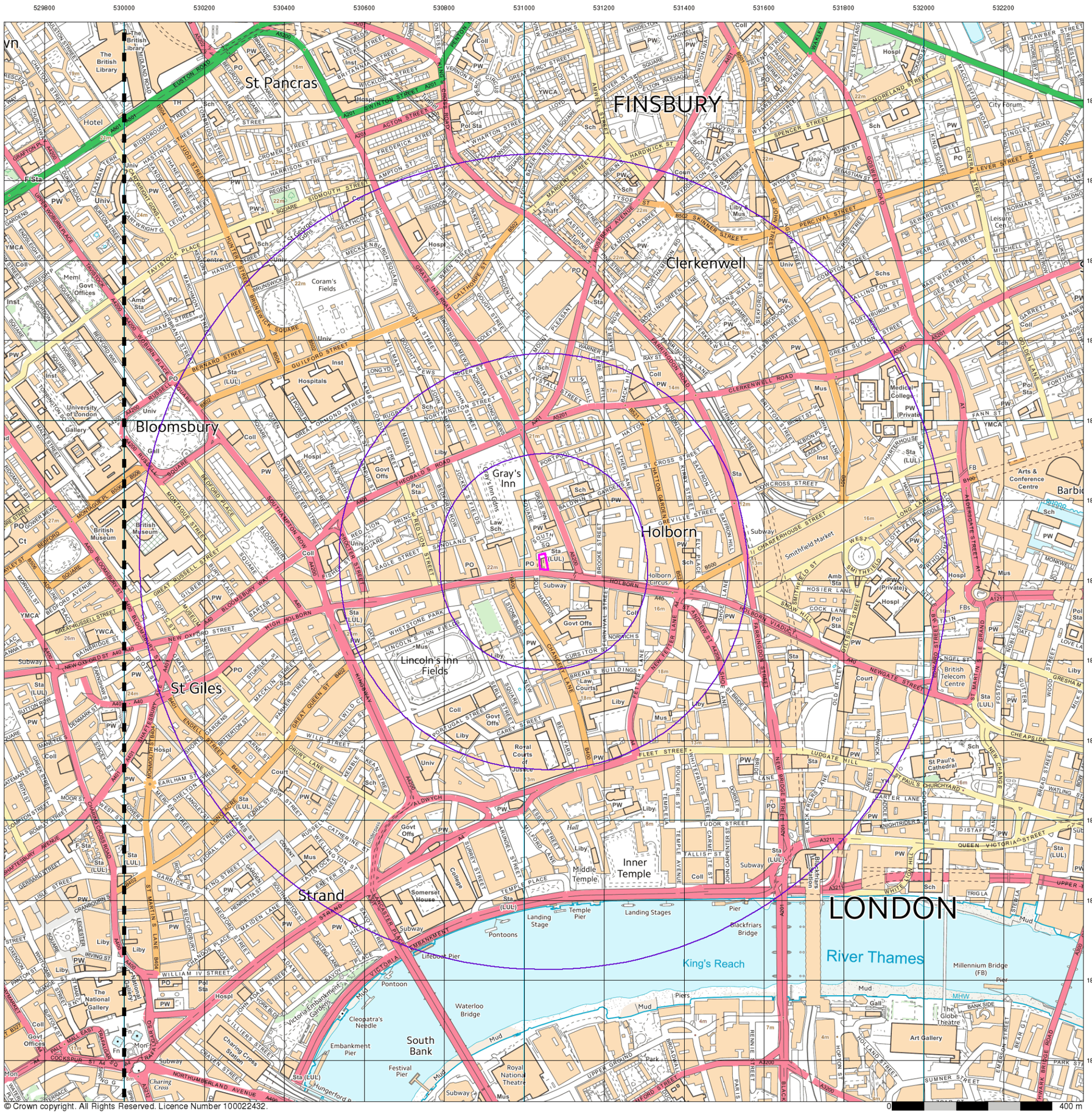
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180800
180600
180400
St Pancras
FINSBURY
Clerkenwell
Bloomsbury
Holborn
Gray's Inn
Lincoln's Inn Fields
St Giles
Strand
Inner Temple
Middle Temple
LONDON
River Thames
King's Reach
South Bank
Waterloo Bridge
Blackfriars Bridge
Millennium Bridge (FB)
Coram's Fields
Smithfield Market
EUSTON ROAD
CLERKENWELL ROAD
HOLBORN
FARRINGDON STREET
NEW OXFORD STREET
THEOBALD'S ROAD
GREAT RUSSELL STREET
GRAYS INN ROAD
ROSEBERY AVENUE
SKINNER STREET
PERCIVAL STREET
GOSWELL ROAD
CITY ROAD
OLD STREET
MOORGATE
LONDON WALL
FLEET STREET
LUDGATE HILL
NEWGATE STREET
CHEAPSIDE
QUEEN VICTORIA STREET
KINGSWAY
ALDWYCH
WHITEHALL
EMBANKMENT
VICTORIA EMBANKMENT
WATERLOO BRIDGE
BLACKFRIARS BRIDGE
MILLENNIUM BRIDGE
A1
A40
A501
A4
A3211
A3212
A200
A201
A400
A4200
A4201
A4202
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EXPLANATION OF SIGNS
USED ON
INSURANCE PLANS OF TOWNS & CITIES

CHAS. E. GOAD, LTD. CIVIL ENGINEERS
56 CROUCH HILL LONDON N.4.

ABBREVIATIONS

ASB.	ASBESTOS
CORR	CORRUGATED IRON
D.I.D.	DOUBLE IRON DOORS
DRA.	DRAPERY
D	DWELLING
ELECT.	ELECTRICIAN
(E.M.)	ELECTRIC MOTORS
(ENG.)	STEAM ENGINE
FURNE.	FURNITURE
GAR.	GARAGE
(G.E.)	GAS ENGINE
H.W.	HARDWARE
I.COLS.	IRON COLUMNS OR STEEL STANCHIONS
JWLY.	JEWELLERY
M.CL.	METAL CLAD
M.W.	MANCHESTER WAREHOUSE
m.l.	MATCH (OR WOOD) LINED
OIL	OIL & COLOR
(O.E.)	OIL ENGINE
P.H.	PUBLIC HOUSE
S.	SHOP
S.I.D.	SINGLE IRON DOORS
S.I.S.	SINGLE IRON SHUTTERS
TAI.	TAILORS
TENS.	TENEMENTS
W.G.	WIRED GLASS
W.N.	WIRE NETTING OVER GLASS

COLORS

- BRICK, STONE OR CONCRETE
- WOOD
- AREAS CLEARED DUE TO ENEMY ACTION
- SKYLIGHTS ON 1 & 2 STORY BUILDINGS
- SKYLIGHTS ON HIGHER BUILDINGS
- METAL BUILDINGS.
- TIMBER PILED OR STACKED

WALLS

- PARTY WALL 2 STORIES OR OVER, A PROBABLE FIRE CUT OFF
- ENTIRE WALL, BUT DOUBTFUL AS FIRE CUT OFF
- IMP. DEFECTIVE WALL — IMPERFECT
- WALL ABOVE, IRON COLS: UNDER
- WALL SOME FLOORS ONLY (OR WOOD OR PLASTER PARTITION)
- ABOVE ROOF 6" TO 1'-6"
- — Dº — 1'-6" TO 2'-6"
- m.l. MATCH OR WOOD LINED
- WOOD CLAD WITH CORRUGATED IRON

OPENINGS

- PASSAGE UNDER
- ON ALL FLOORS
- SOME FLOORS ONLY } UNPROTECTED
- ALL FLOORS (PROTECTED)
- ALL FLOORS (SOME PROTECTED) } SINGLE IRON DOORS
- SOME FLOORS ONLY (PROTECTED)
- ALL FLOORS (SOME PROTECTED)
- ALL FLOORS (PROTECTED) } DOUBLE IRON DOORS
- SOME FLOORS ONLY (PROTECTED)
- WOOD LOADING DOOR
- IRON LOADING DOOR

WINDOWS

- ON ALL OR MOST FLOORS
- MORE THAN USUAL
- OVERLOOKING
- NEARLY ALL GLASS
- OPENINGS THRO' & WINDOWS OVER ON SOME FLOORS ONLY
- } UNPROTECTED
- PROTECTED BY WIRED GLASS
- PROTECTED BY SINGLE IRON SHUTTERS
- PROTECTED BY DOUBLE IRON SHUTTERS.
- WINDOWS IN FRONT & REAR OF BUILDINGS UNDERSTOOD UNLESS OTHERWISE SHOWN

FLOORS

1.2.3.3½ &c ON BUILDINGS ARE NUMBER OF STORIES ABOVE GROUND (3½=3 FLOORS & ATTIC)

2&2B MEANS 2 STORIES & 2 BASEMENTS BAST & SUB-BASEMENT.

SKYLIGHTS

- Λ LESS THAN 50 SQUARE FEET (SAY 10'x5', OR 7'x7')
- OPENINGS THROUGH 2 FLOORS UNDER (EACH STROKE DENOTES AN OPENING.)
- WITH WELL HOLE THROUGH 3 FLOORS
- LANT. LANTERN LIGHT, SIDES ONLY GLASS. } OVER 50 SQ: FT. TO SCALE
- OR VENT. OR RAISED VENTILATOR

HOISTS & LIFTS

- H. OPEN
- H. OPEN TO STREET
- H. OPEN (WOOD FLAPS TO FLOORS)
- H. ENCLOSED BRICK OR FIRE RESISTING WIRED GLASS DOORS
- H. ENCLOSED WOOD OR PLASTER

IRON DOORS SHOWN AS EXPLAINED UNDER "OPENINGS"

ROOFS

ASB	ASBESTOS
C	CONCRETE
CORR:	CORRUGATED IRON
⌐	METAL
P	PATENT (FELT &c)
S	SLATE
T	TILE

PROFILES

WITH NORTH LIGHTS

SUNDRIES

- STEAM BOILERS
- —»— BOILER SET IN BRICK
- FACTORY CHIMNEYS
- (ENG.) STEAM ENGINE
- OVERHANGING WOOD CORNICE
- FIRE ALARM BOX
- —— Dº —— ON KEY PLAN
- HYDRANT
- H HYDRAULIC HYDRANT
- P PRIVATE HYDRANT OR STAND PIPE
- D DOUBLE HYDRANT
- S SALT WATER HYDRANT
- SPRINKLER OR AUTO ALARM BELL

REFERENCE NUMBERS

NUMBERS PARALLEL WITH STREET ARE EXISTING STREET Nºs

WHERE TWO SETS OF STREET Nºs IN SAME BLOCK COINCIDE, ADDITIONAL ARBITRARY Nºs ARE GIVEN TO ONE SET (500 & UPWARDS.)

WHERE BUILDINGS TO WHICH THEY APPLIED ARE DEMOLISHED, STREET & ARBITRARY Nºs ARE SHOWN & CROSSED THROUGH ON REVISION

—48'— ARE STREET WIDTHS.

