford, on the Site.

12th November 1940

1No. HE fell on the fairway, 300yds east of the Road, Orsett Golf Course, on the Site. It was recorded as UXB.

13th November 1940

4No. HE bombs fell on Green Lane, on the Site. They were recorded as UXB.

UXBs (number unspecified) were removed from the Lighteridge and Dredger dust chute, east of Tilbury Fort, on the Site.

24th November 1940

1No. HE bomb fell on Hall Farm, South Ockendon, on the Site. It was recorded as UXB.

25th November 1940

2No. HE bombs fell on Castle Farm, Bulphan, on the Site.

29th November 1940

2No. HE bombs fell on West Tilbury, on the Site.

1No. HE bomb fell on Castle Farm, Bulphan, on the Site.

4th December 1940

1No. HE bomb fell on Dock Road, Tilbury, approximately 50m north of the Site.

9th December 1940

1,000No. IBs fell between Mucking and West Tilbury, including the Site.

IBs fell between East and West Tilbury, including on the Site.

1No. UXIB was located on East Tilbury Marshes, on the Site.

10th November 1940

2No. HE bombs fell to the northeast of a roundabout on the A13, Baker Street, on the Site. They were recorded as UXB and removed.

12th December 1940

9No. HE bombs fell north of Baker Street, on the Site.

3No. HE bombs fell on open ground at Botany Farm and Hobletts Farm, on the Site.

1No. HE bomb fell 300yds south of Heath Place Farm, on the Site.

16th December 1940

1No. HE bomb fell near High House Farm, on the Site. It was recorded as UXB.

17th December 1940

1No. HE bomb fell on Rainbow Shaw, Linford, on the Site. It was recorded as UXB.

20th December 1940

1No. UXB was removed from Orsett Heath, on the Site.

4th January 1941

2No. HE bombs fell 700yds northeast of Heath Place Farm, on the Site.

2No. HE bombs fell on Orsett Heath, on the Site.

1No. HE bomb fell on open ground near Heath Place Farm, Orsett Heath, on the Site.

9th January 1941

HE bombs fell on fields in West Tilbury, on the Site.

12th January 1941

1No. HE bomb fell 10yds south of St Andrews Road, near the PLA Workers Compound, Tilbury, in close proximity to the Site. This was recorded as UXB.

1No. HE bomb fell on open ground northeast of Tilbury Docks, in close proximity to the Site.

1No. HE bomb fell at the rear No. 22 Shed, Tilbury Dock, in close proximity to the Site.

1No. HE bomb fell south of Dock Road, Tilbury, in close proximity to the Site.

1No. HE bomb fell on railway lines near Tilbury Dock Station, approximately 20m north of the Site.

1No. HE bomb fell at the southeast corner of No. 23 Shed, Tilbury Docks, approximately 50m south of the Site.

HE bombs (number unspecified) fell near Orsett Camp, on the Site. No exact locations were specified.

1No. OB and 1No. HE bomb fell on Fairfield Avenue, Little Thurrock, on the Site.

17th January 1941

1No. HE bomb fell 200yds northwest of Heath Place Farm, Orsett Heath, on the Site. It was recorded as UXB.

19th January 1941

1No. UXB was removed from allotments near St Andrews Road, Tilbury, on the Site.

25th January 1941

1No. HE bomb fell 400yds south of Heath Place Farm, Orsett Heath, on the Site.

5th February 1941

IBs fell on Orsett Heath, on the Site.

IBs at Grays Corner, on the Site.

6th February 1941

100No. IBs fell been Orsett Heath and Orsett Golf Course, including the Site.

10th February 1941

IBs fell on Orsett, on the Site.

IBs fell on Hall Farm, South Ockendon, on the Site.

IBs fell on South Ockendon, on the Site.

11th February 1941

2No. HE bombs fell on Green Lane, Baker Street, on the Site.

12th February 1941

1No. HE bomb fell on the Bata Shoe Factory, East Tilbury, on the Site.

15th February 1941

1No. HE bomb fell on Hill Farm, Orsett, on the Site. It was recorded as UXB.

4th March 1941

16No. HE bombs fell on East Tilbury, 4No. of which fell near the gun battery at Buckland Farm, on the Site.

2No. HE bombs fell near South Hall Farm, East Tilbury, on the Site. They were recorded as UXB.

5th March 1941

1No. HE bomb fell on Bowaters Farm, East Tilbury, on the Site.

