1ST LINE DEFENCE

UXO SOLUTIONS

Detailed Unexploded Ordnance (UXO) Threat Assessment

Project Name	73 – 75 Avenue Road		
Client	GEA Limited		
Site Address	73 – 75 Avenue Road, London, NW8 6HP		
Report Reference	2111AT01	Revision	01
Date	3rd February 2015		
Originator	AT		

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Executive Summary

Site Location

The site is situated in the London Borough of Camden, in Hampstead, close to Primrose Hill.

To the north-east of the site runs the B525 Avenue Road, while Queen's Grove lies to the south-east of the site. Further houses fronting onto Avenue Road and Queen's Grove lie to the north- and south-west. The surrounding area is predominantly residential, with further housing lying on Elseworthy Road and Wadham Gardens to the east, and Queensmead to the west. Primrose Hill lies to the far east of the site.

The site is centred on the approximate OS grid reference: **TQ 2692183821**

Proposed Works

The site is proposed to be redeveloped with two houses with double basements, extending to approximately 8m below ground level. There will therefore be deep excavations and even deeper contiguous piling. Exploratory holes are also planned on site.

Geology and Bomb Penetration Depth

Site specific draft borehole logs were available for the site at the time of writing of this report. It should be noted that at the location of the pool, which was excavated into the ground, any sand and gravel may be from made ground associated with the pool. Thirteen borehole logs were undertaken on site. Five of these went down to 3m. The first layer on each was always topsoil, with a layer of made ground next on four out of the five. A layer of Sand and Gravel was recorded on two of the boreholes. All of the five ended on a layer of clay. Due to the limited depth of available borehole information, it has not been possible to calculate the maximum bomb penetration depth at this time. An assessment of the maximum bomb penetration depth can be made on site by a UXO Specialist. One of the borehole logs can be seen in **Annex D**.

UXO Risk Assessment

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

- The Metropolitan Borough of Hampstead was subject to a **Moderate** density of bombing with 166 bombs recorded per 1000 acres. The site was situated approximately 4.5km north-west of the centre of London, which experienced very high levels of bombing throughout WWII.
- The Metropolitan Borough of Hampstead was predominantly a residential borough during WWII with few significant targets of note. Despite this, the borough was located in close proximity to the centre of London and other boroughs that were heavily hit, most notably the borough of St. Pancras and the borough of Marylebone, which bordered Hampstead to the east and south respectively. The relative inaccuracy of bombing and the Luftwaffe's indiscriminate bombing of London meant that Hampstead received a medium bomb density.
- London bomb census mapping and incident records indicate the presence of bombing incidents within the site boundary. A bomb is recorded on the northern boundary of the site, noted as being 'outside number 75' in incident records and a number of incendiary bomb strikes are recorded within the immediate area.
- London bomb damage mapping records 'general blast damage' to number 75 in the north of the site area, but also that number 73, in the southern half of the site, was cleared. It has not been possible to confirm the exact date of cause of the clearance of this house, but it is considered likely to have been due to damage caused by bombing or fire damage, as the site was in the close vicinity of both HE bomb strikes and Incendiary Bomb showers.
- The access level throughout the site would not have been comprehensive. While the access level in the

UXO Risk Assessment

grounds and house no. 75 in the northern half of the site is likely to have been good, it would have been reduced when the house was damaged by the bomb strike that fell outside of the house. (See section 13.7 of this report for more information) The access level within the southern half of the site area would not have been comprehensive.

- The ground cover within the northern half of the site area appears to have been good, as this part of the site was occupied by number 75 and attached grounds, which appear to have been well maintained. The southern half of the site was occupied by grounds that were not well maintained and a house that was cleared. This type of ground cover would have not been conductive to the observation of UXB's.
- 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.
- Through the research process every effort is made to reduce the risk and 'zone' the site in question, but given the nature of the ground cover, the anticipated low/ irregular level of access, and the small site area; when accounting for the risk of 'J-curve', it has not been possible to zone this site.
- 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.
- Some redevelopment appears to have occurred within the site boundary. The southern house, no. 73, has not been rebuilt, but extensions appear to have been made to the northern house, no. 75. The extensions have been made to the rear of the property, extending into the west of the site, and part way to the south-east to the side of the property. Additionally, a swimming pool has been has been excavated into the ground, at the former location of no.73. These developments may have partially mitigated the risk of encountering items of unexploded ordnance, though only at the locations and down to the depths of post-war foundations.