(37') ARE HEIGHTS OF GROUND ABOVE ORDNANCE DATUM

HEIGHT IN FEET OF ADJOINING BUILDINGS WHERE STORIES DIFFER IN HEIGHT

10" 6" 8" SIZES OF WATER MAINS SUPPLYING HYDRANTS

Geotechnical & Environmental Associates

Published Date : 1960

0 25m

1ST LINE DEFENCE
UXO SOLUTIONS

Detailed Unexploded Ordnance (UXO) Threat Assessment

Project Name	19-21 High Holborn		
Client	GEA Ltd		
Site Address	19-21 High Holborn, WC1V 6VS		
Report Reference	2542JF00	Revision	00
Date	20th July 2015		
Originator	JF		

1ST LINE DEFENCE
UXO SOLUTIONS

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Executive Summary

Site Location

The site is situated in the London Borough of Camden in the area of Holborn, approximately 1.63km north-east of the City of London. Immediately west of the proposed site is the 'Citte of Yorke' Public House and a commercial building housing a 'Superdrug' lies to the east. South of the site is High Holborn road with several commercial properties beyond it. To the north of the court lies Gray's Inn Court with the South Square to the adjacent to the site.

The site is centred on the approximate OS grid reference: **TQ 3105081643**

Proposed Works

The exact scope of intrusive works proposed on site was not available at the time of production of this report. However; site investigation works are presumed at the initial stage.

Geology and Bomb Penetration Depth

It has not been possible to determine maximum bomb penetration capabilities due to the limits of available borehole information.

UXO Risk Assessment

1st Line Defence believes that there is a **Low Risk** from UXO across the site. This assessment is based on the following factors:

- The Metropolitan Borough of Holborn was subject to a **Very High** density of bombing with 921.2 items of ordnance recorded per 1,000 acres. Bombing in the area can be attributed to the sites proximity to the City of London, approximately 1.6km north-east and also because of the nearby strategically important targets such as the Inns of Court and the legal and business districts of Westminster.
- The consolidated and weekly London ARP bomb census mapping indicates that one HE bomb fell on or very close to the site boundary. It is thought likely however that this strike may have been misplotted as no further evidence concerning it has been found. Dense bombing is also recorded in close proximity to the site, particularly in the area of South Square and Gray's Inn which may have had a direct impact on the site.
- Holborn Incident Records do not disclose the presence of bombing incidents directly within the boundary of the proposed site. However incidents are recorded in close proximity. A 250kg HE destroyed the South Square chambers and several other buildings were badly damaged, a 250kg bomb also resulted in the demolition of 3 Stone Buildings. It should be noted that the incident records do not however offer a comprehensive account of bombing in the area.
- There are no obvious signs of damage within the site boundary. All structures are present and all roofs appear to be intact within the aerial photography. It is difficult to determine due to shadows minimising the clarity of open ground but there also appear to be no obvious bomb craters or damage at the northern end of the site either.
- Severe damage was recorded within the general area surrounding the site, north of the site within South Square, some chambers were demolished. The chambers immediately north of the site area appear however to have only sustained minor blast damage. This is confirmed within the London County Council Bomb damage, which records no damage at all within the site boundary. Other areas in close proximity to eh site such as 12-13 High Holborn have also been totally destroyed. Damage sustained by bombing in these areas are unlikely to have directly affected the site.
- The site was occupied by three commercial and civil properties. Gray's Inn Gatehouse, Gray's Inn Chambers, and a Public House. In the early years of the war Gray's Inn court, hall and library were badly damaged and abandoned. The buildings present within the site however remained undamaged. It is likely that the gatehouse was still used as an access-way and the Public House would likely have remained open. The site was also situated on a busy street in close proximity to Central London, this further increases the likelihood that regular post-raid checks would be made for items of UXO.

UXO Risk Assessment
• Areas of the site not occupied by buildings during the war appear to comprise of primarily open homogenous made ground. These ground conditions would generally have been conducive to discovering items of UXO. • There is no evidence that the site formerly had any military occupation or usage that could have led to contamination with other items of ordnance. • There has been some post-war redevelopment on the site of proposed works, although the exact nature of the groundwork is unknown. The Public House and Chambers within the site area were combined into one large building. 1st Line Defence have been unable to determine whether the buildings were extended or demolished and rebuilt. The remainder of the site appears to be occupied by hard-standing, tarmacked ground. Where this development has taken place, the risk of encountering shallow buried UXO (especially 1kg incendiaries or anti-personnel bombs) and anti-aircraft projectiles will have been partly mitigated, since any such items may have been discovered during excavations.

Recommended Risk Mitigation Measures
The following risk mitigation measures are recommended to support the proposed works at the 19-21 High Holborn site: **All works** • Site Specific Unexploded Ordnance Awareness Briefings to all personnel conducting intrusive works

In making this assessment and recommending the above risk mitigation measures, the proposed 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.

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Annex B	Recent Aerial Photography
Annex C	Site Plan
Annex D	Pre and Post-WWII Historical Maps
Annex E	Photograph of South Square Damage
Annex F	Photograph of 12 High Holborn
Annex G	Goad Insurance Map
Annex H	Examples of German Air Delivered Ordnance
Annex I	Example of 50kg Bomb Entry Hole
Annex J	Examples of UXO Incidents
Annex K	London WWI Bomb Plot Map
Annex L	WWI Damage Grays Inn Court
Annex M	London WWII Bomb Density Map
Annex N	Luftwaffe Target Reconnaissance Imagery
Annex O	London ARP Consolidated Bomb Census Maps
Annex P	London ARP Weekly Bomb Census Maps
Annex Q	London V1 Flying Bomb Map
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Annex T	Examples of Anti-Aircraft Projectiles

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

Site: 19-21 High Holborn
Client: GEA Ltd

1. Introduction

1.1. Background

1st Line Defence has been commissioned by GEA Ltd to produce a Detailed Unexploded Ordnance (UXO) Threat Assessment for the proposed works at 19-21 High Holborn.

UXO in the UK can originate from three principal sources:

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

In certain parts of the UK buried UXO can present a significant risk to construction works and development projects. Whilst UXO may certainly present a safety risk even the simple discovery of a suspected device during on-going works can cause considerable disruption to production and cause unwanted delays and expense.

This report will examine in detail all the factors that could potentially contribute to a threat from UXO at the site in question. For the majority of sites in the UK the likelihood of encountering UXO of any sort is minimal and generally no further action will be required beyond an initial desktop risk assessment. However, if a potential risk is identified, the report will make recommendations for the most appropriate and work-specific measures available in order to reduce the threat to as low as reasonably practicable. Full analysis and evidence will be provided to allow to client to fully understand the basis for the assessed risk level and any recommendations.

The report directly follows the guidelines set out in the document CIRIA C681 'Unexploded Ordnance (UXO) A Guide for the Construction Industry'.

2. UK Regulatory Environment

2.1. General

There is no formal requirement for undertaking an assessment of UXO risk for construction projects in the UK, nor any specific legislation covering 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.) do undertake a comprehensive and robust assessment or potential risks to employees and that mitigation measures are put in place to address any identified hazards.

2.2. CDM Regulations 2015

This legislation defines the responsibilities of all parties (primarily the Client, the CDM Co-ordinator, the Designer and the Principal Contractor) involved with works. Under CDM2015, the client has the 'legal responsibility for the way that a construction project is managed and run and they are accountable for the health and safety of those working on or affected by the project'.

Although UXO is not specifically addressed, the regulations effectively place obligations on all these 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.

2.3. The 1974 Health and Safety at Work Act

All employers have a responsibility under the Health and Safety at Work Act of 1974 (and the Management of Health and Safety at Work Regulations of 1999) to ensure, so far as is reasonably practicable, the health and safety of their employees and that of other persons who are affected by their work activity (including the general public).

2.4. Additional Legislation

Other relevant legislation includes the Safety at Work Regulations 1999 and The Corporate Manslaughter and Corporate Homicide Act 2007.

3. Role of Commercial UXO Contractors and The Authorities

3.1. Commercial UXO Contractors

The role of an experienced UXO specialist such as 1st Line Defence is to provide expert knowledge and guidance to the client on the most appropriate and cost effective approach to UXO risk management on a site.

The undertaking of Preliminary and Detailed UXO Risk Assessments is the first step in this risk management process. The extensive amount of specialist experience, weapons knowledge, datasets and historical information available to 1st Line Defence in particular, allows a robust, detailed and realistic assessment of the potential risk, and the recommendation of suitable mitigation measures if deemed necessary.

In addition to undertaking specialist Risk Assessments, a commercial UXO contractor will be able to provide pre-construction site survey and clearance/avoidance, as well as a reactive response to any suspect finds.

The presence on site of a qualified UXO Specialist with ordnance recognition skills will avoid unnecessary call-outs to the authorities and allow for arrangement to be made for the removal and disposal of low risk items. If high risk ordnance is discovered, actions will be co-ordinated with the authorities with the objective of causing the minimum possible disruption to site operations whilst putting immediate, safe and appropriate measures in place.

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

3.2. The Authorities

The Police have the responsibility for co-ordinating the emergency services in the case of an ordnance-related incident on a construction site. They will make an initial assessment and if they judge necessary, impose a safety cordon and/or evacuation and call the military authorities Joint Services Explosive Ordnance Disposal (JSEOD) to arrange for investigation and/or disposal. In the absence of an UXO Specialist on site many Police Officers will use the precautionary principle, impose cordon/evacuation and await advice from the JSEOD. The discovery of UXO will invariably cause work to cease on the site and may require the evacuation of the site and neighbouring properties.

The priority JSEOD will give to the police request will depend on their judgement of the nature of the UXO threat, the location, people and assets at risk and the availability of resources. They may respond immediately or as resources are freed up. It can take 1-2 days and often longer for the authorities to respond and deal with a UXB.

Depending on the on-site risk assessment the item of ordnance may be removed from site or destroyed by controlled explosion. In the latter case additional cordons and/or evacuations may be necessary and the process will take longer.

It should be noted that following the discovery of an item of UXO, the military authorities will only carry out further investigations or clearances in very high profile or 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 i.e. the appointment of a commercial contractor to manage the situation.

4. The Report

4.1. Report Objectives

The aim of this report is to undertake a fair, proportionate and comprehensive assessment of the potential risk from UXO at 19-21 High Holborn. Every reasonable effort will be made to ensure that all available and pertinent historical information and records are accessed and checked. Full analysis and evidence will be provided where possible to allow the Client to fully understand the basis for the risk assessment.

Site specific risk mitigation measures will be recommended if deemed necessary, to reduce the threat from explosive ordnance during the envisaged works to as low as reasonably practicable.

4.2. Risk Assessment Process

1st Line Defence undertakes a five-step process for assessing the risk posed by UXO:

1. The risk that the site was contaminated with UXO.
2. The risk 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 considered in detail, site specific and non-site specific factors including:

- Evidence of German bombing, delivery of UXBs, records of abandoned bombs and maximum bomb penetration depth assessment.
- Site history, occupancy and conditions during WWII.
- The potential legacy of Allied military activity.
- Details of the specific UXO threat and any known UXO clearance work.
- The extent of any post-war redevelopment.
- The extent and nature of any proposed works.

4.3. Sources of Information

In order to produce a robust and thorough assessment of UXO risk, detailed historical research has been carried out by specialist researchers. Military records and archive material held in the public domain have been accessed. Information from the following sources has been consulted for this report:

- The National Archives, Kew and Camden Local Studies Archive
- Landmark Maps.
- 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 book and internet resources.