1No. HE bomb fell west of East Tilbury Vicarage, on the Site. It was recorded as UXB.

8th March 1941

4No. HE bombs fell north of Barrington's Farm, Orsett, on the Site. They were recorded as UXB.

9th March 1941

1No. HE bomb fell to the rear of the mill, Orsett, on the Site. It was recorded as UXB.

1No. HE bomb fell at rear of premises, High Street, Orsett, approximately 0.1km south of the Site.

12th March 1941

2No. HE bombs fell on Surridges Marshes between Golden Gate, Mucking and East Tilbury Fort, on the Site.

15th March 1941

2No. HE bombs fell west of Carters Cottages, on the Site. They were recorded as UXB.

2No. HE bombs fell on Carters Cottages, Heath Road, Orsett Heath, on the Site.

1No. HE bomb fell on the Shaw, Orsett Heath, on the Site. It was recorded as UXB and removed.

IBs (number unspecified) fell in fields west of Orsett, including the Site.

IBs (number unspecified) fell on south of Stifford Clays, including the Site.

19th March 1941

HE bombs (unspecified number) fell in a field north of South Ockendon, on the Site.

7th April 1941

1No. UXB was removed from Windmill Cottages, Baker Street, on the Site.

9th April 1941

1No. HE bomb fell on Surridge's Dust Chute, East Tilbury Marshes, on the Site. It was recorded as UXB.

16th April 1941

9No. UXBs were removed from Green Lane, near Stifford Clays Road, on the Site.

17th April 1941

2No. PMs fell on Hall Farm, on the Site.

19th April 1941

1No. HE bomb fell south of Grove Farm, South Ockendon, on the Site. It was recorded as UXB.

HE bombs (unspecified number) fell on Hall Farm, on the Site.

HE bombs fell between Tilbury Laundry and Ferry Road, Tilbury, on the Site.

20th April 1941

2No. HE bombs fell north of West Street, South Ockendon, on the Site. They were recorded as UXB.

1No. HE bomb fell 500yds north of South Ockendon Railway Station, on the Site.

IBs fell on South Ockendon, on the Site.

IBs fell on East Tilbury Marshes, including the Site.

23rd June 1941

1No. HE bomb fell on Grays Corner on the Site. It was recorded as UXB and removed.

30th July 1942

3No. UXBs were removed from a field north of Orsett Camp, on the Site.

23rd December 1942

1No. UXB was discovered near the Old Rectory, East Tilbury, on the Site.

4th January 1943

1No. HE bomb fell on the Bata Shoe Factory, on the Site. It was recorded as UXB.

4th March 1943

1No. HE bomb fell 250yds north of Black Cottages, Hornsby Lane, Orsett Heath on the Site. It was recorded as UXB.

3No. Anti-Personnel Bombs (APB) fell south of Grays Corner, on the Site. They were recorded as Unexploded APBs (UXAPB) and removed.

1No. APB and several IBs fell on Whitecrofts Farm, Orsett, on the Site.

1No. APB fell 100yds southeast of Potash Cottages, on the Site.

1No. APB fell in a field north of Long Lane, near Grays Corner, on the Site. It was recorded as a UXAPB and removed.

9th March 1943

1No. UXAPB was discovered on Baker Street, Orsett, on the Site.

2nd April 1943

1No. APB fell 100yds west of Orsett Heath, on the Site.

3rd April 1943

1No. HE bomb fell 300yds south of the entrance to Heath Place Farm, Orsett Heath, on the Site.

5th April 1943

2No. Armour-Piercing Incendiary (API) bombs and 1No. HE bomb fell 75yds west of Grays Corner, on the Site. They were recorded as UXB and removed.

17th April 1943

1No. HE bomb fell on the Old Rectory, Fen lane, on the Site.

8th May 1943

5No. Firepot IBs fell on Orsett Heath, on the Site.

13th May 1943

1No. HE bomb fell in a wheatfield 300yds east of Health Place Farm, on the Site. It was recorded as UXB.

17th May 1943

1No. HE bomb fell on East Tilbury, on the Site.

6th June 1943

1No. HE bomb on open ground at Botany Farm, on the Site.

7th October 1943

1No. HE bomb fell on the carriage sidings at Tilbury Riverside Station, on the Site.

18th October 1943

2No. HE bombs fell on Orsett Heath, on the Site.

