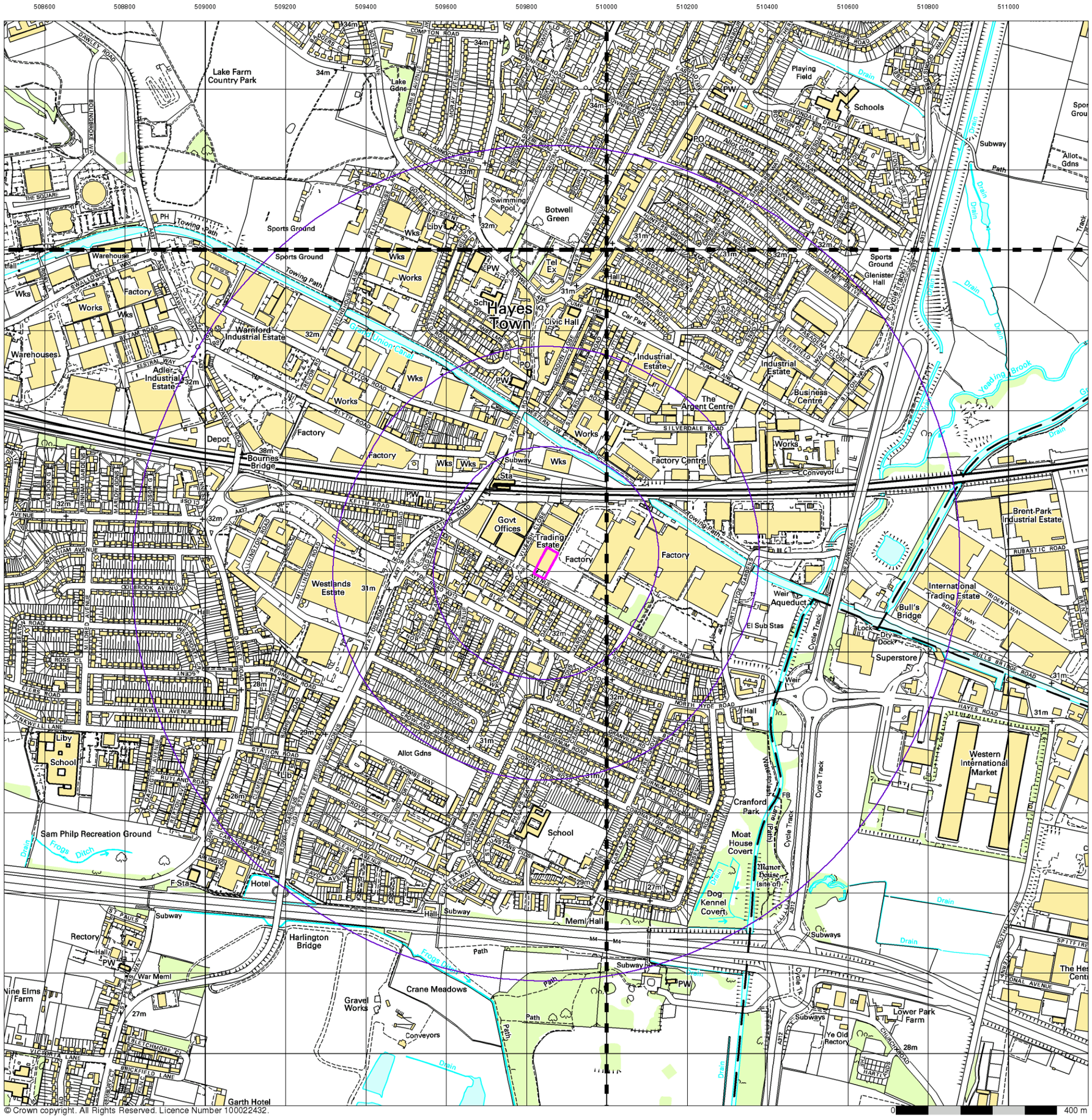


© Crown copyright. All Rights Reserved. Licence Number 100022432.

GEA

10k Raster Mapping

Published 2006

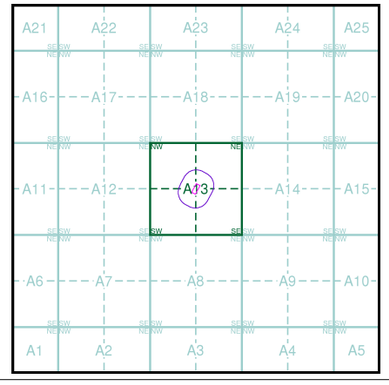
Source map scale - 1:10,000

The historical maps shown were produced from the Ordnance Survey`s 1:10,000 colour raster mapping. These maps are derived from Landplan which replaced the old 1:10,000 maps originally published in 1970. The data is highly detailed showing buildings, fences and field boundaries as well as all roads, tracks and paths. Road names are also included together with the relevant road number and classification. Boundary information depiction includes county, unitary authority, district, civil parish and constituency.

Map Name(s) and Date(s)

TQ08SE 2006 1:10,000	TQ18SW 2006 1:10,000
TQ07NE 2006 1:10,000	TQ17NW 2006 1:10,000

Historical Map - Slice A



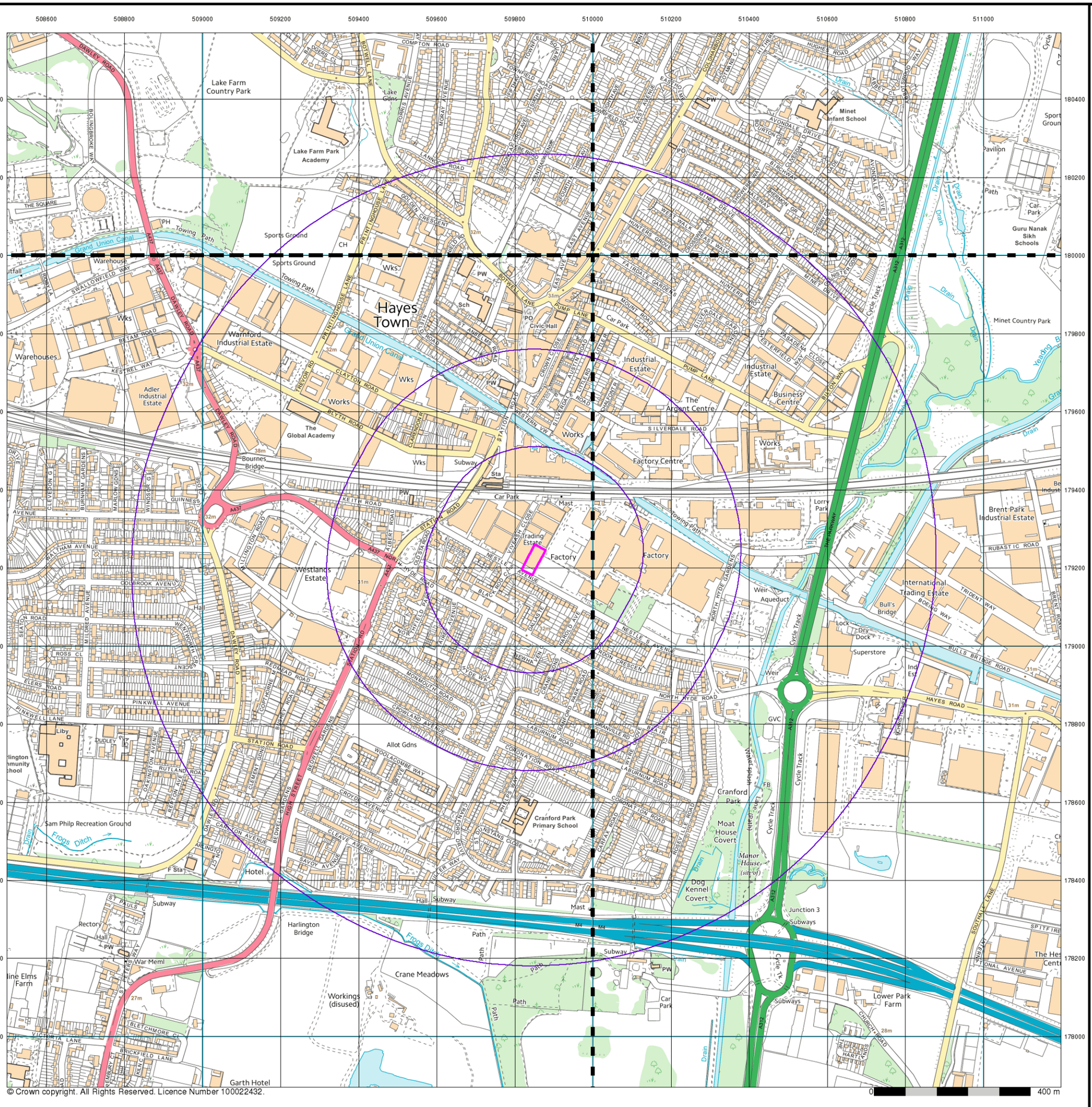
Order Details

Order Number:	175016424_1_1
Customer Ref:	J18167
National Grid Reference:	509850, 179220
Slice:	A
Site Area (Ha):	0.23
Search Buffer (m):	1000

Site Details

9 Nestles Avenue, Hayes, UB3 4SA

Landmark INFORMATION GROUP
Tel: 0844 844 9952
Fax: 0844 844 9951
Web: www.envirocheck.co.uk



© Crown copyright. All Rights Reserved. Licence Number 100022432.

GEA

VectorMap Local

Published 2018

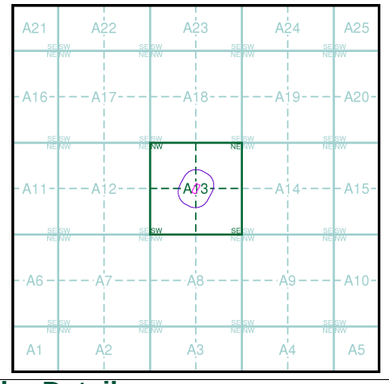
Source map scale - 1:10,000

VectorMap Local (Raster) is Ordnance Survey's highest detailed 'backdrop' mapping product. These maps are produced from OS's VectorMap Local, a simple vector dataset at a nominal scale of 1:10,000, covering the whole of Great Britain, that has been designed for creating graphical mapping. OS VectorMap Local is derived from large-scale information surveyed at 1:1250 scale (covering major towns and cities),1:2500 scale (smaller towns, villages and developed rural areas), and 1:10 000 scale (mountain, moorland and river estuary areas).

Map Name(s) and Date(s)

TQ08SE 2018 Variable	TQ18SW 2018 Variable
TQ07NE 2018 Variable	TQ17NW 2018 Variable

Historical Map - Slice A



Order Details

Order Number:	175016424_1_1
Customer Ref:	J18167
National Grid Reference:	509850, 179220
Slice:	A
Site Area (Ha):	0.23
Search Buffer (m):	1000

Site Details

9 Nestles Avenue, Hayes, UB3 4SA

Landmark INFORMATION GROUP

Tel: 0844 844 9952
Fax: 0844 844 9951
Web: www.envirocheck.co.uk

1st Line Defence Limited
Unit 3, Maple Park, Essex Road, Hoddesdon, Herts, EN11 0EX
Tel: +44 (0)1992 245 020
E-mail: info@1stlinedefence.co.uk
Company No: 7717863
VAT No: 128 8833 79

www.1stlinedefence.co.uk

Express Preliminary UXO Risk Assessment

Client	GEA Ltd
Project	Hayes & Harlington
Site Address	Hayes & Harlington, West London, UB3 4SH
Report Reference	EP5858-00
Date	11/01/18
Originator	EC

Assessment Objective

This preliminary risk assessment is a qualitative screening exercise to assess the likely potential of encountering unexploded ordnance (UXO) at the Hayes and Harlington site. The assessment involves the consideration of the basic factors that affect the potential for UXO to be present at a site as outlined in Stage One of the UXO risk management process.

Background

This assessment uses the sources of information available in-house to 1st Line Defence Ltd to enable the placement of a development site in context with events that may have led to the presence of German air-delivered or Allied military UXO. The report will identify any immediate necessity for risk mitigation or additional research in the form of a Detailed UXO Risk Assessment. It makes use of 1st Line Defence's extensive historical archives, library and unique geo-databases, as well as internet resources, and is researched and compiled by UXO specialists and graduate researchers.