Research involved a visit to the National Archives, Kew.

5. Reporting Conditions

5.1. General Considerations

It is important to note that this desktop assessment is based largely upon research of historical evidence. Although every effort has been made to locate all significant and pertinent information, 1st Line Defence cannot be held accountable for any changes to the assessed level of risk 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 at the time of the reports production.

It is often problematic and sometimes impossible to verify the completeness and accuracy of WWII-era records – see 'Background to Bombing Records'. As a consequence, conclusions as to the exact location, quantity and nature a UXO threat can rarely be definitive. To counter this, it is essential that as many different sources and types of information as possible are consulted and analysed before a conclusion is reached. 1st Line Defence cannot be held responsible for inaccuracies or gaps in the available historical information.

5.2. Background to Bombing Records

In September 1940, the Government started to collect and collate information relating to damage sustained during bombing raids. The data became known as the 'Bomb Census'. Initially, only information relating to London, Birmingham and Liverpool was collated, but quickly the bomb census was extended to cover the rest of the UK.

Its purpose was to provide the Government with a complete picture of raid patterns, types of weapon used and damage caused – in particular to strategic services and installations such as railways, factories and public utilities.

Information was gathered locally by police, Air Raid Wardens and military personnel. They noted when, where and what types of bombs had fallen during an air raid, and passed this on to the Ministry of Home Security. Records of strikes were made either through direct observation or by post-raid surveys. However, the immediate priority was to deal with casualties and minimise damage. As a result, it is only to be expected that the records kept were often incomplete and contradictory.

Prior to the official 'Bomb Census', record keeping in the early months of the war was not comprehensive. The quality, detail and nature of record keeping could vary considerably from borough to borough and town to town. Many records were even damaged or destroyed in subsequent attacks. Records of raids that took place on sparsely or uninhabited areas were often based upon third party or hearsay information and are 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.

6. The Site

6.1. Site Location

The site is situated in the London Borough of Camden in the area of Holborn, approximately 1.63km north-east of the City of London.

Immediately west of the proposed site is the 'Citte of Yorke' Public House and a commercial building housing a 'Superdrug' lies to the east. South of the site is High Holborn road with several commercial properties beyond it. To the north of the court lies Gray's Inn Court with the South Square to the adjacent to the site.

The site is centred on the approximate OS grid reference: **TQ 3105081643**

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

6.2. Site Description

The proposed site is an irregular shaped parcel of land. The site lies on High Holborn and covers numbers 19-21. The western border of the site houses Gray Inn Gate, and three storey gatehouse which serves as the entrance to the Gray Inn Court of Law. The northern area of the site comprises of predominately open hard-standing ground with an unknown structure in the centre northern area. Rymill Stationers and Post Office currently occupy the eastern and southern areas of the site.

A recent aerial photograph, site boundary and plan drawing of the site area are presented in **Annex B** and **Annex C** respectively.

7. Scope of the Proposed Works

7.1. General

The exact scope of intrusive works proposed on site was not available at the time of production of this report. However; site investigation works are presumed at the initial stage.

8. Ground Conditions

8.1. General Geology

The British Geological Survey (BGS) map shows the site to be underlain by the London Clay formation – Clay, Silt and Sand, of the Palaeogene Period.

8.2. Site Specific Geology

Site specific geotechnical information was not made available to 1st Line Defence at the time of writing this report. However; GEA Ltd provided historic borehole data for 29a High Holborn. Borehole data for 29a High Holborn indicates made ground conditions down to 2m with superficial deposits of soft brown sandy, silty clay with fine medium gravel down to a level of 4.6m. From 4.6m down to the base level of this borehole reading of 40m stiff brown, silty clay is recorded with light brown sand and fine-medium gravel. However; between 20m and 30m the clay gradually changes colour to blue-grey and then grey. At 37m a claystone boulder is recorded. This information cannot provide an accurate

assessment of geology within the proposed site. It does however provide an insight into geology in the area.

9. Site History

9.1. Ordnance Survey Historical Maps

Pre and post-WWII historical maps for the site were obtained by GEA Ltd from Landmark Maps. These are presented in **Annex D**.

WWI Period		
Date	**Scale**	**Description**
1916	1:2,500	Mapping indicates the presence of predominately commercial properties within the site area. Gray's Inn Gate is marked in the western corner of the site. In the eastern section a Public House partially falls within the site location. Further research has determined that this was the location of Gray's Inn Tavern and Coffee shop. The building in the centre of the site area is unmarked. However; further research has determined that the building housed Grey Inn Chambers and most likely contained accommodation and offices for students 'called to the bar.' The general area surrounding the site comprises of predominately commercial and civil buildings. A Public House is recorded immediately east of the site. During this period the pub was called the Irish House. To the north of the site is Gray's Inn Court with the South Square courtyard and chambers to the immediate north.

Pre-WWII		
Date	**Scale**	**Description**
1937	1:1,056	No significant changes appear to have occurred within the site area. It is possible that the building in the centre of the site has been extended. However the previous map edition is of a larger scale than the 1937 edition and it may be that the building was more accurately placed on the later map. Some developments appear to have occurred in the general area surrounding the site. Although not visible in the mapping, further research has determined that the public house to the immediate west of the site was rebuilt in 1922 and renamed 'Henekey's Holborn Inn'

Post-WWII		
Date	**Scale**	**Description**
1952-1953	1:1,250	The general footprint of the site has remained the same as the previous map edition. The only thing to have changed is that on the eastern border numbers 15-18 High Holborn have been combined and part of the site area has been merged with that building. Several changes appear to have occurred within the immediate vicinity of the site and in the general area. The first major change is situated to the north of the site where the South Square chambers were situated. They are recorded as ruins. Further research has determined that these buildings were damaged by bombing. A photograph of the damage can be seen in **Annex E.** Another area of

		ruins are noted to the east of the site at numbers 9-13 High Holborn. A photograph of the damage is available to view in **Annex F.**
1958-1969	1:1,250	No significant changes appear to have occurred within the site area since the previous map edition. It is difficult to determine whether any significant changes have occurred to the area surrounding the site. However; it appears that many of the areas marked as ruins on the previous map edition have been rebuilt.
1991	1:1,250	Significant development has occurred within the site area since the previous map edition. The public house and the building within the centre of the site have been demolished. A new rectangular building has replaced them. Some minor redevelopments have occurred in the general are surrounding the site. For example to the south of the site beyond High Holborn several properties appear to have been extended.

9.2. Insurance Mapping

Pre and post-WWII insurance maps for the site were obtained by 1st Line Defence for this site. These indicate the type and structure of properties that occupied the site area and surrounding buildings. See **Annex G** for the mapping with the site boundary outlined accordingly.

Pre WWII		
Date	**Scale**	**Description**
1922	40ft = 1 inch	This map edition indicates that there were several distinct buildings within the site area during 1922. The Gateway is four storey high with offices and an attic over the entrance. The building in the southern-centre of the site is occupied by Gray's Inn Chambers and offices. The public house is also four storeys high. Above the Gray's Inn Chamber is more offices and a stone staircase. Skylights, Lanterns and Fire Alarms are also recorded.
WWII		
Date	**Scale**	**Description**
1942	40ft = 1 inch	No significant changes appear to have occurred within the site area since the previous map edition, a skylight has been installed above the gate house. Though areas in the vicinity of the site were seriously damaged during the early years of the blitz, they are not marked as green for cleared. 11-12 High Holborn are marked as *rest*. This is a different annotation than in the previous map edition, it also does not show on the key. It is possible that it may represent bomb damage as both buildings were destroyed in 1940.
Post-WWII		
Date	**Scale**	**Description**
1956	40ft = 1 inch	The public house has been demolished. There is now a large building that partially covers the site. Other than this the map edition outlines little significant structural change within the immediate site of proposed works. It is important to note that north of the site the area occupied by Gray's Inn, South Square Chambers is recorded as being under construction. The area was seriously damaged by enemy action during the war. Numbers 11 and 12 have been destroyed and a new large building erected in their place.

10. Aerial Bombing Introduction

10.1. General

During WWI and WWII, many towns and cities throughout 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 techniques often resulted in all areas around a specific target being bombed.

In addition to raids which concentrated on specific targets, indiscriminate bombing of large areas also took place – notably the London 'Blitz', but also affecting 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 and while 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.

The main focus of this report with regards to bombing will be weapons dropped during WWII, although WWI bombing will also be considered.

10.2. Generic Types of WWII German Air-delivered Ordnance

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. A brief summary of these characteristics is given below. Examples of German air delivered ordnance are presented at **Annex H**.

Generic Types of WWII German Air Delivered Ordnance	
High Explosive (HE) Bombs	
Frequency	In terms of weight of ordnance dropped, HE bombs were the most frequent weapon deployed by the Luftwaffe during WWII.
Size/Weight	Most bombs were 50kg, 250kg or 500kg (overall weight, about half of which was high explosive) though larger bombs of up to 2000kg were also used.
Description	High explosive bombs are thick-skinned and typically have sufficient mass and velocity and a suitably streamlined shape to enable them to penetrate the ground if they failed to explode on the surface.
Likelihood of detecting Unexploded	Although efforts were made to identify the presence of unexploded ordnance following a raid, often the damage and destruction caused by bombs which did detonate often made observation of UXB entry holes impossible. The entry hole of an unexploded bomb can be as little as 20cm in diameter and easily overlooked in certain ground conditions (See **Annex I**). Furthermore, ARP documents describe the danger of assuming that damage, actually caused by a large UXB, was due to an exploded 50kg bomb. UXB's therefore present the greatest risk to present–day intrusive works.
Aerial or Parachute Mines	
Frequency	These were much less frequently deployed than HE and Incendiary bombs due to their size, cost and their difficulty technically to deploy.
Size/Weight	Their weight was either 500kg or 1000kg (overall weight, of which about 2/3 was explosive) depending on the type of mine. Their length ranged from 1.73-2.64m.
Description	The Luftmines (LMA-500kg and LMB-1000kg) were magnetic sea mines which were thin walled, cylindrical in shape with a hemispherical nose and were deployed under a green artificial silk parachute about 8m in diameter. They were fitted with magnetic and later with acoustic or magnetic/acoustic firing. When the mine hit the water and sank to more than 8ft, hydrostatic