Recommended Risk Mitigation Measures

The following risk mitigation measures are recommended to support the proposed works at the 73 – 75 Avenue Road site:

All works

- Site Specific Unexploded Ordnance Awareness Briefings to all personnel conducting intrusive works

Shallow intrusive works (trial pits, open excavations, shallow foundations etc.)

- Unexploded Ordnance (UXO) Specialist Presence on Site to support shallow intrusive works

Deep intrusive works (boreholes and piles)

- Intrusive Magnetometer Survey of all Borehole and pile locations down to a maximum bomb penetration depth

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

Site: 73 – 75 Avenue Road
Client: GEA Limited

1. Introduction

1.1. Background

1st Line Defence has been commissioned by GEA Limited to produce a Detailed Unexploded Ordnance (UXO) Threat Assessment for the proposed works at 73 – 75 Avenue Road.

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 he 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'.

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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 2007

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 CDM2007, 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.

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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 73 – 75 Avenue Road. 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 & Archives Centre.
- Landmark Maps.
- English Heritage National Monuments Record.
- Relevant information supplied by GEA Limited.
- 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 Camden Local Studies & Archives Centre and 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.

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6. The Site

6.1. Site Location

The site is situated in the London Borough of Camden, in Hampstead, close to Primrose Hill.

To the north-east of the site runs the B525 Avenue Road, while Queen's Grove lies to the south-east of the site. Further houses fronting onto Avenue Road and Queen's Grove lie to the north and south-west. The surrounding area is predominantly residential, with further housing lying on Elseworthy Road and Wadham Gardens to the east, and Queensmead to the west. Primrose Hill lies to the far east of the site.

The site is centred on the approximate OS grid reference: **TQ 2692183821**

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

6.2. Site Description

The site is a rectangular parcel of land, currently occupied by one detached residential property and an accompanying garden. The building within the south of the site, where is a swimming pool, which is in a state of disrepair. The roof is damaged and the "ribs" of it can be seen.

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 site is proposed to be redeveloped with two houses with double basements, extending to approximately 8m below ground level. There will therefore be deep excavations and even deeper contiguous piling. Exploratory holes are also planned on site.

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 draft borehole logs were available for the site at the time of writing of this report. It should be noted that at the location of the pool, which was excavated into the ground, any sand and gravel may be from made ground associated with the pool. Thirteen borehole logs were undertaken on site. Five of these went down to 3m. The first layer on each was always topsoil, with a layer of made ground next on four out of the five. A layer of Sand and Gravel was recorded on two of the boreholes. All of the five ended on a layer of clay. Due to the limited depth of available borehole information, it has not been possible to calculate the maximum bomb penetration depth at this time. An assessment of the maximum bomb penetration depth can be made on site by a UXO Specialist. One of the borehole logs can be seen in **Annex D**.

9. Site History

9.1. Ordnance Survey Historical Maps

Pre and post-WWII historical maps for the site were obtained by 1st Line Defence from Landmark Maps. These are presented in **Annex E**.

WWI Period		
Date	**Scale**	**Description**
1915	1:2,500	This map edition shows the site to be occupied by two separate properties with attached gardens, which are presumably 73 & 75 Avenue Road. The site is bordered by Avenue Road to the east and Queen's Road to the south. The site is within a residential area and semi-detached houses can be seen in the general area surrounding the site.

Pre-WWII		
Date	**Scale**	**Description**
1938	1:10:560	This map edition is of low quality. Despite this, no change can be seen on site. The closest area of change is to the south of the site, where a large building has taken the place of three houses.

Post-WWII		
Date	**Scale**	**Description**
1954 - 1955	1:2,500	Major change has happened within the site area since the previous map edition. Number 73, the southernmost building of the two, has been completely removed. The entire site area now appears to be part of the grounds of number 75, the surviving house to the north. A small new structure is visible on the western boundary of the site area. A small building labelled 'ruin' can be seen west of the site area.