The assessment directly follows CIRIA C681 guidelines "Unexploded Ordnance, a Guide for the Construction Industry". The document will therefore assess the following factors:

- Basic Site Data
- Previous Military Use
- Indicators of potential aerial delivered UXO threat
- Consideration of any Mitigating Factors
- Extent of Proposed Intrusive Works
- Any requirement for Further Work

It should be noted that the vast majority of construction sites in the UK will have a low or negligible risk of encountering UXO and should be able to be screened out at this preliminary stage. The report is meant as a common sense 'first step' in the UXO risk management process. The content of the report and conclusions drawn are based on basic, preliminary research using the information available to 1st Line Defence at the time this report was produced. It should be noted that the only way to entirely negate risk from UXO to a project would be to support the works proposed with appropriate UXO risk mitigation measures. It is rarely possible to state that there is absolutely 'no' risk from UXO to a project.

 © 1st Line Defence Limited

Risk Assessment Considerations	
Site location and description/current use	The site is located in the London Borough of Hillingdon, in the west of London. Nestles Avenue borders the south-west of the site and Viveash Close defines the eastern border. An area of hard-standing ground, adjacent to a railway, borders the site to the north whilst the west of the site is adjacent to a commercial structure at the junction of Station Road and Nestles avenue. Recent aerial photography shows the site to be occupied by four distinct, large, commercial structures. Associated areas of hard-standing ground are also within the site, especially in the northern and southern areas of the site. The site is approximately centred on the OS grid reference: **TQ 0975279308**
Are there any indicators of current/historical military activity on/close to the site?	Evidence available at this preliminary stage indicates that the site lay within the bounds of National Filling Factory (NFF) No. 7. NFFs were created during WWI to supply munitions for the British military. Available records indicate that the Hayes facility assembled and filled a number of munitions, including artillery projectiles, fuzing, exploders and detonators. Further research is necessary to assess the impact of the site's position within the NFF and its impact upon the chance that the site was contaminated with items of explosive ordnance.
What was the pre- and post-WWII history of the site?	Historical OS mapping initially shows the site as being occupied with open ground, however 1938 map editions show a large structure in the western area of the site. The first available post-war map edition, dated 1963 – 1966, displays significant change within the site. Four large commercial structures are evident within the site in the approximate configuration that exists in the present day. One of the structures in the approximate centre of the site is labelled as an *Employment Exchange*.
Was the area subject to bombing during WWII?	During WWII the site was located within the Urban District of Hayes and Harlington which sustained a low-moderate density of bombing according to official Home Office statistics, with an average of 40.1 items of ordnance recorded per 1,000 acres. This was comprised of 189 high explosive (HE) bombs, 2 parachute mines, 8 oil bombs, 6 V-1 pilotless aircraft and 2 V-2 long range rocket bombs. This totalled 207 items across 5,160 acres. Available bomb mapping for the area does not display any bombing incidents directly within the site area. However bomb strikes are shown in a close proximity to the site, with incidents marked to the north-west and north-east of its location. This demonstrates the presence of bombing within the site's immediate vicinity.
Is there any evidence of bomb damage on/close to the site?	Available evidence suggests the presence of bomb damage within the site area. Available post-war low-resolution photography shows the site as being occupied with commercial structures, in a similar configuration to the present day. Of note is that the structure shown within the site in pre-war mapping, in the west of the area, is notably absent in this photograph. Whilst it cannot be confirmed at this stage, it is possible that the absence of this structure was caused by bomb damage. The site is also not covered by Middlesex County Council war damage mapping, as the map sheet that covers the site area has been lost since the cessation of the war.

 © 1st Line Defence Limited

To what degree would the site have been subject to access?	Due to the possibility the site sustained bomb damage, it cannot be concluded that the site area received a regular level of access throughout the war. It is therefore considered possible that an item of unexploded ordnance fell unnoticed within the site during the war.
To what degree has the site been developed post-WWII?	Discernible development within the site appears to have comprised of the reconstruction of the structure that formerly occupied the western area of the site. This development may have involved some intrusive works. The chance of encountering an item of unexploded ordnance is only considered to be mitigated at the exact location and depths of post-war excavations.
What is the nature and extent of the intrusive works proposed?	It is understood that no intrusive works are currently planned within the site area.

Summary and Conclusions

During WWII the site was located within the Urban District of Hayes and Harlington which sustained a low-moderate bombing density, with an average of 40.1 items of ordnance recorded per 1,000 acres according to official Home Office statistics. Available bombing records do not indicate the presence of any strikes directly within the site, but do display strikes close to the site to the north and north-west. Evidence available at this preliminary stage appears to suggest the presence of bomb damage within the site, as a structure evident in pre-war OS mapping is notably absent in available low-resolution post-war aerial photography. It is possible that the absence of this structure was caused by bomb damage. Due to this possibility, it cannot be concluded that the site received a regular level of access throughout the war. It is therefore considered possible that an item of unexploded ordnance could fall unnoticed within the site.

The site area also lies within the former bounds of National Filling Factory (NFF) No. 7, a WWI explosive ordnance production facility. Available evidence indicates that a range of ordnance was produced at the factory, including artillery projectiles, explosive caps, detonators and fuzing. The presence of this factory strongly indicates the presence of explosive ordnance storage, production or filling within the site area. Further research is necessary to evaluate the site's location within the NFF and its impact upon the chance of contamination from items of WWI explosive ordnance.

Recommendations

Given the findings of this preliminary report **further research** is recommended in the form of a **Detailed UXO Risk Assessment**.

Further research would involve the acquisition of additional resources, including local bombing records, records pertaining to the operation of NFF No.7, additional WWII-era aerial photography and other archival records. The attainment of these sources would aid in a more precise assessment of both the role of the site area during WWI and the site's condition during WWII.

Prior to or in lieu of a Detailed Assessment, it is recommended that appropriate UXO Risk Mitigation Measures are provided for intrusive works proposed.

If the client has any anecdotal or empirical evidence of UXO risk on site, please contact 1st Line Defence.

 © 1st Line Defence Limited

Detailed Unexploded Ordnance (UXO) Risk Assessment

Project Name	9 Nestles Avenue
Client	GEA Ltd
Site Address	9 Nestles Avenue, Hayes, UB3 4SA
Report Reference	DA5858-00
Date	27th July 2018
Originator	HS

Find us on Twitter and Facebook

Company No: 7717863 VAT No: 128 8833 79

www.1stlinedefence.co.uk

1st Line Defence Limited

Unit 3, Maple Park, Essex Road, Hoddesdon, Herts. EN11 0EX

Tel: +44 (0)1992 245 020 info@1stlinedefence.co.uk

Executive Summary

Site Location and Description

The site is located in the town of Hayes within the London Borough of Hillingdon. It is bordered by industrial structures in the north, hardstanding and vegetated waste ground in the east, Nestle Avenue in the south and a large industrial structure to the west. The site is currently occupied by two conjoined large industrial units fronted by a multi-storey office structure, associated access ways, with a hardstanding yard area in the south that extends to meet Nestles Avenue.

The site is approximately centred on the OS grid reference: **TQ 0985779230**.

Proposed Works

The nature and extent of proposed works on site were not available at the time of writing this report.

Geology and Bomb Penetration Depth

The British Geological Survey (BGS) map shows the bedrock geology of the site to be underlain by the Thames Group - clay, silt, sand and gravel of the Palaeogene Period. The superficial deposits are comprised of River Terrace Deposits (undifferentiated) - sand and gravel of the Quaternary Period.

Site specific geotechnical information was not available to 1st Line Defence at the time of the production of this report. An assessment of maximum bomb penetration depth can be made once such data becomes available, or by a UXO specialist during on-site support.

It should be noted that the maximum depth that a bomb could reach may vary across a site and will be largely dependent on the specific underlying geological strata and its density.

UXO Risk Assessment

1st Line Defence has assessed that there is a **Low Risk** from items of unexploded German aerial delivered ordnance, and an overall **Low-Medium Risk** from Allied ordnance on the site. This assessment is based on the following factors:

The Likelihood of German Aerial Delivered Ordnance Contamination

- During WWII, the Urban District of Hayes and Harlington sustained an overall low- moderate density bombing campaign, with an average of 40 items falling per 1,000 acres according to Home Office statistics. Bombing in the local area of Nestle Avenue can be attributed to its location, close to the capital and proximity to areas of local industry and the railway.
- Viable Luftwaffe targets were located in Uxbridge, and the borough was in proximity to major targets in London. Whilst London bomb census mapping does record strikes to have affected areas within the vicinity of the site, including a UXB in the Nestle Sports Field, no bombs are recorded to have fallen within the site boundary. Additionally, these strikes are accounted for in an MCC Log Book of Incidents for Hayes and Harlington, which report one bomb to have fallen on the Nestle Factory and a UXB to have landed in the Nestle Sports Field.
- Pre-war oblique aerial imagery highlights that the construction of the structure on site and those surrounding it was completed by 1939, rather than as the result of post war re-development following bomb damage.
- Similarly, post-war 1946 aerial imagery suggests that the site and bordering areas escaped serious bomb damage. No obvious signs of damage are visible in these areas, such as the presence of cratering, ruins, rubble or debris.
- At the start of WWII, the site was likely subject to a frequent level of regular access, owing to the industrial structures present on site, as well as the close proximity of the site to the Nestle Cocoa Factory Sports Field and residential properties. No evidence, such as damage or nearby bomb strikes, could be found to suggest that this access would have been significantly impeded over the course of the war, or that the ground cover present could have restricted evidence of UXO. Accordingly it is considered likely that frequent checks were maintained, and thus items of UXO would have been observed and reported.
- The conditions in which HAA or LAA projectiles may have fallen unnoticed within the site boundary are considered analogous to those regarding aerial delivered ordnance.

© 1st Line Defence Limited

UXO Risk Assessment

The Likelihood of Allied Ordnance Contamination

- During the WWI period, the site area was located within the boundary of the National Filling Factory No.7, and as such there is potential for contamination from items of allied ordnance to have occurred.
- Available records indicate that the factory was concerned with filling explosive material in a wide variety of ordnance items, in significant quantities during WWI, and later in the war also began to assemble components. Items filled include: HE and shrapnel shells, fuzes, detonators, small arms ammunition and exploders. All of these items were mass-produced in quantity throughout the war by some 10,000 workers.
- The site area was situated within the eastern section of the factory which is recorded to have dealt with the filling of fuzes, friction tubes and exploders. Two magazines are shown to have been located on site, surrounded by piled earth to insulate damage should an accident occur.
- Taking this into account, there is considered to be a residual risk from contamination of WWI-era military ordnance at the site. At the time it was likely not anticipated that the land would be later sold for civilian development, and consequently appropriate explosive ordnance disposal procedure was not always adhered to. It was not uncommon for excess or unwanted ordnance such as fuzes to be buried or burnt within the wider premises as a means of disposal. Records of such practice were rarely kept.
- Elements of the NFF, including the canteen and garages are recorded to have been used as an Instructional Factory in the inter-war period, with conversion work being carried out to convert the machinery so that it could be utilised in coach building and car manufacturing.

Risk of UXO Remaining

- The site was demolished and cleared in the inter-war period, as shown in historical OS mapping from 1934, which highlights the site area as vacant unoccupied land alongside the Nestle sports field. Such demolition, clearance and subsequent re-development is anticipated to have involved some significant intrusive work into the ground.
- Consequently, while the risk of contamination from the National Filling Factory is considered to have been significant, the residual risk of ordnance remaining is considered relatively low, due largely to the clearance and redevelopment work that has taken place.
- Significant clearance and redevelopment work is noted to have taken place on site in the interwar period, with the NFF having been cleared and returned to vacant unoccupied land by 1934 OS mapping. Oblique imagery shows an industrial structure to have been constructed on site by 1939. Post-WWII development has been minimal however, with the structure present on site being the same one observable in 1939.
- If UXO had contaminated the site following its WWI use as an NFF, the contamination is only likely to have been present at relatively shallow depths. The risk of UXO remaining is considered to have been mitigated at the location of and down to the depth of post-war foundations and excavations. It is considered likely that the whole site will have been subject to excavations to shallow depths as a result of post-war redevelopment.

Recommended Risk Mitigation Measures

The following risk mitigation measures are recommended to support the proposed works at the 9 Nestles Avenue site:

All Works

- Site Specific UXO Awareness Briefings to all personnel conducting intrusive works.