	pressure and the dissolution of a soluble plug actuated the magnetic device and the mine became operational against shipping. The mine was also armed with a clockwork bomb fuze which caused the bomb to explode when used against land targets, and this was started by the impact of hitting the ground. The Bombenmine (BM 1000, Monika, or G Mine) was also used. This was fitted with a tail made from Bakelite which broke up on impact. It had a photoelectric cell beneath a cover which detonated the bomb if exposed to light to counteract the work of bomb disposal units.
Likelihood of detecting Unexploded	The aerial mines were either 500kg or 1000kg (overall weight, of which about 2/3 was explosive) depending on the type of mine. Their length ranged from 1.73-2.64m. They were much less frequently deployed than H.E. and Incendiary bombs due to their size, cost and the fact that they could not be delivered to point targets. If functioning correctly, parachute mines would generally have had a slow rate of descent (falling at about 40 mph) 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. When operating as designed they caused considerable damage due to the high weight of explosive and their detonation at or near the surface. However 1st Line Defence does not consider there to be a significant threat from unexploded aerial mines on land.
1kg Incendiary Bombs	
Frequency	In terms of number of weapons dropped these small Incendiaries were the most numerous. Millions of these weapons were dropped throughout WWII.
Size/Weight	1kg
Description	These thermite filled devices were jettisoned from air-dropped containers. Some variants had explosive heads and these present a risk of detonation during intrusive works.
Likelihood of detecting Unexploded	They had very limited penetration capability and in urban areas especially would usually have been located in post-raid surveys. If they failed to initiate and fell in water, on soft vegetated ground, or bomb rubble, they could easily have gone unnoticed.
Large Incendiary Bombs	
Frequency	These items of ordnance were not as common as the 1kg Incendiaries however they were still more frequently deployed than the Parachute Mines and Anti-Personnel Bomblets.
Size/Weight	These could weigh up to 350kg.
Description	They had various flammable fill materials (including oil and white phosphorus), and a small explosive charge. They were designed to explode and burn close to the surface. Although they were often the same shape as HE bombs, they were thin-skinned and generally did not penetrate the surface.
Likelihood of detecting Unexploded	If they 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	
Frequency	They were not commonly used and generally considered to pose a low risk to most works in the UK.
Size/Weight	The size and weight ranged depending on the type used. The most common was the “Butterfly Bomb” (SD2) which weighed 2kg and contained 225 grams of TNT.
Description	The ‘Butterfly Bomb’ had an 8cm long, thin, cylindrical, cast iron outer shell which hinged open when the bomblet deployed gave it the superficial appearance of a large butterfly. A steel cable 15 cm long was attached via a spindle to an aluminium fuze. The wings at the end were canted at an angle to the airflow, which turned the spindle anti-clockwise as the bomblet fell. After the spindle had revolved approximately 10 times (partially unscrewing itself from the bomb) it released a spring-loaded pin inside the fuze, which fully armed the SD2 bomb. They were generally lethal to anyone within a radius of 10 metres (33 ft) and could inflict serious shrapnel

	injuries. There were a number of variants, the most common being the SD2 which weighed 2kg and contained 225 grams of TNT. They were not commonly used and generally considered to pose a low risk to most works in the UK.
Likelihood of detecting Unexploded	SD2 bomblets were not dropped individually, but were packed into containers holding between 6 and 108 submunitions however, AP bombs 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.

10.3. Failure Rate of German Air-Delivered Ordnance

It has been estimated that 10% of the German HE bombs dropped during WWII failed to explode as designed. This estimate is based on the statistics of wartime recovered UXBs and therefore will not have taken account of the unknown numbers of UXBs that were not recorded at the time. It is therefore quite likely that the average failure rate would have been higher than this.

There are a number of reasons why an air-delivered weapon might fail to function as designed:

- Many German bombs were fitted with a clockwork mechanism which could jam or malfunction.
- Malfunction of the fuze or gain mechanism (manufacturing fault, sabotage by forced labour or faulty installation)
- Failure of the bomber aircraft to arm the bombs due to human error or equipment defect.
- Jettison of the bomb before it was armed or from a very low altitude. Most likely if the bomber was under attack or crashing.

War Office Statistics document that a daily average of 84 bombs which failed to function were dropped on civilian targets in Great Britain between 21st September 1940 and 5th July 1941. 1 in 12 of these probably mostly fitted with time delay fuzes exploded sometime after they fell, the remainder were unintentional failures.

From 1940 to 1945 bomb disposal teams dealt with a total of 50,000 explosive items of 50 kg and over i.e. German bombs, 7,000 AAA shells and 300,000 beach mines. These operations resulted in the deaths of 394 officers and men. However, unexploded ordnance is still regularly encountered across the UK, especially in London; see press articles in **Annex J**.

10.4. V-Weapons

From mid-1944, Hitler's 'V-weapon' campaign began. It used newly developed unmanned cruise missiles and rockets. The V1 known as the *Flying Bomb* or *Doodlebug* and the V2, a Long Range Rocket, were launched from bases in Germany and occupied Europe. A total of 2,419 V1s and 517 V2s 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. It should be stressed that 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 threat 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.

11. UXB Ground Penetration

11.1. 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 groundcover
- Underlying geology

Geology is perhaps the most important variable. If the ground is soft, there is more potential for deeper penetration – peat and alluvium are easier to penetrate than gravel and sand for example and the bomb is likely to come to rest at deeper depths. Layers of hard strata will significantly retard and may stop the trajectory of a UXB.

11.2. The J Curve Effect

J-curve is the term used to describe the characteristic curve commonly followed by an air-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.

11.3. 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, mostly in the London area. They then came to conclusions as to the likely average and maximum depths of penetration of different sized bombs in different geological strata.

They concluded that the largest common German bomb, 500kg, had a likely 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 1000kg bomb 12.8m. Theoretical calculations suggested that significantly greater penetration depths were probable.

11.4. Site Specific Bomb Penetration Considerations

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

- WWII Geology – London Clay Formation
- Impact Angle and Velocity – 10-15° from Vertical and 270 metres per second.
- Bomb Mass and Configuration – The 500kg SC (General Purpose) 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 due to the limits of available borehole information.

12. Initiation of Unexploded Ordnance

12.1. General

Unexploded ordnance does not spontaneously explode. All high explosive 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.

12.2. UXB Initiation Mechanisms

There are a number of ways in which UXB can be initiated. These are detailed in the table below.

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 Clock	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	This is the most likely scenario resulting in the weapon detonating; 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 J details UXB incidents where intrusive works have caused UXBs to detonate, resulting in death or injury and damage to plant.

12.3. 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:

- 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 weakening of support structures
- Environment – introduction of potentially contaminating materials

13. The Threat from German UXBs

13.1. World War I

During WWI London was targeted and bombed by Zeppelin Airships and by 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 K** for a WWI bomb plot map of London.)

There were several significant attacks recorded as having hit the Metropolitan Borough of Holborn, of which three occurred in close proximity to the site. The first raid occurred on the 13th October 1915, when two of the Inns of Court; Lincolns Inn and Gray's Inn were damaged. Photography of the damage is available to view in **Annex L.** Little information is known about the two later raids except they occurred on the 6th December 1917 and on the 18th December 1917.

WWI bombs were generally smaller than those used in WWII and were dropped from a lower altitude, resulting 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 threat from WWI UXBs is considered low and will not be further addressed in this report.

13.2. World War II Bombing of Holborn

The Luftwaffe's objective for the attacks on London was to paralyse the commercial life of the capital by bombing the docks, warehouses, wharves, railway lines, factories and power stations.

Holborn (the site was situated within the Municipal Borough of Holborn during WWII) experienced a high density of bombing, as illustrated by the bomb density data figures and maps see **Annex M**. About one seventh of its property was destroyed and 426 people died as a result of the air raids. 621 were also badly injured. This was mainly due to its location on the periphery of the City of London.

There were a number of industry hubs in the area which would have been targeted as part of the Luftwaffe bombing campaign. The site is situated within the Inns of Court a significant business and legal district in London. Its destruction could be seen as an attempt to disrupt the daily life of Britain. Many of the courts took on secondary roles during the war. For example Lincoln's Inn was used as a headquarters for a military regiment. Gray's Inn was severely damaged during the early blitz and therefore was not used for military purposes.

In September 1940, Luftwaffe pilots were equipped with maps depicting districts in London to avoid, such as neutral embassies, and areas to target deliberately. The latter included the City of London, official government buildings and key transport hubs. These sorts of buildings were prolific in the Holborn area at that time. During late 1940-1941, this element of precision ceased and London was designated an 'area target' to be attacked at night from high level.

Luftwaffe target reconnaissance imagery surprisingly shows only a few significant targets of note including a drainage system and a water works. This however was taken at the beginning of the war and would not have been a comprehensive list of all the viable targets in the area. See **Annex N.**

Two significant bombing incidents that occurred in close proximity to the proposed site were photographed. The first on the 8th October 1940 ('Black Saturday'). At least one bomb was dropped on High Holborn, the wrecked building in the first photograph (**Annex F**) is almost certainly 12 High Holborn, and housed Manzoni's restaurant. Photograph two (**Annex F2**) shows a number of rescuers

tunnel into the rubble to find survivors. Approximately 32 people died in this raid, with four dyeing in Manzoni's.

Annex E shows the damage caused when a HE bomb fell on the South Square of Greys Inn Court, immediately north of the site. It is likely that this bomb fell on the week of the 6th January 1941. The square was redeveloped in 1956 by Sir Edward Maufe.

Records of bombing incidents for Holborn are presented in the following sections.

13.3. Second World War Bombing Statistics

The following tables summarise the quantity of German bombs (excluding 1kg incendiaries and anti-personnel bombs) falling on the Metropolitan Borough of Holborn between 1940 and 1945.

Record of German Ordnance Dropped on the Metropolitan Borough of Holborn		
Area Acreage		**406**
Weapons	High Explosive Bombs (all types)	354
	Parachute Mines	7
	Oil Bombs	15
	Phosphorus Bombs	8
	Fire Pot	0
	Pilotless Aircraft (V1)	4
	Long Range Rockets (V2)	1
Total		**374**
Number of Items per 1000 acres		**921.2**

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 incendiaries are not particularly significant in the threat they pose, they nevertheless are items of ordnance that were designed to cause damage and inflict injury and should not be overlooked in assessing the general risk to personnel and equipment. The anti-personnel bombs were used in much smaller quantities and are rarely found today but are potentially more dangerous.

13.4. London Air Raid Precautions Bomb Census Maps

During WWII, the Ministry of Home Security produced consolidated and weekly bomb census maps for London. The maps covering the area of the site were checked for this report. Those showing bomb strikes on and in the vicinity of the site are presented in **Annexes O & P** and are discussed below:

London Consolidated Bomb Maps – Annex O	
Date Range	**Comments**
Night Bombing up to 7th October 1940	No bombs are recorded as having fallen directly within the site area. The closest HE bomb is recorded to the immediate west of the site in Fulwood Place. **Two HE bombs** are also recorded within Chancery Lane to the south of the site. Other areas of note, include the area of the Gray Inn court to the north of the site and areas to the east where several bombs are recorded.
Night Bombing 7th October 1940 to 6th June 1941	Several HE bombs are recorded as having fallen in close proximity to the site boundary. **One HE bomb** of particular note is documented within the South

	Square of Gray Inn Court. Dense bombing is recorded within other areas of the Gray Inn Court and to the south around Lincoln's Inn Court and Chancery Lane. However bombs surround the site and there appear to be no areas that did not fall in close proximity to a bombing raid.
Day bombing 08th October 1940 to 31st December	**One HE bomb strike** is recorded as having fallen within the site boundary.