23rd October 1943

1No. HE bomb fell on Hall Farm, South Ockendon, on the Site.

25th October 1943

2No. HE bombs fell near Goshems Farm, East Tilbury, on the Site.

2nd November 1943

1No. HE bomb fell on Chantry Farm, on the Site.

1No. HE bomb fell on Springfield Farm, Baker Street, on the Site.

HE bombs (unspecified number) fell on East Tilbury, on the Site.

3rd November 1943

HE bombs (number unspecified) fell over a widespread area, including East Tilbury and Orsett, on the Site.

22nd January 1944

702No. IBs fell on Orsett Golf Course, on the Site. In excess of 100No. of these were recorded as UXIB.

29th January 1944

1No. UXPhIB was discovered 60yds northeast of the Gatekeeper's Cottage at Bata Halt, East Tilbury, on the Site.

30th January 1944

1No. HE fell to the southeast of a signal box, Tilbury, on the Site.

1No. HE bomb and several IBs fell on Coalhouse Fort, East Tilbury, on the Site.

IBs fell on Orsett Heath, including the Site.

4th February 1944

1No. HE bomb fell on Fort Road, Tilbury, on the Site.

IBs fell on Tilbury Hotel, on the Site, causing extensive damage, on the Site.

21st February 1944

HE bombs and IBs fell on South Ockendon and Tilbury, within approximately 2km of the Site.

23rd February 1944

1No. IB fell 250yds southeast of the windmill, South Ockendon, on the Site.

18th March 1944

1No. HE bomb fell 130yds southwest of Linford Police House, on the Site. It was recorded as UXB.

1No. HE bomb landed in a wheatfield, East Tilbury, on the Site. It was recorded as UXB.

19th April 1944

5No. HE bombs fell at the Halt, East Tilbury, on the Site.

Several IBs fell on Dock Road, within approximately 80m north of the Site.

16th June 1944

1No. V1 fell 300yds north of Orsett Cock and 200yds west of Brentwood Road, on the Site.

16th August 1944

1No. V1 fell on East Tilbury Marshes, on the Site.

8th October 1944

1No. V1 fell on open ground near Linford, on the Site.

24th October 1944

1No. V1 fell near Castle Farm, Bulphan, on the Site.

11th November 1944

1No. V1 fell north of Arterial Road, Great Warley, on the Site.

15th November 1944

1No. V2 fell in the River Thames, near Surridges Jetty, in close proximity to the Site. It was recorded as a UXV2.

17th November 1944

1No. V1 fell on Orsett Fen, on the Site.

4th December 1944

1No. V2 fell on the sidings, east of Tilbury Riverside Station, on the Site boundary.

9th January 1945

1No. V2 fell north of Mollands Lane, on the Site.

13th January 1945

1No. V2 fell on open ground in Low Street, on the Site.

21st February 1945

1No. V2 fell 800yds north of Grange Farm, on the Site.

10th March 1945

1No. V2 fell southwest of Middle Farm, on the Site.

17th March 1945

1No. UXB was discovered on Fairplay Field, east of Clay Tye Road, North Ockendon, on the Site.

Southern part of the Site

20th April 1940

1No. HE bomb fell on Pepper's Hill Power Station, approximately 0.1km west of the Site.

1st August 1940

3No. HE bombs fell in the River Thames between Tilbury and Coalhouse point, on the Site.

28th August 1940

Several IBs fell on open fields at Westfield Sole, on the Site.

2nd September 1940

11No. HE bombs fell on RAF Gravesend, on the Site.

18No. HE bombs fell on fields along Thong Lane, approximately 0.1km east of the Site. 1No. of these was recorded as UXB.

5th September 1940

1No. HE bomb fell on Toll Gate, Watling Street, on the Site.

7th September 1940

1No. HE bomb fell on Cobham Park Golf Course, on the Site. This was recorded as UXB.

9th September 1940

1No. HE bomb fell on Cobham, on the Site.

11th September 1940

2No. HE bombs fell on open ground south of Chalk Road, on the Site. These were recorded as UXBs.

20th September 1940

1No. HE bomb fell on Cobham Park Golf Course, on the Site.

21st September 1940

2No. HE bombs fell on a field east of Lisle Castle, on the Site.

1No. HE bomb fell on open ground north of Gravesend Road, on the Site.

22nd September 1940

2No. HE bombs fell on open ground near St Mary's Church, Great Warley, approximately 0.1km east of the Site.