© 1st Line Defence Limited

Glossary

Abbreviation	Definition
AA	Anti-Aircraft
AFS	Auxiliary Fire Service
AP	Anti-Personnel
ARP	Air Raid Precautions
AWAS	Air Warfare Analysis Section
DA	Delay-action
EOC	Explosive Ordnance Clearance
EOD	Explosive Ordnance Disposal
FP	Fire Pot
GM	G Mine (Parachute mine)
HAA	Heavy Anti-Aircraft
HE	High Explosive
IB	Incendiary Bomb
LAA	Light Anti-Aircraft
LCC	London County Council
LRRB	Long Range Rocket Bomb (V-2)
LSA	Land Service Ammunition
MOL	Molotov (Incendiary Bomb)
OB	Oil Bomb
PAC	Pilotless Aircraft (V-1)
PB	Phosphorous Bomb
PM	Parachute Mine
POW	Prisoner Of War
RAF	Royal Air Force
RCAF	Royal Canadian Air Force
RFC	Royal Flying Corps
RNAS	Royal Naval Air Service
ROF	Royal Ordnance Factory
SA	Small Arms
SAA	Small Arms Ammunition
SD1000	1,000kg high explosive bomb
SD2	Anti-personnel “Butterfly Bomb”
SIP	Self-Igniting Phosphorous
U/C	Unclassified bomb
UP	Unrotated Projectile (rocket)
USAAF	United States Army Air Force
UX	Unexploded
UXAA	Unexploded Anti-Aircraft
UXB	Unexploded Bomb
UXO	Unexploded Ordnance
V-1	Flying Bomb (Doodlebug)
V-2	Long Range Rocket
WAAF	Women’s Auxiliary Air Force
X	Exploded

© 1st Line Defence Limited

Contents

Executive Summary ..... **II**
Glossary ..... **IV**
Contents ..... **V**
Annexes ..... **VII**
1. Introduction **8**
1.1. Background *8*
2. Method Statement **1**
2.1. Report Objectives *1*
2.2. Risk Assessment Process *1*
2.3. Sources of Information *1*
2.4. General Considerations of Historical Research *2*
3. Background to Bombing Records **2**
4. Background to Allied Records **2**
5. UK Regulatory Environment **3**
5.1. General *3*
5.2. CDM Regulations 2015 ..... *3*
5.3. The 1974 Health and Safety at Work etc. Act *3*
5.4. Additional Legislation *3*
6. Role of Commercial UXO Contractors and The Authorities **3**
6.1. Commercial UXO Contractors *4*
6.2. The Authorities *4*
7. The Site **4**
7.1. Site Location *4*
7.2. Site Description *4*
8. Scope of the Proposed Works **5**
8.1. General *5*
9. Ground Conditions **5**
9.1. General Geology *5*
9.2. Site Specific Geology *5*
10. Site History **5**
10.1. Introduction *5*
10.2. Ordnance Survey Historical Maps *5*
10.3. Historical Photographs of the Site *6*
11. Aerial Bombing Introduction **6**
11.1. General *6*
11.2. Generic Types of WWII German Aerial-delivered Ordnance *7*
11.3. Failure Rate of German Aerial-delivered Ordnance *7*
11.4. V-Weapons *8*
12. UXB Ground Penetration **8**
12.1. General *8*
12.2. The J-Curve Effect *8*
12.3. WWII UXB Penetration Studies *8*
12.4. Site Specific Bomb Penetration Considerations *9*

© 1st Line Defence Limited

13. Initiation of Unexploded Ordnance 9
13.1. General 9
13.2. UXB Initiation Mechanisms 9
13.3. Effects of Detonation 9
14. The Risk from German Aerial Delivered UXBs 10
14.1. World War I 10
14.2. World War II Bombing of Hayes and Harlington 10
14.3. WWII Home Office Bombing Statistics 11
14.4. London Civil Defence Region ARP Bomb Census Maps 11
14.5. Hayes and Harlington Bomb Census Reports 12
14.6. Middlesex County Council Log of Air Raid Incidents for Hayes/Harlington 12
14.7. Hayes and Harlington File of Air Raids 12
14.8. Hayes and Harlington Register of Unexploded Bombs and Shells 13
14.9. Middlesex County Council War Damage Map 13
14.10. WWII-Era Aerial Photography 13
14.11. Abandoned Bombs 14
14.12. Bomb Disposal Tasks 14
14.13. Evaluation of German Aerial Delivered UXB Risk 14
15. The Risk from Allied Ordnance 16
15.1. Introduction 16
15.2. History of National Filling Factory No.7 16
15.3. WWI-era 16
15.4. Post-WWI 17
15.5. Filling Production 17
15.6. Site Plans 18
15.7. Quality of Historical Record 18
16. Examples of Types of Explosive Ordnance Found at Historical Military Sites 18
16.1. General 18
16.2. National Filling Factory No.7 Production Line 18
16.3. Small Arms Ammunition 19
16.4. Land Service Ammunition 19
16.5. Defending the UK From Aerial Attack 20
16.6. Anti-Aircraft Artillery (AAA) 20
16.7. Evaluation of Allied Ordnance Risk 21
17. Ordnance Clearance and Post-WWII Ground Works 23
17.1. General 23
17.2. UXO Clearance 23
17.3. Post-WWI and WWII Redevelopment 23
18. 1st Line Defence Risk Assessment 24
18.1. Risk Assessment Stages 24
18.2. Assessed Risk Level 26
19. Proposed Risk Mitigation Methodology 27
19.1. General 27
Bibliography 28

© 1st Line Defence Limited

Annexes

List of Report Annexes	
Annex A	Site Location Maps
Annex B	Recent Aerial Photography
Annex C	Client Provided Site Plan
Annex D	Pre and Post-WWII Historical Maps
Annex E	1935 and 1939 Oblique Imagery
Annex F	Example of UXO Entry Holes
Annex G	Examples of German Aerial Delivered Ordnance
Annex H	Examples of UXO Incidents
Annex I	WWI Map of Air Raids in London
Annex J	London WWII Bomb Density Map
Annex K	Luftwaffe Reconnaissance Imagery
Annex L	London Civil Defence Region ARP Bomb Census Mapping
Annex M	London Civil Defence Region V-1 Flying Bomb Map
Annex N	Hayes and Harlington Bomb Incident Records
Annex O	1946 RAF Aerial Photography of the Site
Annex P	Examples of Anti-Aircraft Projectiles
Annex Q	Ministry of Labour Correspondence Records
Annex R	Site Plans of NFF No.7 Hayes
Annex S	Examples of Ordnance Produced at NFF No.7 Hayes
Annex T	Examples of Land Service Ammunition
Annex U	Examples of Anti-Aircraft Projectiles

© 1st Line Defence Limited

1st Line Defence Limited
Detailed Unexploded Ordnance (UXO) Risk Assessment

Site: 9 Nestles Avenue, Hayes
Client: GEA

1. Introduction

1.1. Background

1st Line Defence has been commissioned by GEA to conduct a Detailed Unexploded Ordnance (UXO) Risk Assessment for the proposed works at 9 Nestles Avenue, Hayes.

Buried UXO can present a significant risk to construction works and development projects. The discovery of a suspect device during works can cause considerable disruption to operations as well as cause unwanted delays and expense.

UXO in the UK can originate from three principal sources:

1. Munitions resulting from wartime activities including German bombing in WWI and WWII, long range shelling, and defensive activities.
2. Munitions deposited as a result of military training and exercises.
3. Munitions lost, burnt, buried or otherwise discarded either deliberately, accidentally, or ineffectively.

This report will assess the potential factors that may contribute to the risk of UXO contamination. If an elevated risk is identified at the site, this report will recommend appropriate mitigation measures, in order to reduce the risk to as low as is reasonably practicable. Detailed analysis and evidence will be provided to ensure an understanding of the basis for the assessed risk level and any recommendations.

This report complies with the guidelines outlined in *CIRIA C681*, 'Unexploded Ordnance (UXO) A Guide for the Construction Industry'.

© 1st Line Defence Limited

2. Method Statement

2.1. Report Objectives

The aim of this report is to conduct a comprehensive assessment of the potential risk from UXO at 9 Nestles Avenue, Hayes. The report will also recommend appropriate site and work-specific risk mitigation measures to reduce the risk from explosive ordnance during the envisaged works to a level that is as low as reasonably practicable.

2.2. Risk Assessment Process

1st Line Defence has undertaken a five-step process for assessing the risk of UXO contamination:

1. The risk that the site was contaminated with UXO.
2. The risk that UXO remains on the site.
3. The risk that UXO may be encountered during the proposed works.
4. The risk that UXO may be initiated.
5. The consequences of initiating or encountering UXO.

In order to address the above, 1st Line Defence has taken into consideration the following factors:

- Evidence of WWI and WWII German aerial delivered bombing as well as the legacy of Allied occupation.
- The nature and conditions of the site during WWII.
- The extent of post-war development and UXO clearance operations on site.
- The scope and nature of the proposed works and the maximum assessed bomb penetration depth.
- The nature of ordnance that may have contaminated the proposed site area.

2.3. Sources of Information

Every reasonable effort has been made to ensure that relevant evidence has been consulted and presented in order to produce a thorough and comprehensible report for the client. To achieve this the following, which includes military records and archive material held in the public domain, have been accessed:

- The National Archives (Kew, England), London Metropolitan Archives and Hillingdon Archives
- Historical mapping datasets.
- Historic England National Monuments Record.
- Relevant information supplied by GEA Ltd.
- Available material from 33 Engineer Regiment (EOD) Archive.
- 1st Line Defence's extensive historical archives, library and UXO geo-datasets.
- Open sources such as published books and internet resources.

Research involved a visit to Hillingdon Archives, London Metropolitan Archives and The National Archives.

© 1st Line Defence Limited

2.4. General Considerations of Historical Research

This desktop assessment is based largely upon analysis of historical evidence. Every reasonable effort has been made to locate and present significant and pertinent information. 1st Line Defence cannot be held accountable for any changes to the assessed risk level or risk mitigation measures, based on documentation or other data that may come to light at a later date, or which was not available to 1st Line Defence during the production of this report.

It is often problematic and sometimes impossible to verify the completeness and accuracy of WWII-era records. As a consequence, conclusions as to the exact location and nature of a UXO risk can rarely be quantified and are to a degree subjective. To counter this, a range of sources have been consulted and analysed. The same methodology is applied to each report during the risk assessment process. 1st Line Defence cannot be held responsible for any inaccuracies or the incompleteness in available historical information.

3. Background to Bombing Records

During WWII bombing records were gathered by the police, Air Raid Precaution (ARP) wardens and military personnel. Records were maintained in the form of local and regional written records, maps depicting the locations of individual strikes, and maps indicating the levels of damage sustained by structures. Records typically documented when, where and what types of bombs had fallen during an air raid. Records of bomb strikes were made either through direct observation or by post-raid surveys. The immediate priority was focused on assisting casualties and minimising damage. As a result some records were incomplete and contradictory.

The quality, detail and nature of record keeping could vary considerably between boroughs and towns. No two areas identically collated or recorded data. While some local authorities maintained records with a methodical approach, sources in certain areas can be considerably more vague, dispersed, and narrower in scope. Many records were even damaged or destroyed in subsequent bombing raids. Records of raids that took place on sparsely or uninhabited areas were often based upon third party or hearsay information and are therefore not always reliable. Furthermore, records of attacks on military or strategic targets were often maintained separately from the general records and have not always survived.

4. Background to Allied Records

During WWII considerable areas of land were requisitioned by the War Office for the purpose of defence, training, munition production and the construction of airfields. Records relating to military features vary and some may remain censored. Within urban environments datasets will be consulted detailing the location of munition production as well as air and land defences. In rural locations it may be possible to obtain plans of airfields and military establishments, as well as operational training logs, plans and personal memoirs.

The level of detail available in records concerning explosives factories vary due to factors such as their size and importance. In addition, the exact details on the operations of such facilities are often difficult to ascertain for secrecy reasons. There is generally considered to be an elevated 'background' risk in areas defined by a large historic munitions presence. Whilst a wide range of records were consulted in order to determine the risk from items of Allied ordnance, a lack of detailed source availability can sometimes lead to an assumed level of risk from the presence of an ordnance factory. 1st Line Defence cannot be held responsible for inaccuracies or gaps in the available historical information.

© 1st Line Defence Limited

5. UK Regulatory Environment

5.1. General

There is no formal obligation requiring a UXO risk assessment to be undertaken for construction projects in the UK, nor is there any specific legislation stipulating the management or mitigation of UXO risk. However, it is implicit in the legislation outlined below that those responsible for intrusive works (archaeology, site investigation, drilling, piling, excavation etc.) should undertake a comprehensive and robust assessment of the potential risks to employees and that mitigation measures are implemented to address any identified hazards.

5.2. CDM Regulations 2015

The Construction (Design and Management) Regulations 2015 (CDM 2015) define the responsibilities of parties involved in the construction of temporary or permanent structures.

The CDM 2015 establishes a duty of care extending from clients, principle co-ordinators, designers, and contractors to those working on, or affected by, a project. Those responsible for construction projects may therefore be accountable for the personal or proprietary loss of third parties, if correct health and safety procedure has not been applied.