London Weekly Bomb Maps – Annex P	
Date Range	**Comments**
07th to 14th October 1940	Several strikes are recorded as having fallen within the vicinity of the site. One HE bomb was recorded as fallen to the east of the site. A large strike was also recorded to the south and covered the area from Lincolns Inn Fields to Chancery Lane. One HE bomb and One Oil Bomb are recorded north of the site within Grays Inn court.
4th-11th November 1940	No bombs strikes are recorded within the site boundary. Several HE bombs appear to have been dropped in Grays Inn Court and several to the east of the site. However, they do not directly affect the site of proposed works.
11th-18th November 1940	**Two HE bombs** are recorded to the south of the site along with an **Incendiary shower**. However, they do not directly affect the site of proposed works.
02nd – 09th December 1940	A Large **Incendiary shower** is recorded that covered the area from Lincolns Inn in the south to Grays Inn, in the north.
06th-13th January 1941	**One HE bomb** is recorded as having fallen within the site boundary. To the east **One Unexploded HE bomb** and **One HE bomb** are also noted.
03rd- 10th March 1941	No bombs strikes are recorded within the site boundary. Several **Unexploded HE bombs** are noted as having fallen in the area. The highest concentration of these lies to the east of the site where **three Unexploded HE bombs** are recorded. **One exploded HE bomb** is also recorded. **Two Unexploded HE bombs** are also noted to the north.
05th-12th May 1941	No bombs strikes are recorded within the site boundary. To the south several **HE bomb** strikes are recorded. **One HE bombs** is also recorded to the east.
20th-26th March 1944	No bombs strikes are recorded within the site boundary. North-east of the site are **two unexploded 500kg HE bombs**. However, they do not directly affect the site of proposed works.

13.5. London V-Weapon Maps

Plots showing the location of all the V-1 strikes in the London area were compiled by the Ministry of Home Security. The area covering the site was checked and a section of it is presented in **Annex Q**.

V-Weapon Map – Annex Q.	
Date Range	**Comments**
Post-war consolidated Bomb Plot Map	**3 V1 Flying Bombs** fell in the general area. The closest of which is situated approximately 115m south-east of the site. Severe, Significant Damage from V weapons cannot be attributed to the site in question.

V2 Weapon – Long Range Rocket Bombs

Plots showing the location of the V2 strikes in the London area were compiled by the 'Londonist' Newspaper. It is not certain how accurate the information is, information was compiled from several sources such as London County Council bomb damage maps, books and anecdotal evidence.
One V2 strike is recorded in close proximity to the proposed site. It is situated approximately 90.25 west of the site, at Warwick Court. It is unlikely to have directly impacted the site.

13.6. Lincoln's Inn Air Raid Precautions Bomb Incident Records

Written incident records were obtained from the National Archives, Kew and the Camden Local Studies and Archives Centre. A transcript of the associated written records for bombs which fell in the area is presented in the table below. Only those recorded incidents on or in close proximity to the site have been highlighted.

Date Range	Comments
10th October 1940	**Lincolns Inn Fields:** HE bomb fell at approximately 22:50
16th October 1940	**Lincolns Inn Fields:** Land Mine fell at approximately 04:14
11th January 1941	**South Square of Gray's Inn Place:** 250kg High Explosive Bomb detonated at base of buildings causing destruction of a long property. Centre of crater building line 10ft. Presidential office buildings, frontage destroyed. Adjoining buildings badly damaged by the blast.
16th April 1941	**Portpool Lane: off Gray's Inn Road**: Parachute Mine: Fell in road between Portpool buildings (North) and Duncan's Buildings (South) – Blast damage over a wide area.
10th May 1941	**3 Stone Buildings:** Incident report refers to damage from '250kg High Explosive' to 3 Stone Buildings. Wincons Inn. The building is noted as 'practically demolished'.
	Warwick Court Gray's Inn: 50kg High Explosive Bomb resulted in possible fire. This has a cross through, which suggests that the fire was misreported.
	High Holborn Station: Oil Bomb dropped. Only damage done was fire to grounds floor of 2/3 shops in Kingsbourne House – satisfied that the damage was caused by the oil bomb and no incendiary bombs or mines dropped fire
	Lincolns Inn Field: 250kg High Explosive Bomb fell in pond around 40' from Bandstand. No other damage.
	Chancery Lane: HE bomb fell near top, near to offices. Repairs arranged with five weeks to go. (*NB: It is important to note that the exact location of this bomb cannot be confirmed due to the length of Chancery Lane.)*

13.7. London County Council Bomb Damage Map

A map compiled by London County Council showing the extent of bomb damage on the borough was compiled during / after WWII. The section showing the area of the site is presented in **Annex R.**

London County Council Bomb Damage Map – Annex R	
Date Range	**Comments**
Post-War Consolidated Bomb Damage Map	No damage is noted within the immediate site boundary. Serious damage is however recorded in close proximity to the proposed site. Gray's Inn South Square appears to have suffered various levels of damage. Situated immediately north of the site, the chambers obtained some general blast damage but the majority of the South Square was either totally destroyed or damaged so seriously that repairs were doubtful. A photograph of this damage can be seen in Annex E.

	To the east of the site at the location of number 12 High Holborn total destruction is recorded. A photograph of this damage can be seen in Annex X. The area around Warwick Court also has severe damage, most likely attributed to the V2 weapon marked on the map as a large circle. South of the proposed site damage were also recorded.

13.8. WWII-Era Aerial Photographs

High resolution scans of WWII-era aerial photography for the site area were obtained from the National Monuments Record (Historic England). Imagery dated 23rd August 1945 is presented in **Annex S.**

There are no obvious signs of bomb damage within the proposed site. All roofs appear to be intact throughout the site. However; it is difficult to determine whether any damage or craters are present in the northern section of the site, as shadows from the surrounding buildings appear to have obscured the view and minimised the clarity of the photograph.

There are however signs of bomb damage both in the immediate vicinity and the general area surrounding the site. North of the site serious damage has occurred within the South Square Chambers. This correlates with the London County Council Bomb Damage Map. Some roofs are still intact but vast piles of debris are present throughout the South Square. The section of the chambers immediately north of the site appears to have escaped the worst of the damage.

As expected to the east of the site numbers 12 and 13 High Holborn have been completely demolished, although the debris present in Annex X appears to have been cleared. Severe damage is visible within Warwick Court, with several roofs damaged and areas that have been completely destroyed. To the south of the site within Chancery Lane several properties have suffered severe damage with others being totally demolished.

A view of the wider area is located in **Annex S2**.

13.9. 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 were 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. The closest officially registered abandoned bomb was situated 3.75km south of the site.

13.10. 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 Ltd will be advised.

13.11. Evaluation of Bombing Records

Item	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 Metropolitan Borough of Holborn was subject to a **Very High** density of bombing with 921.2 items of ordnance recorded per 1,000 acres. Bombing in the area can be attributed to the sites proximity to the City of London, approximately 1.6km north-east and also because of the nearby strategically important targets such as the Inns of Court and the legal and business districts of Westminster. The consolidated and weekly London ARP bomb census mapping indicates the presence of one HE bomb strike that fell within the site boundary. Dense bombing is also recorded in close proximity to the site, particularly in the area of South Square and Gray's Inn which may have had a direct impact on the site. Holborn Incident Records do not disclose the presence of bombing incidents directly within the boundary of the proposed site. However incidents are recorded in close proximity. A 250kg HE destroyed the South Square chambers and several other buildings were badly damaged, a 250kg bomb also resulted in the demolition of 3 Stone Buildings. The incident records do not however offer a comprehensive account of bombing in the area. Only large raids during 1941 and 1942 are covered in any detail and only special reports from Lincoln's Inn were covered during 1940. Neither the London ARP bomb nor the Holborn Incident records offer a comprehensive account of bombing in the area. It is difficult to determine therefore the exact number of bombs that fell within the area and it is also possible that items of ordnance may have fallen unrecorded within the site boundary.
Ground Cover *The type & amount of ground cover existing during WWII would have a substantial influence on any visual indication that may indicate UXO being present.*	The proposed site comprised of several buildings during WWII; A Gatehouse, Gray's Inn Chambers and a Public House. The groundcover for the remaining sections of the proposed site appears to comprise of primarily hard-standing made ground. This type of groundcover is generally considered conducive to discovering items of UXO.
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 are also likely to have been subject to post-raid checks for evidence of UXO.*	Evidence suggests that the proposed site would have had a relatively high level of access throughout the war. The site was occupied by three commercial and civil properties. A Gatehouse, Gray's Inn Chambers, and a Public House. Even after Gray's Inn was badly damaged and shut in the early years of the war it is likely that these buildings would continue to be occupied and the gateway used for access. The Public House would almost certainly have remained open which further increases the likelihood that regular post-raid checks would be made for items of UXO.

Damage *If buildings or structures on a site suffered 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*	There are no obvious signs of damage within the site boundary. All structures are present and all roofs appear to be intact within the Aerial Photography. It is difficult to determine due to shadows minimising the clarity of open ground but there also appear to be no obvious bomb craters. Damage has occurred within the general area surrounding the site for example to the north of the boundary within South Square, some chambers were demolished. The chambers immediately north of the site area however; appear to have only sustained minor blast damage. This is confirmed within the London County Council Bomb damage. Other areas in close proximity to eh site such as 12-13 High Holborn have also been totally destroyed. Damage sustained by bombing in these areas are unlikely to have directly affected the site due to a buffer zone of roadways and properties between the site and the damaged areas.
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 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.

14. The Threat from Allied Military Ordnance

14.1. General

In addition to the threat from aerial delivered UXO, this report also assesses the potential risk from Allied military ordnance. Contamination from items of Land Service (LSA) and Small Arms Ammunition (SAA) may result, for example, from historic occupation of an area or its use for military training. Inner city sites can be at risk from buried unexploded Anti-Aircraft projectiles fired during WWII.

14.2. Land Service Ammunition

The term LSA covers all items of ordnance that are propelled, placed or thrown during land warfare. They may be filled or charged with explosives, smoke, incendiary or pyrotechnics. They can be broken into five main groups:

Mortars	A bomb, normally nosed-fused and fitted with its own propelling charge. Its flight is stabilised by the use of a fin. They are usually tear-dropped shape (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. They are either High Explosive or Carrier (i.e. smoke, incendiary or pyrotechnic).
Grenades	A short range weapon (explosive range 15-20m) which can be thrown by hand or alternatively fired from the end of a rifle or a purposely designed grenade launcher. They can either be High Explosive or Carrier (usually smoke) and common variants have a classic 'pineapple' shape.

Projectiles	A projectile (or shell) is defined as an object which can be propelled by force, normally from a gun, and continues in motion by virtue of its kinetic energy. It contains a fuzing mechanism and a filling. Projectiles can be High Explosive, Carrier or Shot (a solid projectile).
Rockets	A rocket is defined as a missile that obtains thrust from a rocket engine. Military rockets are used to propel warheads to an intended target. This warhead will contain an explosive charge normally initiated on contact or at a predetermined height / proximity from target.
Landmines	A landmine is a munition designed to be placed under, on, or near the ground or other surface and to be exploded by the presence, proximity or contact of a person or vehicle.

Unexploded or partially unexploded Mortars and Grenades are among the most common items of LSA encountered in the UK as they could be transported and utilised anywhere. They are commonly encountered in areas used by the military for training and are often found discarded on or near historic military bases.

As with UXBs, items of LSA do not become inert or lose their effectiveness with age. Time can cause items to become more sensitive and less stable. This applies equally to items submerged in water or embedded in silts, clays or similar materials. The greatest risk occurs when an item of ordnance is struck or interfered with. This is likely to occur when mechanical equipment is used or when unqualified personnel pick up munitions.

14.3. Defending London from Aerial Attack

Both passive and active defences were deployed against enemy bombers attacking targets in the London region.