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 F**.

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 G**). 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 that 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 H**.

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 limited depth of available borehole information. A site specific assessment of maximum bomb penetration depth can be made by a UXO Specialist on-site or once site specific geotechnical information becomes available.

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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 H 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 I** for a WWI bomb plot map of London.)

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 Hampstead

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. As the war progressed this strategy gradually changed to the indiscriminate bombing of civilian areas in an attempt to disrupt everyday life and hurt morale. The Metropolitan Borough of Hampstead (in which the site was located during WWII) was subject to a medium density bombing campaign as illustrated by the London bomb density data figures and map, see **Annex J**.

The Metropolitan Borough of Hampstead during WWII was predominantly a residential borough with few significant targets of note. Despite this, the borough was located in close proximity to the centre of London and boroughs that were hit heavily, most notably the borough of St. Pancras and the borough of Marylebone, which bordered Hampstead to the east and south respectively. The relative inaccuracy of bombing and the Luftwaffe's indiscriminate bombing of London meant that Hampstead received a medium bomb density.

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 the London Port Authority and railways, maintained separate records.

Records would be in the form of typed or hand written incident notes, maps and statistics. Bombing data was carefully analysed, not only due to the requirement to identify those parts of the capital 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 Hampstead are presented in the following sections.

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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 Hampstead between 1940 and 1945.

Record of German Ordnance Dropped on the Metropolitan Borough of Hampstead		
Area Acreage		**2,265**
Weapons	High Explosive Bombs (all types)	321
	Parachute Mines	6
	Oil Bombs	31
	Phosphorus Bombs	5
	Fire Pot	0
	Pilotless Aircraft (V1)	10
	Long Range Rockets (V2)	3
Total		**376**
Number of Items per 1000 acres		**166**

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. Hampstead Air Raid Precautions Bomb Census Map

A bomb census map which shows High Explosive, V-weapon and Incendiary Bomb strikes on the borough was obtained from Camden Local Studies & Archives Centre. The section showing the area of the site is presented in **Annex K**.

Hampstead Consolidated Bomb Map – Annex K	
Date Range	**Comments**
Consolidated bomb plot map: 1940 - 1945	This map was compiled post-war and contains bomb strikes within Hampstead between 1940 and 1945. Plotted on this map are High Explosives, individual Incendiary strikes (presumably large Incendiaries such as Oil Bombs and Phosphorus Bombs), V1 Flying Bombs and V2 Long Range Rockets. This map seems to match up with the London Bomb Census Maps (see below). **The closest bomb to the site appears to be on the northern boundary of the site, and may have landed within the site boundary.** The second closest bomb is on St. John's Wood Park, to the east. The site is very close to the boundary of the Borough of Hampstead, and thus strikes to the west and south cannot be seen, as these areas are within the London Borough of Marylebone.

13.5. 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 **Annex L** and are discussed below:

London Consolidated Bomb Maps – Annex L	
Date Range	**Comments**
Night Bombing up to 7th October 1940	Two HE bombs fell east of the site, on Elsworthy Road, while one HE bomb fell west of the site on the railway.
7th October 1940 to 6th June 1941	**Six HE bombs can be seen on this map edition. The closest bomb to the site appears to be on the northern boundary of the site, and may have landed within the site boundary. The second closest bomb is on St. John's Wood Park, to the east.**

London Weekly Bomb Maps – Annex L	
Date Range	**Comments**
7th to 14th October 1940	One HE bomb can be seen, south-east of the site on Avenue Road, near the junction of Acacia Road.
16th to 23rd December 1940	**Three HE bombs and an Incendiary Shower can be seen. One HE bomb appears to have hit the northern border of the site, matching up with the consolidated bombing map. The site was also covered by an Incendiary Shower and was close to another HE bomb strike on St. John's Wood Park.**
27th January – 3rd February 1941	An Incendiary Shower can be seen to the east of the site area, mostly over Primrose Hill and surrounding roads.
14th – 20th February 1944	One Phosphorus Bomb landed south of the site between Woronzow Road and Norfolk Road.

13.6. 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 M**.