Although the CDM does not specifically reference UXO, the risk presented by such items is both within the scope and purpose of the legislation. It is therefore implied that there is an obligation on parties to:

- Provide an appropriate assessment of potential UXO risks at the site (or ensure such an assessment is completed by others).
- Put in place appropriate risk mitigation measures if necessary.
- Supply all parties with information relevant to the risks presented by the project.
- Ensure the preparation of a suitably robust emergency response plan.

5.3. The 1974 Health and Safety at Work etc. Act

All employers have a responsibility under the Health and Safety at Work etc. Act 1974 and the Management of Health and Safety at Work Regulations 1999, to ensure the health and safety of their employees and third parties, so far as is reasonably practicable and conduct suitable and sufficient risk assessments.

5.4. Additional Legislation

In the event of a casualty resulting from the failure of an employer/client to address the risks relating to UXO, the organisation may be criminally liable under the Corporate Manslaughter and Corporate Homicide Act 2007.

6. Role of Commercial UXO Contractors and The Authorities

© 1st Line Defence Limited

6.1. Commercial UXO Contractors

In the event that a risk of UXO contamination is detected at the proposed site, the support of a UXO specialist may be recommended. A UXO specialist may be able to avoid unnecessary call-outs to the authorities through the disposal or removal of low risk items. In addition a specialist will assist in the swift recognition of high risk items, and will thereafter co-ordinate with the local authority with the objective of causing minimal levels of disruption to site operations, whilst putting in place safe and appropriate measures.

For more information on the role of commercial UXO specialists, see *CIRIA C681*.

6.2. The Authorities

The police have a responsibility to co-ordinate the emergency services in the event of an ordnance-related incident at a construction site. Upon inspection they may impose a safety cordon, order an evacuation, and call the military authorities Joint Services Explosive Ordnance Disposal (JSEOD) to arrange for investigation and/or disposal. In the absence of a UXO specialist, police officers will usually employ such precautionary safety measures, thereby causing works to cease, and possibly requiring the evacuation of neighbouring businesses and properties.

The priority given to the police request will depend on JSEOD's judgement of the nature of the UXO risk, the location, people and assets at risk, as well as the availability of resources. The speed of response varies; authorities may respond immediately or in some cases it may take several days for the item of ordnance to be dealt with.

Depending on the on-site risk assessment the item of ordnance may be removed from the site and/or destroyed by a controlled explosion. The latter process is lengthy and may necessitate the establishment of addition cordons and evacuations.

Following the removal of an item of UXO, the military authorities will only undertake further investigations or clearances in high risk situations. If there are regular UXO finds on a site the JSEOD may not treat each occurrence as an emergency and will recommend the construction company puts in place alternative procedures, such as the appointment of a commercial contractor to manage the situation.

7. The Site

7.1. Site Location

The site is located in the town of Hayes within the London Borough of Hillingdon. It is bordered by industrial structures in the north, hardstanding and vegetated waste ground in the east, Nestle Avenue in the south and a large industrial structure to the west.

The site is approximately centred on the OS grid reference: **TQ 0985779230**.

Site location maps are presented in **Annex A**.

7.2. Site Description

The site is currently occupied by two conjoined large industrial units fronted by a multi-storey office structure, associated access ways, with a hardstanding yard area in the south that extends to meet Nestles Avenue.

© 1st Line Defence Limited

A recent aerial photograph and site plan are presented in **Annex B** and **Annex C** respectively.

8. Scope of the Proposed Works

8.1. General

The nature and extent of proposed works on site were not available at the time of writing this report.

9. Ground Conditions

9.1. General Geology

The British Geological Survey (BGS) map shows the bedrock geology of the site to be underlain by the Thames Group - clay, silt, sand and gravel of the Palaeogene Period. The superficial deposits are comprised of River Terrace Deposits (undifferentiated) - sand and gravel of the Quaternary Period.

9.2. Site Specific Geology

Site specific geotechnical data was not available during the production of this report.

10. Site History

10.1. Introduction

The purpose of this section is to identify the composition of the site pre and post-WWII. It is important to establish the historical use of the site, as this may indicate the site's relation to potential sources of UXO as well as help with determining factors such as the land use, groundcover, likely frequency of access and signs of bomb damage.

10.2. Ordnance Survey Historical Maps

Relevant historical maps were obtained for this report and are presented in **Annex D.** See below for a summary of the site history shown on acquired mapping.

WWI Period		
Date	**Scale**	**Description**
1914	1:2,500	This map shows the site to be situated within vacant unoccupied land, which is located to the south of an orchard lining the railway. A road is situated to the south of the site, with several terraced residential properties visible in the south-west.

Pre-WWII		
Date	**Scale**	**Description**
1934	1:2,500	This map edition shows the site area to be situated within an expansive area of open ground labelled as a *Sports Ground.* To the east of the site both a *Bowling Green* and *Tennis Courts* are situated with a *Cocoa Factory* noted further north-

© 1st Line Defence Limited

		east. To the south of the site, the road has now been labelled Nestles Avenue, with the opposite side being lined by a line of residential properties.

Post-WWII		
Date	**Scale**	**Description**
1963-1966	1:1,250	This map illustrates some significant structural changes to have taken place on site in the immediate post-war years. The site is now occupied by a large industrial structure, and is surrounded by *Government Offices* to the north. The *Sports Ground* is still situated to the east, with the *Tennis Courts* and *Bowling Green* occupying much the same footprint they had in pre-war mapping. Another large commercial structure is immediately adjacent to the site in the east, with a new road Viveash Close being constructed further east.

10.3. Historical Photographs of the Site

Historical photographs have been consulted from the Aerofilms collection available from Britain From Above. The following photographs provide a view of the site in 1935 and 1939 (see **Annex E**). See below for a description of this photography.

Title of Photograph	Comments
Nestles Avenue, The Nestle Cocoa Factory and environs, Hayes, 1935	This photo depicts the site from the south, highlighting its position within a football pitch on the Nestle Cocoa Factory sports field. Tennis courts and a bowling green are situated to the east of the site area, whilst detached residential properties are clearly observable on the southern side of Nestles Avenue.
Nestles Cocoa Factory, Hayes, from the north-east, 1939	This image captures the site area from the north-east, and clearly highlights development work has taken place on site. Two conjoined industrial structures fronted by a multi-storey office block and hardstanding ground has been recently constructed within in the site footprint. A multitude of other industrial structures have been constructed surrounding the site to the north and west. Fenced tennis courts are visible to the east of the site.

11. Aerial Bombing Introduction

11.1. General

During WWI and WWII, many towns and cities across the UK were subjected to bombing which often resulted in extensive damage to city centres, docks, rail infrastructure and industrial areas. The poor accuracy of WWII targeting technology and the nature of bombing techniques often resulted in neighbouring areas to targets sustaining collateral damage.

In addition to raids which concentrated on specific targets, indiscriminate bombing of large areas also took place, this occurred most prominently in the London 'Blitz', though affected many other towns and cities. As discussed in the following sections, a proportion of the bombs dropped on the UK did not detonate as designed. Although extensive efforts were made to locate and deal with these UXBs at the time, many still remain buried and can present a potential risk to construction projects.

© 1st Line Defence Limited

The main focus of research for this section of the report will concern German aerial delivered weapons dropped during WWII, although WWI bombing will also be considered.

11.2. Generic Types of WWII German Aerial-delivered Ordnance

An understanding of the type and characteristics of the ordnance used by the Luftwaffe during WWII allows an informed assessment of the hazards posed by any unexploded items that may remain in situ on a site.

Generic Types of WWII German Aerial Delivered Ordnance		
Type	**Frequency**	**Likelihood of detection**
High Explosive (HE) bombs	In terms of weight of ordnance dropped, HE bombs were the most frequently deployed by the Luftwaffe during WWII.	Although efforts were made to identify the presence of unexploded ordnance following an air raid, often the damage and destruction caused by detonated bombs made observation of UXB entry holes impossible. The entry hole of an unexploded bomb can be as little as 20cm in diameter and was easily overlooked in certain ground conditions (see **Annex F**). Furthermore, ARP documents describe the danger of assuming that damage, actually caused by a large UXB, was due to an exploded 50kg bomb. UXBs therefore present the greatest risk to present–day intrusive works.
Aerial or Parachute mines (PM)	There were deployed less frequently than HE and IBs due to size, cost and the difficulty of deployment.	If functioning correctly, PMs generally would have had a slow rate of descent and were very unlikely to have penetrated the ground. Where the parachute failed, mines would have simply shattered on impact if the main charge failed to explode. There have been extreme cases when these items have been found unexploded. However, in these scenarios, the ground was either extremely soft or the munition fell into water.
1kg Incendiary bombs (IB)	In terms of the number of weapons dropped, small IBs were the most numerous. Millions of these were dropped throughout WWII.	IBs had very limited penetration capability and in urban areas would often have been located in post-raid surveys. If they failed to initiate and fell in water, on soft vegetated ground, or bombed rubble, they could have gone unnoticed.
Large Incendiary bombs (IB)	These were not as common as the 1kg IBs, although they were more frequently deployed than PMs and AP bomblets.	If large IBs did penetrate the ground, complete combustion did not always occur and in such cases they could remain a risk to intrusive works.
Anti-personnel (AP) bomblets	These were not commonly used and are generally considered to pose a low risk to most works in the UK.	SD2 bomblets were packed into containers holding between 6 and 108 submunitions. They had little ground penetration ability and should have been located by the post-raid survey unless they fell into water, dense vegetation or bomb rubble.

Images and brief summaries of the characteristics of the above listed German aerial delivered ordnance are presented in **Annex G**.

11.3. Failure Rate of German Aerial-delivered Ordnance

It has been estimated that 10% of WWII German aerial delivered HE bombs failed to explode as designed. Reasons for why such weapons might have failed to function as designed include:

- Malfunction of the fuze or gain mechanism (manufacturing fault, sabotage by forced labour or faulty installation).
- Many were fitted with a clockwork mechanism that could become immobilised on impact.
- Failure of the bomber aircraft to arm the bombs due to human error or an equipment defect.
- Jettisoning the bomb before it was armed or from a very low altitude. This most likely occurred if the bomber aircraft was under attack or crashing.

From 1940 to 1945 bomb disposal teams dealt with a total of 50,000 explosive items of 50kg, over, 7,000 anti-aircraft projectiles and 300,000 beach mines. Unexploded ordnance is still regularly encountered across the UK, see press articles in **Annex H**.

© 1st Line Defence Limited

11.4. V-Weapons

Hitler's 'V-weapon' campaign began from mid-1944. It used newly developed unmanned cruise missiles and rockets. The V-1 known as the *flying bomb* or *pilotless aircraft* and the V-2, a long range rocket, were launched from bases in Germany and occupied Europe. A total of 2,419 V-1s and 517 V-2s were recorded in the London Civil Defence region alone.

Although these weapons caused considerable damage their relatively low numbers allowed accurate records of strikes to be maintained. These records have mostly survived. There is a negligible risk from unexploded V-weapons on land today since even if the 1000kg warhead failed to explode, the weapons are so large that they would have been observed and the risk dealt with at the time. Therefore, V-weapons are referenced in this report not as a viable risk factor, but primarily in order to help account for evidence of damage and clearance reported.

12. UXB Ground Penetration

12.1. General

An important consideration when assessing the risk from a UXB is the likely maximum depth of burial. There are several factors which determine the depth that an unexploded bomb will penetrate:

- Mass and shape of bomb.
- Height of release.
- Velocity and angle of bomb.
- Nature of the ground cover.
- Underlying geology.

Geology is perhaps the most important variable. If the ground is soft, there is a greater potential of deeper penetration. For example, peat and alluvium are easier to penetrate than gravel and sand, whereas layers of hard strata will significantly retard and may stop the trajectory of a UXB.

12.2. The J-Curve Effect

J-curve is the term used to describe the characteristic curve commonly followed by an aerial delivered bomb dropped from height after it penetrates the ground. Typically, as the bomb is slowed by its passage through underlying soils, its trajectory curves towards the surface. Many UXBs are found with their nose cone pointing upwards as a result of this effect. More importantly however is the resulting horizontal offset from the point of entry. This is typically a distance of about one third of the bomb's penetration depth, but can be up to 15m.

12.3. WWII UXB Penetration Studies

During WWII the Ministry of Home Security undertook a major study on actual bomb penetration depths, carrying out statistical analysis on the measured depths of 1,328 bombs as reported by bomb disposal (BD) teams. Conclusions were made as to the likely average and maximum depths of penetration of different sized bombs in different geological strata.

For example, the largest common German bomb (500kg) had a likely concluded penetration depth of 6m in sand or gravel but 11m in clay. The maximum observed depth for a 500kg bomb was 11.4m and for a 1,000kg bomb 12.8m. Theoretical calculations suggested that significantly greater penetration depths were probable.