23rd September 1940

4No. HE bombs fell on open ground, Lower Shorne, on the Site.

1No. fell on open ground near RAF Gravesend, on the Site.

24th September 1940

1No. HE bomb fell on North Kent railway line, Gravesend, on the Site.

4No. HE bombs fell on open ground northwest of Shorne, on the Site. These were recorded as UXBs.

1No. HE bomb fell on the training ship HMS Cornwall, River Thames, on the Site.

3No. HE bombs fell on grounds of Denton Isolation Hospital, approximately 0.1km north of the Site. 1No. of these was recorded as UXB.

15No. HE bombs fell between Watling Street on the Site, and the entrance of Northumberland Bottom Camp, approximately 0.2km south of the Site.

27th September 1940

Several IBs fell on Northumberland Bottom Camp, approximately 0.2km south of the Site.

2nd October 1940

1No. HE bomb fell on open ground north of London Road, Thong, on the Site.

3rd October 1940

Several IBs fell between East Court Farm and Filborough Marshes, on the Site.

Several IBs fell on RAF Gravesend on the Site.

Several IBs fell on open ground near Gravesend Road, approximately 0.1km south of the Site.

6th October 1940

2No. HE bombs fell on open ground east of Denton Hospital, on the Site.

8th October 1940

1No. HE bomb fell on open ground south of North Kent Railway Line, on the Site.

10th October 1940

1No. HE bomb fell on open ground, Shorne, on the Site.

11th October 1940

3No. OBs fell on RAF Gravesend, on the Site.

16th October 1940

Several IBs fell on Bourne Road, on the Site.

18th October 1940

Several IBs fell between Walmer Avenue on the Site, and Crutches Lane, approximately 0.3km north of the Site.

20th October 1940

1No. HE bomb fell on the runway outside the main hanger, RAF Gravesend, on the Site.

21st October 1940

1No. HE bomb fell on Walting Street, Thong, on the Site. This was recorded as UXB.

22nd October 1940

4No. HE bombs and 1No. OB fell on Claylane Woods, Thong, on the Site.

1No. HE bomb fell on Tunbury Avenue, Westfield Sole, adjacent to the northern boundary of the Site.

23rd October 1940

1No. HE bomb fell at 59 and 61 Thong Lane, adjacent to the western boundary of the Site.

Several IBs fell on Chalk, on the Site.

Several HE bombs fell on Thong Lane, Chalk, approximately 0.1km southeast of the Site.

27th October 1940

1No. HE bomb fell on open ground near Lower Bell Inn, on the Site.

3No. HE bombs fell on open ground northeast of Pilgrims Way, approximately 0.3km north of the Site.

31st October 1940

1No. HE bomb fell on open ground near Watling Street, Gravesend, approximately 0.1km south of the Site.

1st November 1940

Several IBs fell on RAF Gravesend, on the Site.

3rd November 1940

3No. HE bombs fell on open ground north of Northern Railway Line, on the Site.

4th November 1940

2No. HE bombs fell on the Warren, Shorne, approximately 0.1km northwest of the Site.

5th November 1940

2No. HE bombs fell on Cheney Farm, Thong Lane, on the Site.

1No. HE bomb fell on grounds of Denton Isolation Hospital, approximately 0.1km north of the Site.

14No. HE bombs fell between Shornemead Fort, approximately 0.3km southeast of the Site, and Great Grabble Woods, approximately 2km north of the Site.

6th November 1940

8No. HE bombs fell on open ground near Gravesend Road, on the Site.

15th November 1940

1No. HE bomb fell on open ground south of Watling Street, on the Site.

20th November 1940

6No. HE bombs fell on Filborough Marshes, on the Site. 5No. of these were recorded as UXBs.

24th November 1940

Several IBs fell on Singlewell, Gravesend, approximately 0.2km northeast of the Site.

8th December 1940

Several IBs fell on open ground near Lower Higham Road, Lower Shorne, on the Site.

19th December 1940

1No. HE bomb fell on fields near Gads Hill Farm, Highham, approximately 0.1km south of the Site. This was recorded as UXB.

20th December 1940

8No. HE bombs fell on open ground near Gads Hill Farm, approximately 0.1km south of the Site.

11th January 1941

1No. HE bomb fell on West Park, on the Site.

23rd February 1941

15No. HE bombs fell on woodland near Harp Farm, Boxley, on the Site.