Passive Defences	Active Defences
These included defence tactics such as: • To hinder the identification of targets, by using lighting blackouts at night and camouflaging strategic installations. • To mislead bomber pilots into attacking decoy sites located away from the city with the use of dummy buildings or lighting to replicate that of the city under attack. • To force attacking aircraft to higher altitudes with the use of barrage balloons.	These relied on a coordinated combination of a number of installations in order to actively engage and oppose attacking aircraft. Some of these installations were: • Fighter aircraft to act as interceptors. • Anti-aircraft gun batteries. • The use of rockets and missiles (later during WWII).

14.4. Anti-Aircraft Artillery (AAA) and Projectiles

At the start of WWII two types of Anti-Aircraft Artillery (AAA) guns were deployed: Heavy Anti-Aircraft Artillery (HAA), using large calibre weapons such as the 3.7" QF (Quick Firing) gun and Light Anti-Aircraft Artillery (LAA) using smaller calibre weapons such as 40mm Bofors gun.

During the early war period there was a severe shortage of AAA available and older WWI 3" and modified naval 4.5" guns were deployed alongside those available 3.7" weapons. The maximum ceiling height of fire at that time was around 11,000m for the 3.7" gun and less for other weapons. As the war progressed improved variants of the 3.7" gun were introduced and, from 1942, large 5.25 inch weapons began to be brought into service. These had significantly improved ceiling heights of fire reaching over 18,000m.

The LAA batteries were intended to engage fast low flying aircraft and were typically deployed around airfields or strategic installations. These batteries were mobile and could be moved to new positions

with relative ease when required. The most numerous of these were the 40mm Bofors gun which could fire up to 120 x 40mm HE shells per minute to over 1800m.

The HAA projectiles were high explosive shells, usually fitted with a time delay or barometric pressure fuze to make them explode at a pre-determined height. If they failed to explode or strike an aircraft, they would eventually fall back to earth. Details of the most commonly deployed WWII AAA projectiles are shown below:

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

Although the larger unexploded projectiles could enter the ground they did not have great penetration ability and are therefore likely to be found close to WWII ground level. These shells are frequently mistakenly identified as small German air-delivered bombs, but are differentiated by the copper driving band found in front of the base. With a high explosive fill and fragmentation hazard these items of UXO present a significant risk if encountered. The smaller 40mm projectiles are similar in appearance and effect to small arms ammunition and, although still dangerous, present a lower hazard because of a lower explosive content. They are still dangerous because they were fitted with an impact initiated fuze which was also a spin-decay self-destruct mechanism.

Numerous unexploded AAA shells were recovered during and following WWII and are still occasionally encountered on sites today.

The closest recorded HAA battery to the site was situated approximately 3.38km west of the site in the vicinity of Hyde Park.

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

14.5. Evaluation of Allied Military Ordnance Risk

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

Item	Conclusion
Military Camps	1st Line Defence could find no evidence of a Military Camp within the site.
Anti-Aircraft Defences	1st Line Defence could find no evidence of Anti-Aircraft Defences in the site proximity.
Home Guard Activity	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	There is no evidence of any defensive structures in the vicinity of the site.

Training or firing ranges	No evidence of these could be found.
Defensive Minefields	No evidence of these could be found.
Ordnance Manufacture	No evidence of ordnance manufacture could be found.
Military Related Airfields	The site was not situated within the vicinity of a military airfield.
Explosive Ordnance Clearance Tasks	1st Line Defence holds no records of EOD operations on the site.

15. Ordnance Clearance and Post-WWII Ground Works

15.1. General

The extent to which any ordnance clearance activities have taken place on site or extensive ground works have occurred is relevant since on the one hand they may indicate previous ordnance contamination but also may have reduced the risk that ordnance remains undiscovered.

15.2. 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.

15.3. Post war Redevelopment

There has been some re-development on the site post WWII. The extent of the developments and depth of foundations can partly mitigate the UXO risk as any present items of UXO may have been uncovered during the works.

The only significant development occurred after 1969 but prior to 1991, the public house and central building (Gray's Inn Chamber) were combined into one building. It is not known whether the previous buildings were demolished and rebuilt or were just extended. It is therefore not possible to determine what the depths of foundations and partially mitigate the UXO Risk.

16. 1st Line Defence Risk Assessment

16.1. Risk Assessment Stages

Taking into account the quality of the historical evidence, the assessment of the overall threat to the proposed works 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 located and evaluated pre- and post-WWII Ordnance Survey maps, London WWII ARP bomb plots from 1940 to 1945, London County Council Bomb Damage Maps, London Group Three Bomb Incident Records, in-house data and post WWII era aerial photographs for the site. The record is of an okay quality, major incidents are recorded across multiple sources and in detail. Some Incidents have been accounted for in written records and their locations confirmed/corroborated between different record sets. However; some smaller incidents have not been recorded in the written records.
The Risk that the Site was Contaminated with UXO	After considering the following facts, 1st Line Defence believes that there is a **Low Risk** that unexploded high explosive bombs fell unnoticed and unrecorded within the site boundary. • The Metropolitan Borough of Holborn was subject to a **Very High** density of bombing with 921.2 items of ordnance recorded per 1,000 acres. Bombing in the area can be attributed to the sites proximity to the City of London, approximately 1.6km north-east and also because of the nearby strategically important targets such as the Inns of Court and the legal and business districts of Westminster. • The consolidated and weekly London ARP bomb census mapping indicates that one HE bomb fell on or very close to the site boundary. It is thought likely however that this strike may have been misplotted as no further evidence concerning it has been found. Dense bombing is also recorded in close proximity to the site, particularly in the area of South Square and Gray's Inn which may have had a direct impact on the site. • Holborn Incident Records do not disclose the presence of bombing incidents directly within the boundary of the proposed site. However incidents are recorded in close proximity. A 250kg HE destroyed the South Square chambers and several other buildings were badly damaged, a 250kg bomb also resulted in the demolition of 3 Stone Buildings. It should be noted that the incident records do not however offer a comprehensive account of bombing in the area. • There are no obvious signs of damage within the site boundary. All structures are present and all roofs appear to be intact within the aerial photography. It is difficult to determine due to shadows minimising the clarity of open ground but there also appear to be no obvious bomb craters or damage at the northern end of the site either. • Severe damage was recorded within the general area surrounding the site, north of the site within South Square, some chambers were demolished. The chambers immediately north of the site area appear however to have only sustained minor blast damage. This is confirmed within the London County Council Bomb damage, which records no damage at all within the site boundary. Other areas in close proximity to eh site such as 12-13 High Holborn have also been totally destroyed. Damage sustained by bombing in these areas are unlikely to have directly affected the site. • The site was occupied by three commercial and civil properties. Gray's Inn Gatehouse, Gray's Inn Chambers, and a Public House. In the early years of the war Gray's Inn court, hall and library were badly damaged and abandoned. The buildings present within the site however remained undamaged. It is likely that the gatehouse was still used as an access-way and the Public House would likely have remained open. The site was also situated on a busy street in close proximity to Central London, this further increases the likelihood that regular post-raid checks would be made for items of UXO.

	• Areas of the site not occupied by buildings during the war appear to comprise of primarily open homogenous made ground. These ground conditions would generally have been conducive to discovering items of UXO. • There is no evidence that the site formerly had any military occupation or usage that could have led to contamination with other items of ordnance.
The Risk that UXO Remains on Site	There has been some post-war redevelopment on the site of proposed works, although the exact nature of the groundwork is unknown. The Public House and Chambers within the site area were combined into one large building. 1st Line Defence have been unable to determine whether the buildings were extended or demolished and rebuilt. The remainder of the site appears to be occupied by hard-standing, tarmacked ground. Where this development has taken place, the risk of encountering shallow buried UXO (especially 1kg incendiaries or anti-personnel bombs) and anti-aircraft projectiles will have been partly mitigated, since any such items may have been discovered during excavations.
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 overall risk will depend on the extent of the works, such as the numbers of boreholes/piles (if required) and the volume of the excavations. Since an air-dropped bomb may come to rest at any depth between just below ground level and its maximum penetration depth, there is also a chance that such an item could be encountered during shallow excavations (for services or site investigations) into the original WWII ground level.
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 than, say, machine excavation where the force of impact is generally lower and the item more likely to be observed. If a UXB is struck by piling or percussive drilling equipment, the force of the impact can be sufficient to detonate the main high explosive charge irrespective of the condition of the fuze or other components. Violent vibration might also impart enough energy to a chemical detonator for it to function, and there is a potential risk that clockwork fuzes could restart. If piling works are planned at 19-21 High Holborn, there is a potential risk that a UXB, if present, could be initiated. The risk of initiation is assessed to be considerably lower for any shallow intrusive works planned.
The Consequences of Encountering or Initiating Ordnance	The repercussions of the inadvertent detonation of UXO during intrusive ground works are potentially profound, 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 put in place, 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 a high-profile site and sites where it is necessary to evacuate the public from the surrounding area. A site may be closed for anything 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 item 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 turns out to have been unnecessary.

16.2. Assessed Risk Level

Taking into consideration the findings of this study, 1st Line Defence considers there to be a **Low Risk** from unexploded ordnance on the site of proposed works.

Low Risk

This site was occupied by undamaged structures with no obvious signs of ground disturbance, structures in the general area surrounding the site were severely damaged however they appear to have had no direct impact on the site in question. Although a bomb strike was recorded on/close to the site on London bomb census mapping, it is thought likely when considering other evidence, that the strike was mis-plotted.

Ordnance Type	Risk Level			
	Negligible	Low	Medium	High
German UXB's		✓		
Allied AAA		✓		
German Incendiaries and AP bomblets		✓		
Other Allied Military Ordnance	✓			

17. Proposed Risk Mitigation Methodology

17.1. General

The following risk mitigation measures are recommended to support the proposed works at 19-21 High Holborn:

Type of Work	Recommended Mitigation Measure
All Works	• **Site Specific Unexploded Ordnance Awareness Briefings to all personnel conducting intrusive works.** A specialised briefing is always advisable when there is a possibility of explosive ordnance contamination. It is an essential component of the Health & Safety Plan for the site and conforms to requirements of CDM Regulations 2015. All personnel working on the site should be instructed on the identification of UXB, actions to be taken to alert site management and to keep people and equipment away from the hazard. Posters and information of a general nature on the UXB threat should be held in the site office for reference and as a reminder.