© 1st Line Defence Limited

12.4. Site Specific Bomb Penetration Considerations

When considering an assessment of the bomb penetration at the site of proposed works the following parameters have been used:

- WWII geology – Thames Group - Clay, Silt, Sand and Gravel.
- Impact angle and velocity – 10-15° from vertical and 270 metres per second.
- Bomb mass and configuration – The 500kg SC HE bomb, without retarder units or armour piercing nose (this was the largest of the common bombs used against Britain).

It has not been possible to determine maximum bomb penetration capabilities at this stage due to the lack or limitations of site specific borehole geotechnical information. An assessment can be made once such information becomes available or by an UXO Specialist on-site.

13. Initiation of Unexploded Ordnance

13.1. General

Unexploded ordnance does not spontaneously explode. All high explosive filling requires significant energy to create the conditions for detonation to occur. In the case of unexploded German bombs discovered within the construction site environment, there are a number of potential initiation mechanisms.

13.2. UXB Initiation Mechanisms

UXB Initiation	
Direct Impact	Unless the fuze or fuze pocket is struck, there needs to be a significant impact e.g. from piling or large and violent mechanical excavation, onto the main body of the weapon to initiate a buried iron bomb. Such violent action can cause the bomb to detonate.
Re- starting the Clockwork Fuze	A small proportion of German WWII bombs employed clockwork fuzes. It is probable that significant corrosion would have taken place within the fuze mechanism over the last 70+ years that would prevent clockwork mechanisms from functioning. Nevertheless, it was reported that the clockwork fuze in a UXB dealt with by 33 EOD Regiment in Surrey in 2002 did re-start.
Friction Impact	The most likely scenario resulting in the detonation of a UXB is friction impact initiating the shock-sensitive fuze explosive. The combined effects of seasonal changes in temperature and general degradation over time can cause explosive compounds to crystallise and extrude out from the main body of the bomb. It may only require a limited amount of energy to initiate the extruded explosive which could detonate the main charge.

Annex H2 details incidents where intrusive works have caused items of UXO to detonate, resulting in death or injury and damage to plant.

13.3. Effects of Detonation

When considering the potential consequences of a detonation, it is necessary to identify the significant receptors that may be affected. The receptors that may potentially be at risk from a UXO detonation on a construction site will vary depending on the site specific conditions but can be summarised as follows:

© 1st Line Defence Limited

- People – site workers, local residents and general public.
- Plant and equipment – construction plant on site.
- Services – subsurface gas, electricity, telecommunications.
- Structures – not only visible damage to above ground buildings, but potentially damage to foundations and the weakening of support structures.
- Environment – introduction of potentially contaminating materials.

14. The Risk from German Aerial Delivered UXBs

14.1. World War I

During WWI Britain was targeted and bombed by Zeppelin Airships as well as Gotha and Giant fixed-wing aircraft. An estimated 250 tons of ordnance (high explosive and incendiary bombs) was dropped on Greater London, more than half of which fell on the City of London (see **Annex I** for a WWI bomb plot map of London). WWI maps detailing Zeppelin and Bomber raids in Greater London were consulted, yet no significant attacks were recorded to have directly affected the site area during the war.
WWI bombs were generally smaller than those used in WWII and were dropped from a lower altitude. This resulted in limited UXB penetration depths. Aerial bombing was often such a novelty at the time that it attracted public interest and even spectators to watch the raids in progress. For these reasons there is a limited risk that UXBs passed undiscovered in the urban environment. When combined with the relative infrequency of attacks and an overall low bombing density the risk from WWI UXBs is considered low and will not be further addressed in this report.

14.2. World War II Bombing of Hayes and Harlington

The Luftwaffe's main objective for the attacks on London was to inhibit the capital's commercial output. To achieve this they targeted the docks, warehouses, wharves, railway lines, factories and power stations. As the war progressed this strategy gradually changed to the indiscriminate bombing of civilian areas in an attempt to subvert public morale.

During WWII the site was located within the Urban District of Hayes and Harlington, which sustained an overall low-medium density of bombing, as represented by bomb density mapping presented in **Annex J**. This was mainly due to its location on the periphery of west London, which avoided the majority of the bombing campaigns focused on the central and eastern areas of the capital. However, Hayes and Harlington did still sustain regular bombing, with a number of targets identified in the wider surrounding area.

Uxbridge RAF depot, situated approximately 5.6km north-west of the site boundary, is highlighted on Luftwaffe reconnaissance photography (see **Annex K**) which confirms its status as a target. The depot was one of several RAF stations in the region – RAF Northolt, RAF Langley and RAF Heston were also situated in the surrounding area of the site. Another potential target not identified on Luftwaffe reconnaissance photography was RAF Heathrow, the modern day Heathrow Airport, situated approximately 3km south of the site boundary; the aerodrome was bombed on several occasions during WWII. Neighbouring areas would often be affected by the presence of such targets, largely due to the inaccuracy of aerial bombing on adjacent areas to avoid having to return to base with ordnance still on board – known as 'tip and run' raids. Much of the bombing on the region can be attributed to these potential targets and any bombing inflicted upon the civilian population.

Records of bombing incidents in the civilian areas of London were collected by the Air Raid Precautions wardens and collated by the Civil Defence Office. Some other organisations, such as port and railway authorities, maintained separate records. Records would be in the form of typed or hand written

© 1st Line Defence Limited

incident notes, maps and statistics. Bombing data was carefully analysed, not only due to the requirement to identify those parts of the country most needing assistance, but also in an attempt to find patterns in the Germans' bombing strategy in order to predict where future raids might take place.

Records of bombing incidents for the U.D. of Hayes and Harlington are presented in the following sections.

14.3. WWII Home Office Bombing Statistics

The following table summarises the quantity of German aerial delivered bombs (excluding 1kg incendiaries and anti-personnel bombs) dropped on Hayes and Harlington between 1940 and 1945.

Record of German Ordnance Dropped on the Urban District of Hayes and Harlington		
Area Acreage		**5,160**
Weapons	High Explosive bombs (all types)	189
	Parachute mines	2
	Oil bombs	8
	Phosphorus bombs	0
	Fire pots	0
	Pilotless aircraft (V-1)	6
	Long range rocket bombs (V-2)	2
Total		**207**
Number of Items per 1,000 acres		**40.1**

Source: Home Office Statistics
This table does not include UXO found during or after WWII.

Detailed records of the quantity and locations of the 1kg incendiary and anti-personnel bombs were not routinely maintained by the authorities as they were frequently too numerous to record. Although the risk relating to IBs is lesser than that relating to larger HE bombs, they were similarly designed to inflict damage and injury. Anti-personnel bombs were used in much smaller quantities and are rarely found today but are potentially more dangerous. Although Home Office statistics were not recorded, both types of item should not be overlooked when assessing the general risk to personnel and equipment.

14.4. London Civil Defence Region ARP Bomb Census Maps

During WWII, the ARP Department within the Research and Experiments Branch of the Ministry of Home Security produced consolidated, weekly and V-1 pilotless aircraft bomb census maps for the London Civil Defence Region. These maps collectively shows the approximate locations of bombs, mines and rockets. The site area was checked on each available map sheet, those showing bomb incidents on and in the immediate vicinity of the site are discussed below and are presented in **Annex L.**

London Consolidated Bomb Census Maps – Annex L1- L2	
Date Range	**Comments**
Bombing 1940, 1941 to 18th August 1943	No bomb strikes are recorded on site or in the immediate surrounding area of the site.

© 1st Line Defence Limited

Night Bombing up to 7th October 1940	No bomb strikes are recorded on site or in the immediate surrounding area of the site.
Day Bombing 8th October to 31st December 1940	No bomb strikes are recorded to have affected the site boundary, however one is plotted on the railway to the north-west in the vicinity of Hayes train station.
Night Bombing 7th October 1940 to June 1941	No bombs are recorded to have affected the site, however multiples bomb strikes are recorded in the vicinity. Three strikes are recorded to have affected the north and north-west of the site on the railway, with a further four recorded on the vicinity of the Nestle factory to the east, the closest strike being approximately 20m from the site boundary.

London Weekly Bomb Census Maps – Annex L3	
Date Range	**Comments**
7th to 14th October 1940	No bombs are plotted within or close to the site boundary. Four HE bombs are recorded to have affected the area to the east of the site, two of which are plotted to have fallen on the Nestle Cocoa Factory, with two plotted on open ground further to the west.
11th to 18th November 1940	No bombs are plotted to have affected the site. Three HE bombs are recorded to have fallen to the north of the site area on the railway, with a further HE recorded to the south-west.

V-1 Pilotless Aircraft Bomb Census Map – Annex M	
Date Range	**Comments**
1944-45	One V-1 flying bomb fell in the general area of the site Due to distance, this strike is not considered to have directly impacted the proposed site. Damage from V-1 weapons cannot be attributed to the site in question.

14.5. Hayes and Harlington Bomb Census Reports

Bomb census reports compiled by the Research and Experiments Branch of the Ministry of Home Security during WWII were consulted at The National Archives. These reports recorded information such as the date, time, type and damage caused by major bomb incidents in Hayes and Harlington and are therefore not often comprehensive. Whilst these records were consulted, no reference to the site area or its environs could be found.

14.6. Middlesex County Council Log of Air Raid Incidents for Hayes/Harlington

A log of air raid incidents likely compiled by information produced by local ARP wardens, volunteers and police officers for Middlesex County Council was consulted at London Metropolitan Archives. These reports recorded information such as the date, time, type and damage caused by bomb incidents in the Urban District of Hayes and Harlington.. A transcribed example of the records affecting the site area and the surrounding vicinity are presented below.

Middlesex County Council Log of Air Raid Incidents for Hayes and Harlington	
Date Range	**Comments**
10th October 1940	Minor bombing, HE on Nestle's Factory, Sandow Rd. 1 casualty.

14.7. Hayes and Harlington File of Air Raids

© 1st Line Defence Limited

This file from Hillingdon Archives was comprised of message forms that were relayed to headquarters, with requests and information on the condition of damaged properties. This record was compiled by local Air Raid Precaution (ARP) personnel and volunteers during the war. Though no reference was found to any bombs falling within the site boundary a transcript of the associated written records for bombs which fell in the vicinity of the site area is presented in the table below. Example imagery of these entries is presented in **Annex N**.

Hayes and Harlington Bomb Incident Records	
Date Range	**Comments**
10th October 1940	20:20pm- One HE bomb is recorded to have fallen on the Nestle Cocoa Factory. The report notes that '1 serious casualty' was sustained by this attack. A stretcher party was dispatched to attend to the casualty and left the depot at 20:46pm.
10th October 1940	22:05pm-A UXB is reported in the sports field of the Nestle Factory, which is alter confirmed.

14.8. Hayes and Harlington Register of Unexploded Bombs and Shells

A register complied by Hayes and Harlington Civil Defence personnel detailing unexploded bomb (UXB) and shell incidents to have affected this district was consulted at Hillingdon Archives. Though no reference was found to any bombs falling within the site boundary a transcript of the associated written records for bombs which fell in the vicinity of the site area is presented in the table below.

Hayes and Harlington Register of Unexploded Bombs and Shells	
Date Range	**Comments**
10th October 1940	20:30pm- 1 HE Nestle Factory Sports Field. Police report exploded bomb crater, bomb disposed of.

14.9. Middlesex County Council War Damage Map

Map sheets compiled by Middlesex County Council (MCC) showing the extent of wartime bomb damage on the Urban District of Hayes and Harlington were consulted at London Metropolitan Archives. Unfortunately, the site is situated in an area where mapping has been lost or destroyed.

14.10. WWII-Era Aerial Photography

A high resolution scan of WWII-era aerial photography for the site area was obtained from the National Monuments Record Office (Historic England). This photograph provides a record of the potential composition of the site during the war, as well as its condition immediately following the war (**see Annex O**).

WWII-Era Aerial Photography – Annex O	
Date	**Description**
RAF Photography 22nd June 1946	This immediate post war photograph indicates that the site and the industrial structures surrounding it appear to have survived the war externally intact, occupying the same footprint as they had pre-war, and show no immediately visible signs of damage. The sports field to the east however does appear patchy and worn, perhaps due to regular access and

© 1st Line Defence Limited

	use. To the west of the site, beyond Viveash Close, an area of hardstanding yard appears patchy and uneven, perhaps the result of constant access or goods storage.