15th March 1941

2No. HE bombs fell on open ground near Thong Lane, on the Site.

2No. HE bombs fell on open ground near Thong Lane, on the Site.

1No. HE bomb fell on the junction of Thong Lane and A226, on the Site.

1No. HE bomb fell on field at Chalk, on the Site.

1No. HE bomb fell on the rear 58 Chalk Road, on the Site.

1No. HE bomb fell on Chalk Vicarage, on the Site.

1No. HE bomb fell on rear garden, Chalk Road, on the Site. This was recorded as UXB.

Several IBs fell on West Park, on the Site.

19th April 1941

1No. HE bomb fell on Pepper Hill Power Station, approximately 0.1km west of the Site.

1No. HE bomb fell on Hall Road, Northfleet, approximately 0.1km north of the Site.

20th April 1941

3No. HE bombs fell on Church Lane, Chalk, on the Site.

2No. HE bombs fell on open ground near Church Lane, Chalk, on the Site.

1No. HE bomb fell on Thong Lane, on the Site.

21st April 1941

2No. HE bombs fell on open ground near Gravesend Road, on the Site.

1No. HE bomb fell on open ground north of Lower Higham Road, on the Site.

25th April 1941

1No. HE bomb fell on a field near water works, Codham Lane, approximately 0.1km east of the Site. This was recorded as UXB.

26th April 1941

2No. HE bombs fell on Brewers Wood, Shorne, on the Site.

23rd June 1941

2No. PMs fell on Gads Hill, approximately 0.1km south of the Site.

27th June 1941

1No. HE bomb fell on New Fish Pond, Watling Street, on the Site.

1No. HE bomb fell on open ground near Higham, approximately 0.1km north of the Site.

4th July 1943

1No. HE bomb fell on Henhurst Cottages, Henhurst Road, on the Site.

21st October 1943

3No. HE bombs fell on open ground near Shorne Ifield Road, on the Site.

31st December 1943

1No. HE bomb fell on a field opposite the Crown Garage, Gravesend Road, approximately 50m north of the Site.

22nd January 1944

Several IBs fell on the south-eastern part of RAF Gravesend, on the Site.

4th February 1944

1No. HE bomb fell on the Gravesend Sewage Works, approximately 0.1km south of the Site. This was recorded as UXB.

24th February 1944

1No. HE bomb fell on a field at Queen's Farm, Shorne, approximately 0.1km east of the Site.

2nd March 1944

1No. HE bomb fell on West Court Farm, Denton, approximately 0.1km west of the Site. This was recorded as UXB.

Several IBs fell on the eastern/western runway of RAF Gravesend, on the Site. An unspecified number of these were recorded as UXIBs.

21st June 1944

3No. HE bombs fell on Claylane Wood, Thong, on the Site. These were recorded as UXBs.

3rd August 1944

1No. HE bomb fell east of RAF Gravesend, on the Site. This was recorded as UXB.

1No. V1 fell on Nissen Hut, Shorne, on the Site.

16th August 1944

1No. V1 fell on a barrage balloon over the River Thames, on the Site.

17th August 1944

1No. HE bomb fell on Eastcourt Marshes, on the Site. This was recorded as UXB.

21st August 1944

1No. HE bomb fell on open ground south of Lower Higham Road, on the Site. This was recorded as UXB.

10th March 1945

1No. UXB was recovered on open ground south of Watling Street, adjacent to the southern boundary of the Site.