In making this assessment and recommending these risk mitigation measures, the proposed 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 **20th July 2015**

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

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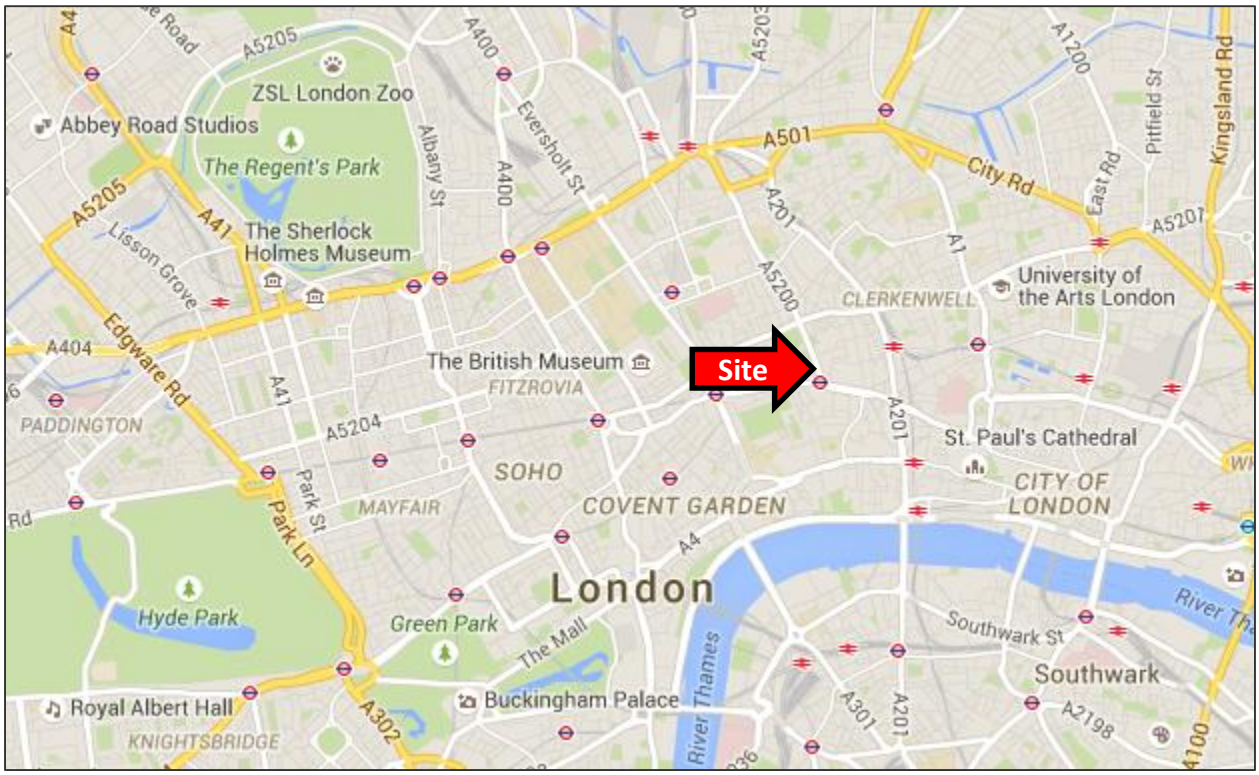
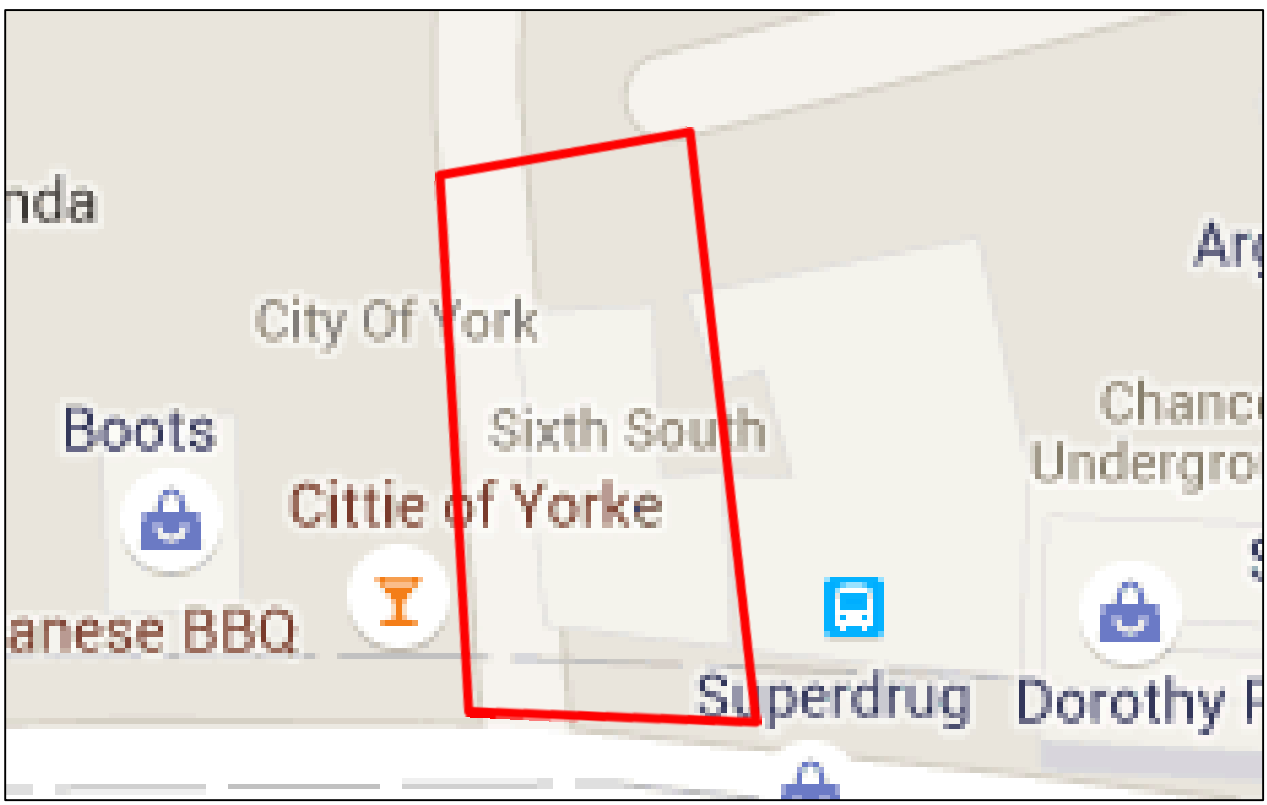
This report has been prepared by 1st Line Defence Limited with all reasonable care and skill. The report contains historical data and information from third party sources. 1st Line Defence Limited has sought to verify the accuracy and completeness of this information where possible, but cannot be held 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.

Site Location Maps

Annex: **A**





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Client: **GEA Ltd**

Project: **19-21 High Holborn**

Ref: **OPN2542**

Source: Google Maps

Approximate site boundary

N

Recent Aerial Photography

Annex: **B**

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Approximate site boundary

N

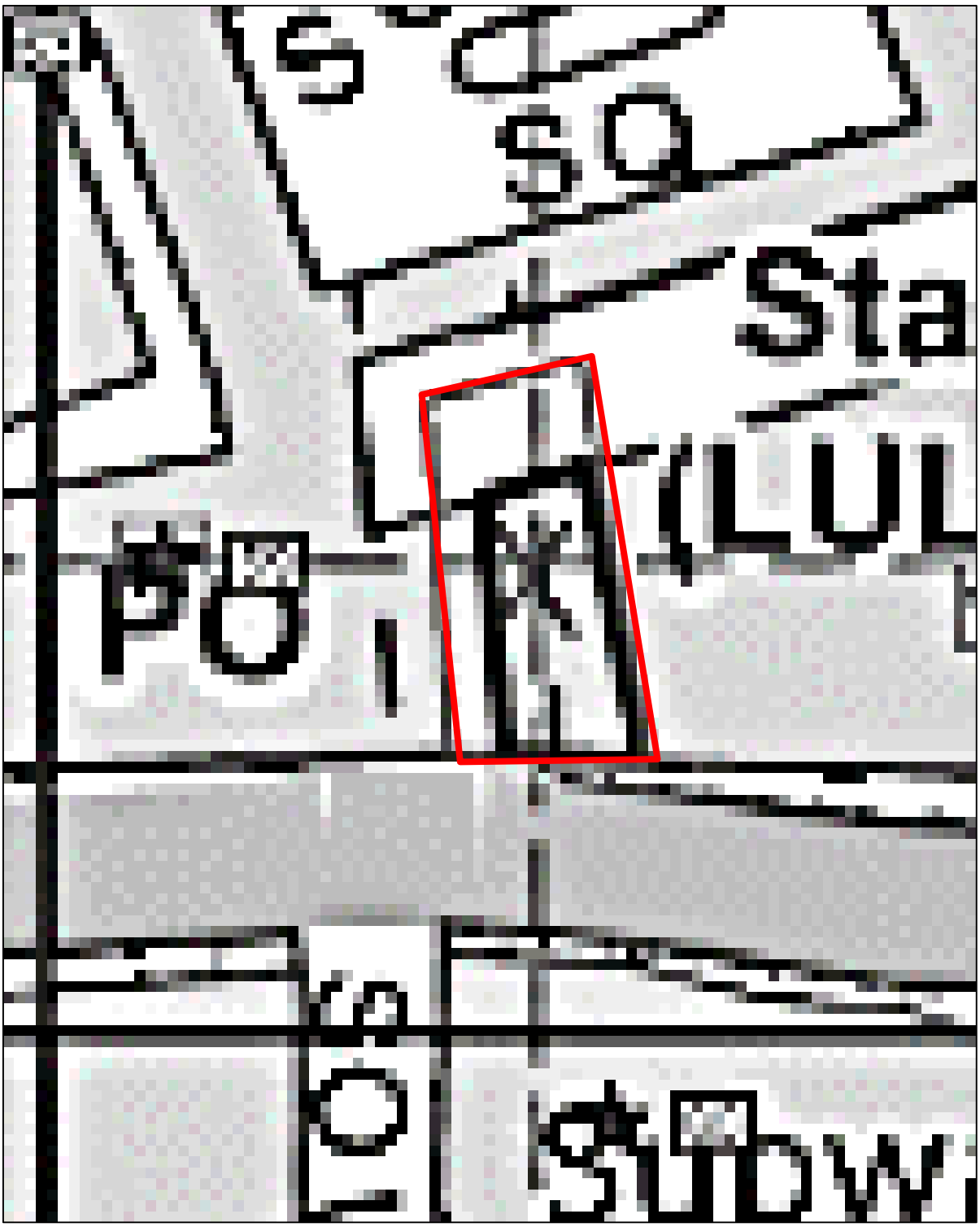
Project: **19-21 High Holborn**

Ref: **OPN2542**

Source: Google Earth ™ Mapping Services

Site Plan

Annex: C



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Client: **GEA Ltd**

Approximate site boundary

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Project: **19-21 High Holborn**

Ref: **OPN2542**

Source: GEA Ltd

1916 Historical Map

Annex: D

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Ref: **OPN2542**

Source: Landmark Maps

Approximate site boundary

N

1937 Historical Map

Annex: D2

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🟥 **Approximate site boundary**