14.11. Abandoned Bombs

A post air-raid survey of buildings, facilities, and installations would have included a search for evidence of bomb entry holes. If evidence of an entry hole was encountered, Bomb Disposal Officer Teams would normally have been requested to attempt to locate, render safe, and dispose of the bomb. Occasionally, evidence of UXBs was discovered but due to a relatively benign position, access problems, or a shortage of resources the UXB could not be exposed and rendered safe. Such an incident may have been recorded and noted as an 'abandoned bomb'.

Given the inaccuracy of WWII records and the fact that these bombs were 'abandoned', their locations cannot be considered definitive or the lists exhaustive. The MoD states that 'action to make the devices safe would be taken only if it was thought they were unstable'. It should be noted that other than the 'officially' abandoned bombs, there will inevitably be UXBs that were never recorded.

1st Line Defence holds no records of officially registered abandoned bombs at or near the site of the proposed works.

14.12. Bomb Disposal Tasks

The information service from the Explosive Ordnance Disposal (EOD) Archive Information Office at 33 Engineer Regiment (EOD) is currently facing considerable delay. It has therefore not been possible to include any updated official information regarding bomb disposal/clearance tasks with regards to this site. A database of known disposal/clearance tasks has been referred to which does not make reference to such instances occurring within the site of proposed works. If any relevant information is received at a later date GEA will be advised.

14.13. Evaluation of German Aerial Delivered UXB Risk

Factors	Conclusion
Density of Bombing *It is important to consider the bombing density when assessing the possibility that UXBs remain in an area. High levels of bombing density could allow for error in record keeping due to extreme damage caused to the area.*	The U.D. of Hayes and Harlington was subject to an overall low – medium density of bombing, with an average of 40 bombs recorded per 1,000 acres according to Home Office statistics. London bomb census mapping indicates that the area surrounding the site was affected by several bomb incidents, however none are recorded to have directly affected the site footprint. Whilst the Middlesex County Council incident log for Hayes and Harlington does not directly refer to any bomb incidents directly affecting the site, it does detail several incidents to have affected the Nestle Cocoa Factory, to the east of the site area. One HE bomb is recorded to have affected the factory with one serious casualty sustained. The Hayes and Harlington UXB register also records a UXB in the Nestle Factory sports field adjacent to the site. A Visual Overlay of bombing incidents is presented in **Annex O2**

© 1st Line Defence Limited

Damage *If buildings or structures on a site sustained bomb or fire damage any resulting rubble and debris could have obscured the entry holes of unexploded bombs dropped during the same, or later, raids. Similarly, a High Explosive bomb strike in an area of open agricultural land will have caused soil disturbance, increasing the risk that a UXB entry hole would be overlooked.*	Due to the absence of MCC war damage mapping, it has not been possible to discern if the site area was recorded to have sustained any bomb damage. Despite the absence of this damage mapping, no obvious signs of bomb related damage is observable within the site area. Historical OS mapping, does illustrate significant changes to have taken place between pre-and post-war map editions, with multiple industrial structures having been constructed both on and surrounding the site. Oblique photography from 1939 does depict these structures, and consequently that this development was constructed prior to the outbreak of war. Immediate post-war aerial photography from 1946 shows no immediately obvious signs of bomb related damage such as craters, debris, or structural damage to neighbouring buildings. The sports field to the east does show some areas of patchy ground, however these appear to be more consistent with access to the field as opposed to anything relating to bomb damage.
Access Frequency *UXO in locations where access was irregular would have a greater chance of passing unnoticed than at those that were regularly occupied. The importance of a site to the war effort is also an important consideration as such sites are likely to have been both frequently visited and subject to post-raid checks for evidence of UXO.*	At the outbreak of WWII, it is anticipated that the site was subject to a good degree of frequent regular access, owing to the industrial structures occupying the site, the sports field to the east, as well as its proximity to residential housing and roads. The fact that a UXB was reported in the sports field to the east highlights that access and checks were being made following raids, even within areas not occupied by structures. No bomb strikes or structural changes are recorded to have taken place on site, with the site appearing much the same in post-war OS mapping as it did in pre-war oblique photography. Accordingly, it is not anticipated that access to the site would have been significantly impeded over the course of the war, and it is deemed likely that regular checks would have been made to the site, and accordingly items of UXO should have been observed and reported.
Ground Cover *The nature of the ground cover present during WWII would have a substantial influence on any visual indication that may indicate UXO being present.*	During the war, it is anticipated that the site featured ground cover that was conducive to the observation of UXO entry holes, being comprised of large industrial structures as well as a hardstanding yard area in the south.
Bomb Failure Rate	There is no evidence to suggest that the bomb failure rate in the locality of the site would have been dissimilar to the 10% normally used.
Abandoned Bombs	1st Line Defence holds no records of abandoned bombs at or within the site vicinity.
Bombing Decoy sites	1st Line Defence could find no evidence of bombing decoy sites within the site vicinity.
Bomb Disposal Tasks	1st Line Defence could find no evidence of bomb disposal tasks within the site boundary and immediate area.

© 1st Line Defence Limited

15. The Risk from Allied Ordnance

15.1. Introduction

According to records, the site resided within the boundaries of the former No.7 National Filling Factory; also known as Emergency Factory No.2, which was constructed in 1915 to increase the output of munitions during WWI. This factory occupied 200 acres and was primarily involved with the filling of shells, fuzes and detonators with explosives as well as the assembly of shells fuzes and gaines.

When undertaking work within or immediately adjacent to an historic ordnance production facility, it can often be assumed that the risk of contamination from explosive ordnance is elevated above the 'background' level of the surrounding area. This assumption of risk is based on the following reasoning:

- In most cases, explosive ordnance would be produced and stored within the vicinity of such facilities. The types of ordnance produced varied depending on the specifics of the concerned facility. This may have included small arms, high explosive bombs and artillery projectiles.
- Not all ordnance production facilities were engaged in the production of high explosive material. Some works that concerned only the manufacturing of bomb, shell and cartridge casings. These factories are notably distinct and differently categorised from other facilities however, if no specific information is available for an individual facility, the potential for explosive ordnance production must be assumed.
- Due to the nature of ordnance production facilities, production often started and ceased in a hurried manner. The military generally did not anticipate or were not concerned by the fact that the land would be later sold for civilian development, and consequently appropriate ordnance disposal procedure was not always adhered to. It was not uncommon for excess or unwanted ordnance to be buried or burnt within the perimeters of a military establishment as a means of disposal. Records of such practice were rarely kept.

There are several factors that may serve to either affirm, increase, or decrease the level of risk within an ordnance manufacturing facility. Such factors are typically dependent upon the proximity of the proposed area of works to a number of features. The risk of contamination from Allied ordnance may also relate to the function of the facility and any incidents recorded within, or proximate to the factory.

This section will examine the history of the factory and assess to what degree, if any, the site could have become contaminated as a result of the historic military use of the surrounding area.

15.2. History of National Filling Factory No.7

It is understood that National Filling Factory No.7 not only specialised in the filling of munitions, but also diversified into production, to include a variety of military ordnance and related components. See below for further information.

15.3. WWI-era

The construction of National Filling Factory (NFF) No.7 at Hayes was completed in October 1915, in order to increase the production and filling of shells for use in WWI. The location of the factory was chosen due to its close proximity to the Great Western Railway (GWR), and was situated on its line from Paddington to Slough, providing excellent transportation links both for receiving assembly components and the transportation of the finished munitions to where they were needed.

Originally the factory was primarily tasked with the filling of 18-pounder artillery shells with block explosive propellant charges, however when plans to construct an additional filling factory in Watford were abandoned, the factory was extended. The resulting extension increased the factor area to some 200 acres and allowed the factory to fill 200 tons of amatol and 100 tons of lyddite per week. As the war progressed, the factory was tasked with more assembly and filling tasks, including the filling of

© 1st Line Defence Limited

gaines when the NFF at Southwark ceased this work. The factory also needed a substantial workforce in order to complete its production quota. Initially this comprised of mainly men, however as the war progressed women took over the majority of the workforce, indeed, in March 1917 the workforce consisted of 8,780 women and 1,849 men.

Whilst the factory was rapidly decommissioned following the end of hostilities in 1918, little detail is known about the exact date that production was ceased and when the factory was unoccupied.

See Annex P for WWI-era photographs showing filling production within the NFF No.7 Hayes.

15.4. Post-WWI

The immediate post-WWI history of the NFF No.7 factory is not clear, however records of correspondence, obtained from The National Archives, between the Ministry of Labour and the Ministry of Munitions, indicate that the "majority of buildings were absolutely full of stores. "It is clear from these correspondences that the Ministry of Labour was interested in obtaining the factory or a small portion of it from the Ministry of Munitions so that it could be converted into a Government Instructional Factory (GIF), for the training of unskilled workers in the trade of car building.

Correspondence shows that by 1920 the canteen and garage of the NFF was being occupied as an Instructional Factory, in order to teach former servicemen the trade of coach-building and car body work. This continued until 1923, where corresponded reveals that the "keys to the old factory at Hayes were handed to the manager of the Disposal and Liquidation Commission."

It is unclear whether this led to the immediate demolition or clearance of the factory, however the factory is shown to have been cleared prior to the 1934 OS map edition covered in **Section 10.2.**

See **Annex Q** for excerpts of these correspondences.

15.5. Filling Production

Like other filling factories, NFF No.7 was tasked with the filling of a wide variety of munitions and ordnance components, and as the war progressed also started the assembly of some of these items. The factory was divided into the production of various items, with the west section completing the assembly of 18-pdr shells, the east with the filling of fuzes, friction tubes and C.E (Composition, Explosive) pellets. The cap and detonator section handled the filling of primer caps and detonators with unstable mercury fulminate, and was guarded. The amatol section was spaced out for safety and was tasked with filling shells with liquid amatol, initially by hand and then by machine. Finally, the cartridge section assembled cartridges and shells, and filled them with the relevant explosive propellant.

The table below presents the components produced and filled at the No.7 NFF at Hayes in May 1916.

Weekly production and filling output- Week ending 18th May 1916		
Item	**Filled**	**Assembled**
Shells, HE (unspecified calibre)	31,293	83,944
Shells, Shrapnel (unspecified calibre)		32,000
Cartridges	89,170	N/A
Friction Tubes	44,440	
Primers	117,160	
Exploders	272,000	
Detonators	422,310	
Fuzes	177,098	

© 1st Line Defence Limited

Gaines	177,531	147,021
Adapters	N/A	
Primer Caps	125,914	N/A

15.6. Site Plans

A WWI-era plan of the NFF No.7 highlights the extent of the factory's footprint, and also shows the various production areas. The wider factory is shown to encompass the area from the immediate south of the GWR line in approximately the position of the Hayes and Harlington Station, this extends approximately 1.2km to the south, in the approximate vicinity of the current M4 Motorway.

The site of proposed works is situated in the eastern section of the factory, an area shown on the plan to feature a multitude of magazines and covered passageways, dispersed in order to minimise the effect of a blast should an accident occur. It is likely that earth was piled high around each magazine, to act as a buffer.

It is not possible to precisely identify the nature of the magazine structures on site, however this section of the site is within the area of the factory known to fill fuzes.

Both the plan of the NFF No.7, and a visual representation of the site within the factory are presented in **Annex R.**

15.7. Quality of Historical Record

The record set is of generally good quality, and whilst it is not comprehensive, it presents a reasonably clear picture of the history of the Filling Factory during and following WWI. Specific information on the ordnance items assembled and filled on site was available, as well as production figures.

The records are not without inconsistencies however, as the history of the factory in the immediate post-war period could not be found.

16. Examples of Types of Explosive Ordnance Found at Historical Military Sites

16.1. General

Many areas across the UK may be at risk from Allied UXO due to both wartime and peacetime military use. Typical military activities and uses that may have led to a legacy of military UXO at a site include weapons manufacture and storage areas, former minefields, home guard positions, anti-aircraft emplacements, training and firing ranges, as well as military camps.

Although land formerly used by the military were usually subject to clearance before they returned to civilian use, items of UXO are sometimes discovered and can present a potential risk to construction projects. This section of the report discusses the generic types of Allied ordnance typically encountered on areas associated with former military activity.

16.2. National Filling Factory No.7 Production Line

The most likely ordnance to be encountered on former ordnance manufacturing sites are the items or components manufactured at that installation. These items may contaminate sites where significant quantities of ordnance was being produced or stored, especially where such conditions of manufacture were unfavourable, such as emergency factories or those constructed hastily.