Appendix 7 Bibliography

- Baxter G G, Owen K A and Badlock P, Aircraft Casualties in Kent Part I: 1939 to 1940, 1990
- Birtles P, World War 2 Airfields, 1999
- Bodleian Library, German Invasion Plans for the British Isles 1940, 2007
- Bowyer JF M, Action Stations Revisited: The complete history of Britain's military airfields: No. 2 Central England and the London Area, 2004
- Bulloch G, Steeds J E , Green K, Sainsbury M G, Brockwell J S & Slade N J, Land Contamination: Technical Guidance on Special Sites: MoD Land
- Burridge D, 20th Century Defences in Britain: Kent, 1997
- Bulloch G, Steeds J E, Green K, Sainsbury M G, Brockwell J S, & Slade N J, R&D Technical Report P5-042/TR/03, Land Contamination: Technical Guidance on Special Sites: Explosives Manufacturing & Processing Sites
- CIRIA, Unexploded Ordnance (UXO), a Guide for the Construction Industry, 2009
- Clarke N J, Luftwaffe Target Reconnaissance, German aerial Photography 1939-1942, 1996
- Clarke N J, Adolf's British Holiday Snaps: Luftwaffe Aerial Reconnaissance Photographs of England, Scotland and Wales, 2012
- Cocroft W D, Dangerous Energy, 2000
- Cocroft W D, Thomas R J, Cold War, 2003
- Collier B, The Defence of the United Kingdom, 1957
- CONWEP, Army TM5-855-1/Airforce AFPAM 32-1147(I)/Navy NAVFAC P-1080/DSWA DAHSCWEMAN-97, 1997
- Department of the Environment, Sampling Strategies for Contaminated Land, Department of the Environment: Contaminated Land Research Report, CLR Report No. 4, 1994.
- Dobinson C S, Twentieth Century Fortifications in England, Volume I 1, Anti-aircraft artillery, England's air defence gun sites. 1914 – 46. Council for British Archaeology, 1996
- Dobinson C S, Twentieth Century Fortifications in England, Volume I 2, Anti-aircraft artillery, Site gazetteer, WWI. Council for British Archaeology, 1996
- Dobinson C S, Twentieth Century Fortifications in England, Volume I. 3. Anti-aircraft artillery, 1914-46, Site gazetteer, WWII HAA & ZAA. Council for British Archaeology, 1996
- Dobinson C S, Twentieth Century Fortifications in England, Volume I 4, Anti-aircraft artillery, Site gazetteer, WWII LAA. Council for British Archaeology, 1996
- Dobinson C S, Twentieth Century Fortifications in England, Volume I 5, Anti-aircraft artillery, Sources. Council for British Archaeology, 1996
- Dobinson C S, Twentieth Century Fortifications in England, Volume II, Anti-invasion defences of WWII. Council for British Archaeology, 1996
- Dobinson C S, Twentieth Century Fortifications in England, Volume III, Bombing decoys of WWII, England's passive air defence 1939-45. Council for British Archaeology, 1996
- Dobinson C S, Twentieth Century Fortifications in England, Volume VIII, Civil defence in WWII, Protecting England's Civil Population. Council for British Archaeology, 1996

- Dobinson C S, Twentieth Century Fortifications in England, Supporting paper AA/1 Searchlight sites in WWII. Council for British Archaeology, 1996
- Dobinson C S, Fields of Deception, Britain's Bombing Decoys of World War II, 2000
- Dobinson C S, AA Command, 2001
- Fegan T, The Baby Killers, 2002
- Foley M, Front-Line Thames, 2008
- Foley M, Front-Line Essex, 2005
- Front Line 1940-41, The Official Story of the Civil Defence of Britain, 1942
- Groves C, The Home Guard of Britain, 1943
- Gulvin K R, Kent Home Guard, 1980
- Halpenny B B, Action Stations Military Airfields of Greater London, 1993
- Innes G B, British Airfields of the Second World War, 1995
- Ogley B, Kent at War: The Unconquered County 1939-1945, 1994
- Osborne M, Defending Britain, Twentieth-Century Military Structures in the Landscape, 2004
- Ramsey W, The Blitz Then and Now, Vol 2, 1988
- Ramsey W, The Blitz Then and Now, Vol 3, 1990
- Rawson A, British Army Handbook 1914-1918, 2006
- Reynolds R & Catton J, Thurrock goes to War, 1997
- Shephard R W & Cetti J, Royal Ordnance Future Systems Group Working Paper FSG/WP/47, 1987
- Smith D J, Britain's Military Airfields 1939-45, 1989
- Soulsby R & Clark S, Bed shear-stresses under combined waves and currents on smooth and rough beds, HR Wallingford Report TR137, 2006
- Tomes I M, Harmar O P & Thorne C R, Sediment Impact Analysis for the Lower Thames Flood Strategy, 2006
- Tomes I M, Proceedings of the Eighth Federal Interagency Sedimentation Conference (8thFISC), 2006
- Turner F, Gravesend Airport 1939 to 1945, 2000
- Turner F, Gravesend Bomb Damage in WW2, 2000
- Wyatt J R, Unexploded Bombs (UXB) in the Thames Marshes, 2000
- Wynn T, Your Towns & Cities in World War Two: Kent at War 1939-45, 2019
- Zetica, ZeticaUXO Handbook: a guide to dealing with UXO during construction, 2018

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