N

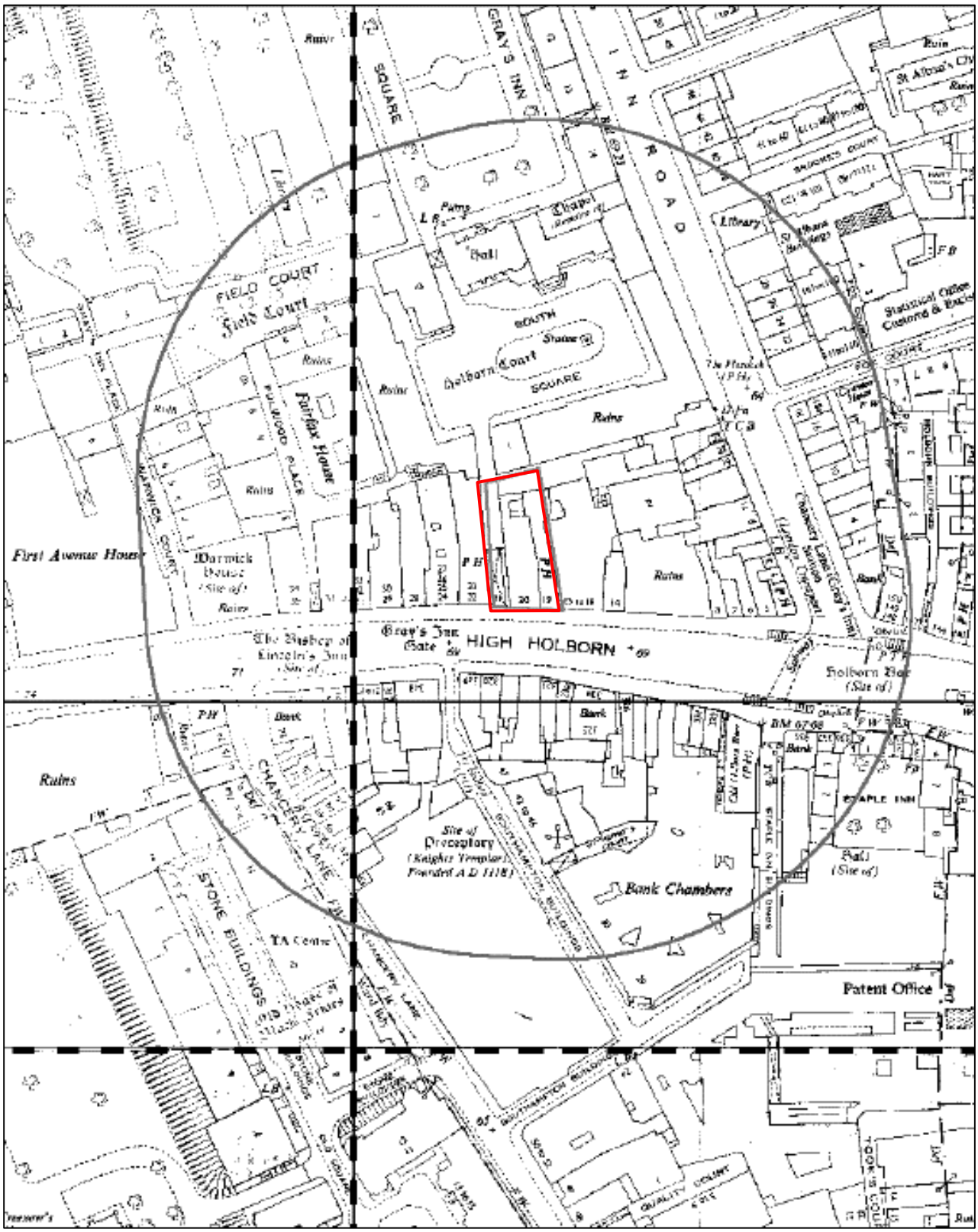
Project: **19-21 High Holborn**

Ref: **OPN2542**

Source: Landmark Maps

1952-1953 Historical Map

Annex: **D3**



Client: **GEA Ltd**

Approximate site boundary

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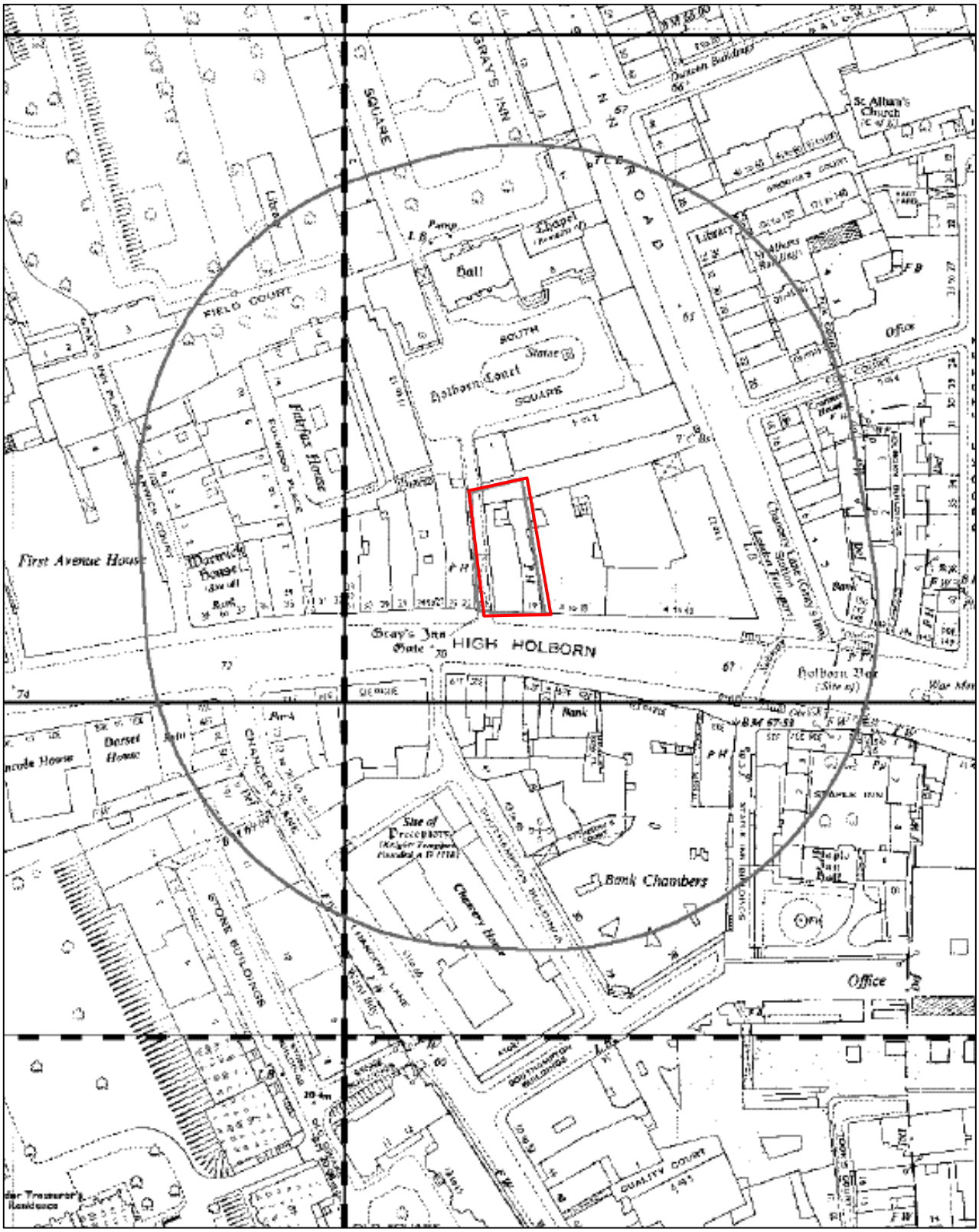
Project: **19-21 High Holborn**

Ref: **OPN2542**

Source: Landmark Maps

1958-1969 Historical Map

Annex: D4



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Client: **GEA Ltd**

Project: **19-21 High Holborn**

Ref: **OPN2542**

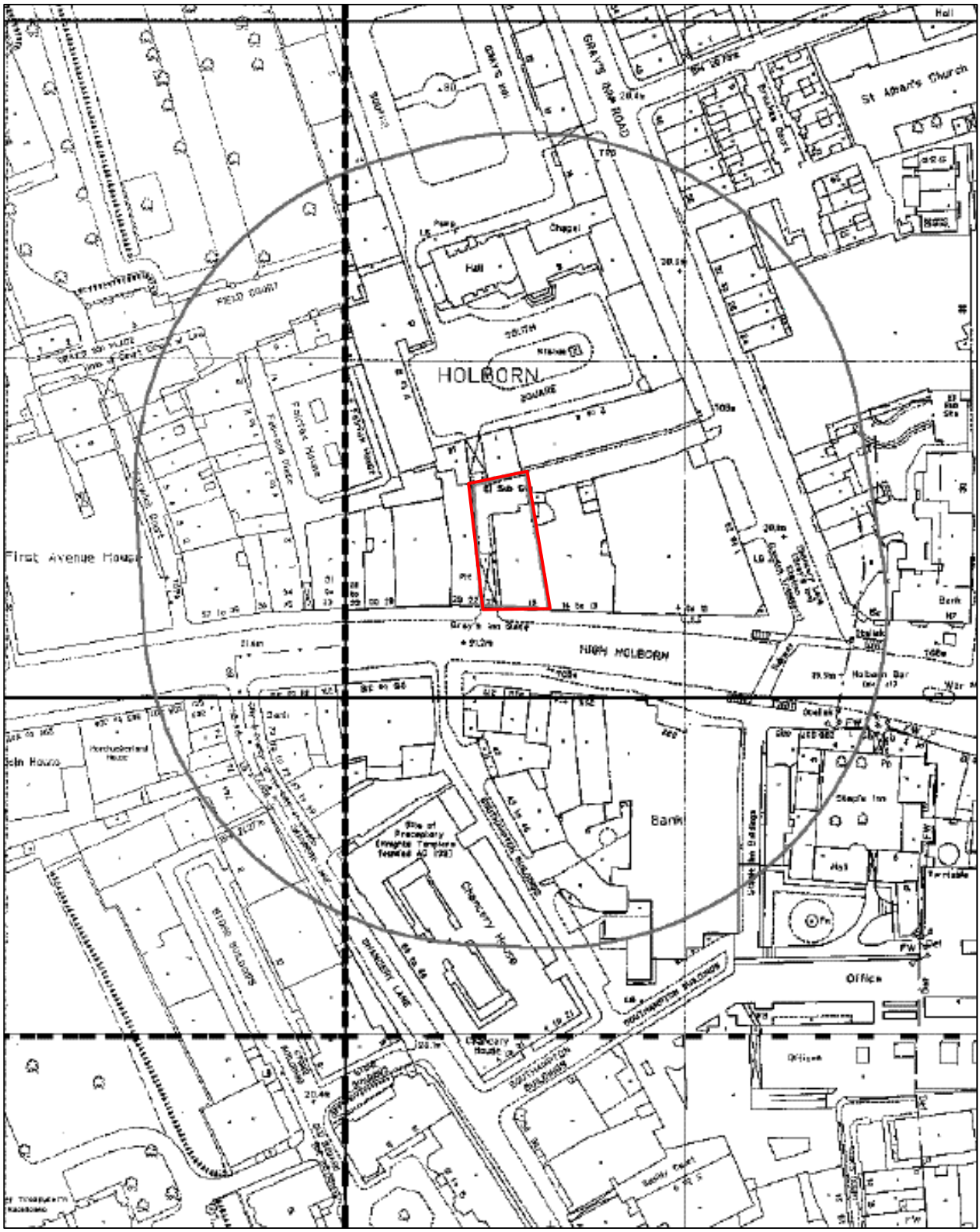
Source: Landmark Maps

Approximate site boundary

N

1991 Historical Map

Annex: D5



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Ref: **OPN2542**

Source: Landmark Maps

Approximate site boundary

N