Items known to have been produced at the NFF No.7 are shown below, with pictorial examples presented in **Annex S.**

© 1st Line Defence Limited

National Filling Factory No.7 Production Line	
Item	**Description**
Shells- HE and Shrapnel	A payload-carrying projectile that, as opposed to solid shot, contains an explosive filing designed to detonate on initiation. Usually fired from artillery, combat vehicles and warships.
Fuzes	An explosive initiator that when activated causes munitions it is used with to explode. Typical used on projectiles fired by guns (field, anti-aircraft, coast and naval), as well as howitzers and mortars. Types include time fuzes, contact fuzes and proximity fuzes.
Friction Tubes	A type of primer comprised of a copper tube packed with powder, with a branch bent at an angle, which is filled with a friction composition in which a friction bar is embedded. When removed the friction bar causes the tube to ignite, activating any secondary charge it is used with.
Detonators	An ignition based explosive trigger used to activate larger secondary charges, such as those in a shell. Often housed in a fuse, detonators of the WWI period were largely manufactured from Mercury Fulminate.
Gaines	A type of igniter that is packed with a powder pellet, and is used for igniting the detonating wave necessary for detonating a HE shell.
Primer Caps	A single-use contact initiation device containing primary explosive that is inserted into fired munitions, such as small arms ammunition and shells in order to activate propellant charges for projectiles.

16.3. Small Arms Ammunition

The most common type of ordnance encountered on land formerly occupied by the military are items of Small Arms Ammunition (SAA). SAA refers to the complete round or cartridge designed to be discharged from varying sized hand-held weapons such as rifles, machine guns and pistols. SAA can include bullets, cartridge cases and primers/caps. Example images of SAA are presented in **Annex G.**

16.4. Land Service Ammunition

Items of Land Service Ammunition (LSA) can also be found within any land of former military usage, such as an army barracks or training area. The term LSA covers items of ordnance that are propelled, placed, or thrown during land warfare. These items may be filled or charged with explosives, smoke, incendiary, or pyrotechnics and can be divided into five main groups:

Land Service Ammunition	
Item	**Description**
Mortar Rounds	A mortar round is normally nosed-fuzed and fitted with its own propelling charge. Its flight is stabilised by the use of a fin. They are usually tear-drop shaped (though older variants are parallel sided), with a finned 'spigot tube' screwed or welded to the rear end of the body which houses the propellant charge. Mortars are either High Explosive or Carrier (i.e. smoke, incendiary, or pyrotechnic).
Grenades	A grenade is a short range weapon designed to kill or injure people. It can be hand thrown or fired from a rifle or a grenade launcher. Grenades either contain high explosive or smoke producing pyrotechnic compounds. The common variants have a classic 'pineapple' shape.
Projectiles	A projectile (or shell) is propelled by force, normally from a gun, and continues in motion using its kinetic energy. The gun a projectile is fired from usually determines its size. A projectile contains a fuzing mechanism and a filling. Projectiles can be high explosive, carrier or Shot (a solid projectile).

© 1st Line Defence Limited

Rockets	Rockets were commonly designed to destroy heavily armoured military vehicles (anti-tank weapon). The device contains an explosive head (warhead) that can be accelerated using internal propellants to an intended target. Anti-aircraft rocket batteries were also utilised as part of air defence measures.
Landmines	A landmine is designed to be laid on or just below the ground to be exploded by the proximity, or contact of a person or vehicle. Landmines were often placed in defensive areas of the UK to obstruct potential invading adversaries.

In the UK unexploded or partially exploded mortars and grenades are the most common items of LSA encountered, as they could be transported and utilised anywhere. They are mostly encountered in areas used for military training and are often found discarded on or near historical military bases.

Images of the most commonly found items of LSA and weapons are presented in **Annex T.**

16.5. Defending the UK From Aerial Attack

During WWII the Ministry of Defence employed a number of defence tactics against the Luftwaffe from bombing major towns, cities, manufacturing areas, ports and airfields. These can be divided into passive and active defences (examples are provided in the table below).

Active Defences	Passive Defences
• Anti-aircraft gun emplacements to engage enemy aircraft. • Fighter aircraft to act as interceptors. • Rockets and missiles were used later during WWII.	• Blackouts and camouflaging to hinder the identification of Luftwaffe targets. • Decoy sites were located away from targets and used dummy buildings and lighting to replicate urban, military, or industrial areas. • Barrage balloons forced enemy aircraft to greater altitudes. • Searchlights were often used to track and divert adversary bomber crews during night raids.

Active defences such as anti-aircraft artillery present a greater risk of UXO contamination than passive defences. Unexploded ordnance resulting from dogfights and fighter interceptors is rarely encountered and difficult to accurately qualify.

16.6. Anti-Aircraft Artillery (AAA)

During WWII three main types of gun sites existed: heavy anti-aircraft (HAA), light anti-aircraft (LAA) and 'Z' batteries (ZAA). If the projectiles and rockets fired from these guns failed to explode or strike an aircraft they would descend back to land. The table below provides further information on the operation and ordnance associated with these type of weapons.

Anti-Aircraft Artillery	
Item	**Description**
HAA	These large calibre guns such as the 3.7" QF (Quick Firing) were used to engage high flying enemy bombers. They often fired large HE projectiles, which were usually initiated by integral fuzes triggered by impact, area, time delay or a combination of aforementioned mechanisms. The closest HAA was located approximately 3.32km south-west of the site, however the range of a projectile can be up to 15km.

© 1st Line Defence Limited

LAA	These mobile guns were intended to engage fast, low flying aircraft. They were typically rotated between locations on the perimeters of towns and strategically important industrial works. As they could be moved to new positions with relative ease when required, records of their locations are limited. The most numerous of these were the 40mm Bofors gun which could fire up to 120 x 40mm HE projectiles per minute to over 1,800m.			
Variations in HAA and LSA Ammunition	**Gun type**	**Calibre**	**Shell Weight**	**Shell Dimensions**
	3.0 Inch	76mm	7.3kg	76mm x 356mm
	3.7 Inch	94mm	12.7kg	94mm x 438mm
	4.5 Inch	114mm	24.7kg	114mm x 578mm
	40mm	40mm	0.9kg	40mm x 311mm
Z-AA	The three inch unrotated rocket/projectile known as the UP-3 had initially been developed for the Royal Navy. The UP-3 was also used in ground-based single and 128-round launchers known as ''Z'' batteries. The rocket, containing a high explosive warhead was often propelled by cordite.			
29mm Spigot Mortars (Blacker Bombards)	This was an infantry anti-tank weapon. A heavy steel rod (spigot) would be driven into the hollow tail of a projectile to ignite the explosive charge located in the rear of the projectile, and lead to it being propelled toward a target. It was not an effective method of air defence and was mainly used in defensive positons at key locations. If encountered, a spigot mortar projectile will resemble a mortar round, but with an elongated metal tail rod.			
Quick Firing (QF) 1 and 2 Pounder	QF 1 and 2 Pounders, or 'pom poms' were a light battery most often used by the navy. During the beginning of WWII they were used to defend targets in the absence of more effective LAA or HAA.			
Machine Gun Posts	These were established at some significant military and industrial positions. Machine guns were a largely ineffective form of AAA. Machine guns usually fired the .303 Round.			

The conditions in which an HAA or LAA projectiles may have fallen unnoticed within a site area are analogous to those regarding aerial delivered ordnance. For detailed analysis on the ground conditions and access frequency within the proposed site, see the Evaluation of German Aerial Delivered UXB Risk in, **Section 14.13**.

Illustrations of Anti-Aircraft artillery, projectiles and rockets are presented at **Annex U**.

16.7. Evaluation of Allied Ordnance Risk

1st Line Defence has considered the following potential sources of Allied ordnance contamination:

Sources of Contamination	Conclusion

© 1st Line Defence Limited

Ordnance Manufacture *Ordnance manufacture indicates an increased chance that items of ordnance were stored, or disposed of, within a location.*	The site of proposed works is known to have been associated with historical ordnance manufacture activities, being situated within the National Filling Factory No.7 during the WWI period. The site boundary was historically situated within a section of the factory that is recorded to have dealt with the manufacture and filling of large quantities of fuzes, friction tubes and C.E. pellets. Two storage magazines are shown to have been situated within the site boundary. Taking the above into account, there is considered to be a potential residual risk of contamination from WWI-era military ordnance at the proposed site. At the time it was likely not anticipated that the land would be later sold for civilian development, and consequently appropriate explosive ordnance disposal procedure was not always adhered to. It was not uncommon for excess or unwanted ordnance such as fuzes to be buried or burnt within the wider premises as a means of disposal. Records of such practice were rarely kept. Immediate post-WWI records are not comprehensive, but indicate that the factory was disused shortly following the end of hostilities, and used as storage space. Correspondence from the Ministry of Labour indicates that a section of the factory was used in the 1920s as a Government Instructional Factory to educated demobbed soldiers and sailors in the trade of coach and car building. Ordnance handled at National Filling factories were filled with explosive material, with the site area being situated within a section of the site known to handle the filling of ordnance components. As such there is considered to be an elevated risk of the contamination of the site area with items of Allied ordnance.
Anti-Aircraft Defences *Anti-Aircraft defences were employed across the country. Proximity to anti-aircraft defences increases the chance of encountering AA projectiles.*	1st Line Defence could find no evidence of Anti-Aircraft defences such as a HAA or LAA gun emplacement occupying or bordering the site. The closest HAA was located approximately 3.32km south-west of the site, however the range of a projectile can be up to 15km. The conditions in which HAA or LAA projectiles may have fallen unnoticed within a site footprint are analogous to those regarding German aerial delivered ordnance.
Home Guard Activity *The Home Guard regularly undertook training and ordnance practice in open areas, as well as burying ordnance as part of anti-invasion defences.*	Evidence of Home Guard training areas and activities is difficult to obtain. 1st Line Defence has no evidence of any Home Guard activities on the site.
Defensive Positions *Defensive positions suggest the presence of military activity, which is often indicative of ordnance storage, usage or disposal.*	There is no evidence of any defensive features formerly located on or bordering the site footprint.

© 1st Line Defence Limited

Training or firing ranges *Areas of ordnance training saw historical ordnance usage in large numbers, often with inadequate disposal of expended and live items. The presence of these ranges significantly impact on the risk of encountering items of ordnance in their vicinity.*	There is no evidence of such features affecting the site.
Defensive Minefields *Minefields were placed in strategic areas to defend the country in the event of a German invasion. Minefields were not always cleared with an appropriate level of vigilance.*	There is no evidence of defensive minefields affecting the site.
Military Camps *Military camps present an elevated risk from ordnance simply due to the large military presence and likelihood of associated live ordnance training.*	1st Line Defence could find no evidence of a military camp within the site.
Military Related Airfields *Military airfields present an elevated risk from ordnance simply due to the large military presence and likelihood of associated live ordnance training or bombing practice.*	The site was not situated within the perimeters or vicinity of a military airfield.

17. Ordnance Clearance and Post-WWII Ground Works

17.1. General

It is important to consider the extent to which any explosive ordnance clearance (EOC) activities or extensive ground works have occurred on site. This may indicate previous ordnance contamination or reduce the risk that ordnance remains undiscovered.

17.2. UXO Clearance

1st Line Defence has no evidence that any official ordnance clearance operations have taken place on site. Note however that we have not received confirmation of this fact from 33 EOD Regiment.

17.3. Post-WWI and WWII Redevelopment

The site has been subject to several periods of extensive redevelopment as described below

Post-WWI, the NFF known to have occupied the site area and surrounding environs was cleared, with the area shown to have been occupied by open vacant land following this development. Additional development is shown to have taken place in the period immediately preceding WWII, with an industrial structure connected to the Nestle Cocoa Factory having been constructed.

© 1st Line Defence Limited

Post-WWII, re-development work on site has been minor, with the structures present on site being those erected during the pre-war period.

The risk from deep-buried unexploded bombs is only considered mitigated at locations where post war piling or deep foundations have taken place.

18. 1st Line Defence Risk Assessment

18.1. Risk Assessment Stages

Taking into account the quality of the historical evidence, the assessment of the overall risk from unexploded ordnance is based on the following five considerations:

1. That the site was contaminated with unexploded ordnance.
2. That unexploded ordnance remains on site.
3. That such items will be encountered during the proposed works.
4. That ordnance may be initiated by the works operations.
5. The consequences of encountering or initiating ordnance.

UXO Risk Assessment	
Quality of the Historical Record	The research has evaluated pre- and post-WWII Ordnance Survey maps, Luftwaffe reconnaissance imagery, pre-war oblique aerial imagery, London Civil Defence air raid damage reports, MCC Log Book of air raid incident for Hayes and Harlington, local Hayes and Harlington ARP wartime message forms, Ministry of Munitions records, Ministry of Labour correspondence and WWI NFF plans. The WWI record set is of generally good quality. Details of the history of the NFF that had formerly occupied the site area are reasonably comprehensive and covers the items produced at the factory, as well as its extent and the position of the site area within it. The WWII record set is both largely comprehensive, detailed and presents bomb incidents recorded in London bomb census mapping. Bomb incidents affecting the area are accounted for, with the only incident within close proximity being a UXB that was recorded to have been 'disposed of.' The only limitation of the available record set is that MCC War Damage Mapping was missing for this area, as well as the lack of records for the NFF immediately post WWI.
The Risk that the Site was Contaminated with UXO	After considering the following facts, 1st Line Defence has assessed that there is a **Low Risk** that items of unexploded German aerial delivered and anti-aircraft ordnance could have fallen unrecorded within the site boundary. There is considered to be a **Medium Risk** of contamination from Allied Ordnance at the site (mitigating factors post-war reduce the overall risk to Low-Medium). This assessment is based on a range of factors including the site's historic usage, bomb density, damaged sustained, development work and frequency of access, see below: **The Likelihood of German Aerial Delivered Ordnance Contamination** • During WWII, the Urban District of Hayes and Harlington sustained an overall low-moderate density bombing campaign, with an average of 40 items falling per 1,000 acres according to Home Office statistics. Bombing in the local area of Nestle Avenue can be attributed to its location, close to the capital and proximity to areas of local industry and the railway. • Viable Luftwaffe targets were located in Uxbridge, and the borough was in proximity to major targets in London. Whilst London bomb census mapping does

© 1st Line Defence Limited

record strikes to have affected areas within the vicinity of the site, including a UXB in the Nestle Sports Field, no bombs are recorded to have fallen within the site boundary. Additionally, these strikes are accounted for in an MCC Log Book of Incidents for Hayes and Harlington, which report one bomb to have fallen on the Nestle Factory and a UXB to have landed in the Nestle Sports Field.

- Pre-war oblique aerial imagery highlights that the construction of the structure on site and those surrounding it was completed by 1939, rather than as the result of post war re-development following bomb damage.
- Similarly, post-war 1946 aerial imagery suggests that the site and bordering areas escaped serious bomb damage. No obvious signs of damage are visible in these areas, such as the presence of cratering, ruins, rubble or debris.
- At the start of WWII, the site was likely subject to a frequent level of regular access, owing to the industrial structures present on site, as well as the close proximity of the site to the Nestle Cocoa Factory Sports Field and residential properties. No evidence, such as damage or nearby bomb strikes, could be found to suggest that this access would have been significantly impeded over the course of the war, or that the ground cover present could have restricted evidence of UXO. Accordingly it is considered likely that frequent checks were maintained, and thus items of UXO would have been observed and reported.
- The conditions in which HAA or LAA projectiles may have fallen unnoticed within the site boundary are considered analogous to those regarding aerial delivered ordnance.

<u>The Likelihood of Allied Ordnance Contamination</u>

- During the WWI period, the site area was located within the boundary of the National Filling Factory No.7, and as such there is potential for contamination from items of allied ordnance to have occurred.
- Available records indicate that the factory was concerned with filling explosive material in a wide variety of ordnance items, in significant quantities during WWI, and later in the war also began to assemble components. Items filled include: HE and shrapnel shells, fuzes, detonators, small arms ammunition and exploders. All of these items were mass-produced in quantity throughout the war by some 10,000 workers.
- The site area was situated within the eastern section of the factory which is recorded to have dealt with the filling of fuzes, friction tubes and exploders. Two magazines are shown to have been located on site, surrounded by piled earth to insulate damage should an accident occur.
- Taking this into account, there is considered to be a residual risk from contamination of WWI-era military ordnance at the site. At the time it was likely not anticipated that the land would be later sold for civilian development, and consequently appropriate explosive ordnance disposal procedure was not always adhered to. It was not uncommon for excess or unwanted ordnance such as fuzes to be buried or burnt within the wider premises as a means of disposal. Records of such practice were rarely kept.
- Elements of the NFF, including the canteen and garages are recorded to have been used as an Instructional Factory in the inter-war period, with conversion work being carried out to convert the machinery so that it could be utilised in coach building and car manufacturing.
- The site was demolished and cleared in the inter-war period, as shown in historical OS mapping from 1934, which highlights the site area as vacant unoccupied land alongside the Nestle sports field. Such demolition, clearance and subsequent re-development is anticipated to have involved some significant intrusive work into the ground.
- Consequently, while the risk of contamination from the National Filling Factory is considered to have been significant, the residual risk of ordnance remaining is

© 1st Line Defence Limited

	considered relatively low, due largely to the clearance and redevelopment work that has taken place.
The Risk that UXO Remains on Site	Significant clearance and redevelopment work is noted to have taken place on site in the interwar period, with the NFF having been cleared and returned to vacant unoccupied land by 1934 OS mapping. Oblique imagery shows an industrial structure to have been constructed on site by 1939. Post-WWII development has been minimal however, with the structure present on site being the same one observable in 1939. If UXO had contaminated the site following its WWI use as an NFF, the contamination is only likely to have been present at relatively shallow depths. The risk of UXO remaining is considered to have been mitigated at the location of and down to the depth of post-war foundations and excavations. It is considered likely that the whole site will have been subject to excavations to shallow depths as a result of post-war redevelopment.
The Risk that UXO may be Encountered during the Works	The most likely scenarios under which items of UXO could be encountered during construction works is during piling, drilling operations or bulk excavations for basement levels. The risk of encountering will depend on the extent of the works, such as the numbers of boreholes/piles (if required) and the volume of the excavations. An aerial delivered bomb may come to rest at any depth between just below ground level and its maximum penetration depth. Consequently there is also a possibility that UXBs could be encountered during shallow excavations (for services or site investigations) into the original WWII ground level. There is not considered to be any significant risk of encountering UXO during works planned within the footprint and down to the depth of any post-war buildings/excavations. Beyond these depths and away from these areas, a risk of encounter could conceivably remain.
The Risk that UXO may be Initiated	The risk that UXO could be initiated if encountered will depend on its condition, how it is found, and the energy with which it is struck. Certain construction activities such as piling and percussive drilling pose a greater risk of initiating UXO in comparison to machine excavation, where the force of impact is generally lower and the item is more likely to be observed. If piling works are planned at 9 Nestles Avenue there is a potential risk that a UXB, if present, could be initiated. The risk of initiation is assessed to be lower for any shallow intrusive works planned.
The Consequences of Encountering or Initiating Ordnance	The repercussions of the inadvertent detonation of items of UXO during intrusive ground works are potentially severe, both in terms of human and financial cost. A serious risk to life and limb, damage to plant and total site shutdown during follow-up investigations are potential outcomes. If appropriate risk mitigation measures are undertaken, the chances of initiating an item of UXO during ground works is comparatively low. The primary consequence of encounter of UXO will therefore be economic. This would be particularly notable in the case of sites with a high-profile or where it is necessary to evacuate the public from the surrounding area. A site may be closed from a few hours to a week with potentially significant cost in lost time. It should be noted that even the discovery of suspected or possible items of UXO during intrusive works (if handled solely through the authorities), may also involve loss of production. Generally, the first action of the police in most cases will be to isolate the locale whilst awaiting military assistance, even if this becomes unnecessary.

18.2. Assessed Risk Level

© 1st Line Defence Limited

Taking into consideration the findings of this study, 1st Line Defence has assessed that there is a **Low Risk** from German and anti-aircraft unexploded ordnance at the site of proposed works. A **Low-Medium Risk** of contamination from WWI-era Allied ordnance has also been identified.

Ordnance Type	Risk Level			
	Negligible	Low	Medium	High
German Unexploded HE Bombs		✓		
German 1kg Incendiary Bombs		✓		
Anti-Aircraft Artillery Projectiles		✓		
Allied Military Land Service Ammunition (Grenades, Mortars, Fuzes etc.)		✓		
Allied SAA (small arms ammunition)		✓		

19. Proposed Risk Mitigation Methodology

19.1. General

The following risk mitigation measures are recommended to support the proposed works at the 9 Nestles Avenue site.

Type of Work	Recommended Mitigation Measure
All Works	• **Site Specific UXO Awareness Briefings to all personnel conducting intrusive works.** As a minimum precaution, all personnel working on the site should be briefed on the basic identification of UXO and what to do in the event of encountering a suspect item. This should in the first instance be undertaken by a UXO Specialist. Posters and information on the risk of UXO can be held in the site office for reference.

In making this assessment and recommending these risk mitigation measures, if known, the works outlined in the 'Scope of the Proposed Works' section were considered. Should the planned works be modified or additional intrusive engineering works be considered, 1st Line Defence should be consulted to see if a re-assessment of the risk or mitigation recommendations is necessary.

1st Line Defence Limited **27th July 2018**

This Report has been produced in compliance with the Construction Industry Research and Information Association (CIRIA) C681 guidelines for the writing of Detailed UXO Risk Assessments.

© 1st Line Defence Limited

Bibliography

- Bates, H. E., *Flying Bombs over England*, Frogletts Publications Ltd., 1994
- Castle, I., *London 1914-17: The Zeppelin Menace*, Osprey Publications Ltd., 2008
- Castle, I., *London 1917-18: The Bomber Blitz*, Osprey Publications Ltd., 2010
- Clarke, N. J., *Adolf Hitler's Holiday Snaps: German Aerial Reconnaissance Photography of London and the Home Counties 1939 – 1943*, N. J. Clarke Publications., 1996
- Clarke, N. J., *Adolf's British Holiday Snaps: Luftwaffe Aerial Reconnaissance Photographs of England, Scotland and Wales*, Fonthill Media Ltd., 2012
- Dobinson, C., *AA Command: Britain's Anti-Aircraft Defences of the Second World War*, Methuen., 2001
- Fegan, T., *The 'Baby Killers': German Air raids on Britain in the First World War*, Leo Cooper Ltd., 2002
- Fleischer, W., *German Air-Dropped Weapons to 1945,* Midland Publishing., 2004
- Jappy, M. J., *Danger UXB: The Remarkable Story of the Disposal of Unexploded Bombs during the Second World War*, Channel 4 Books., 2001
- Morris, J., *German Air Raids on Britain: 1914 – 1918*, The Naval & Military Press., 1993
- Price, A., *Blitz on Britain, The Bomber Attacks on the United Kingdom 1939 – 1945*, Purnell Book Services Ltd., 1977
- Ramsey, W., *The Blitz Then and Now, Volume 1*, Battle of Britain Prints International Ltd., 1987
- Ramsey, W., *The Blitz Then and Now, Volume 2*, Battle of Britain Prints International Ltd., 1988
- Ramsey, W., *The Blitz Then and Now, Volume 3*, Battle of Britain Prints International Ltd., 1990
- Scofield, J., *Modern Military Matters*., Council for British Archaeology., 2004
- Stone, K., et al., *Unexploded Ordnance (UXO) A Guide For The Construction Industry (C681)*., CIRIA, 2009
- Whiting, C., *Britain Under Fire: The Bombing of Britain's Cities 1940-1945*, Pen & Sword Books Ltd., 1999
- Johnston,I., *Beardmore Built, The Rise and Fall of a Clydeside Shipyard*, Cyldesbank District Libraries & Museums Department, 1993
- Cocroft, W., *Dangerous Energy, the Archaeology of Gunpowder and Military Explosives Manufacture*, English Heritage, 2000
- Ministry of Munitions, *The Official History of The Ministry of Munitions,* Ministry of Munitions, 1914

© 1st Line Defence Limited

This report has been prepared by 1st Line Defence Limited with all reasonable care and skill. The report contains historical data and information from third party sources. 1st Line Defence Limited has sought to verify the accuracy and comprehensiveness of this information where possible but cannot be held accountable for any inherent errors. Furthermore, whilst every reasonable effort has been made to locate and access all relevant historical information, 1st Line Defence cannot be held responsible for any changes to risk level or mitigation recommendations resulting from documentation or other information which may come to light at a later date.

This report was written by, is owned by and is copyrighted to 1st Line Defence Limited. It contains important 1st Line Defence information which is disclosed only for the purposes of the client's evaluation and assessment of the project to which the report is about. The contents of this report shall not, in whole or in part be used for any other purpose apart from the assessment and evaluation of the project; be relied upon in any way by the person other than the client, be disclosed to any affiliate of the client's company who is not required to know such information, nor to any third party person, organisation or government, be copied or stored in any retrieval system, be reproduced or transmitted in any form by photocopying or any optical, electronic, mechanical or other means, without prior written consent of the Managing Director, 1st Line Defence Limited, Unit 3, Maple Park, Essex Road, Hoddesdon EN11 0EX. Accordingly, no responsibility or liability is accepted by 1st Line Defence towards any other person in respect of the use of this report or reliance on the information contained within it, except as may be designated by law for any matter outside the scope of this report.

© 1st Line Defence Limited