V-Weapon Map – Annex M	
Date Range	**Comments**
Post-war consolidated Bomb Plot Map	**No V1 Flying Bombs** fell in the general area of the site, and the nearest strike appears to be at least 500m away. Damage from V weapons therefore cannot be attributed to the site in question.

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13.7. Hampstead Air Raid Precautions Bomb Incident Records

Written incident records were obtained from the Camden Local Studies & 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**
14th September 1940	Suspected UXB at number 40 Avenue Road, which was later found to merely be a metal fragment.
16th September 1940	One High Explosive Bomb on Avenue Close.
19th September 1940	One High Explosive Bomb, an Oil Bomb and Incendiary Bombs all fell on Avenue Close.
7th October 1940	Incendiary Bombs in the roadway of Avenue Road & over both Avenue Road and St John's Wood Park.
8th October 1940	One HE bomb on St. Stephen's Close.
9th October 1940	One HE bomb on the garage of number 12 Avenue Road.
10th October 1940	One High Explosive Bomb on Avenue Close.
12th October 1940	Incendiary Bombs on Avenue Close.
6th November 1940	One AA shell in the garden of number 26 / 28 Avenue Road.
12th November 1940	One High Explosive Bomb in the road outside number 98 Avenue Road.
15th November 1940	Incendiary Bombs on Avenue Close & St. Stephen's Close.
21st December 1940	**One High Explosive Bomb 'outside Number 75' Avenue Road. This matches up with the strike on the northern boundary of the site seen on the London Bomb Census Maps, and this report confirms that the bomb did not strike the building in the north of the site.** One High Explosive Bomb strike on 35 & 36 St. John's Wood Park, immediately west of the site area.
30th January 1941	Incendiary Bombs in the road on Avenue Road.
11th March 1941	An unidentified bomb fell on St. Stephen's Close. The bomb was noted to be 'small and yellow'.
11th May 1941	A 'considerable number' of incendiary bombs fell in the quadrangle of Avenue Close, the Reservoir Grounds and gardens on Avenue Road. All of the devices were dealt with by wardens and troops.
7th October 1943	One AA Shell on Barrow Hill Reservoir.
19th February 1944	Incendiary Bombs on Avenue Close, along with a larger Phosphorus Bomb. One Phosphorus bomb on 34 Avenue Road.
23rd February 1944	One AA shell fell on 69 Avenue Road.
24th February 1944	250 Incendiary Bombs around the area of St. John's Wood Park.
17th June 1944	One AA shell in the roadway near 30 St. John's Wood Park.

13.8. 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 N**.

London County Council Bomb Damage Map – Annex N	
Date Range	**Comments**
Post-War Consolidated Bomb Damage Map	This bomb damage map indicates the presence of bomb damage caused by enemy action in the area of the proposed site. The southernmost house within the site is labelled as 'Cleared' (shaded green). Clearance on this mapping can either mean clearance as a result of bomb damage or clearance as part of a planned redevelopment program; although planned redevelopment is considered unlikely within an area not designated for slum clearance or major urban redevelopment. It is more likely that the house was cleared due to damage caused by bombing or fires caused by incendiary bombs. The house in the north of the site, no.75, is recorded as having sustained serious blast damage, likely from the strike adjacent to the house, which is seen in both bomb census maps and incident reports.

13.9. WWII-Era Aerial Photographs

High resolution scans of WWII-era aerial photography for the site area were obtained from the National Monuments Record (English Heritage). Imagery dated 10th May 1946 is presented in **Annex O**.

This image, from 1946, shows the site to be roughly divided into two halves, corresponding to two different properties. The northern half of the site, number 75, appears to be occupied by a house with attached gardens. There are no obvious signs of serious damage or bombing in this half of the site area, and no reason to think the access level or ground cover in this half of the site would have been anything less than reasonable.

In the southern half of the site, within number 73, a series of foundations are visible. Given that the London County Council Bomb Damage Map labels this area as cleared, it is entirely possible that the house on site was heavily damaged as a result of bomb strikes or fire damage during the main period of the blitz, with some limited clearance/ re-development later starting on site, but halted for a significant period of the war years. This would have meant that the access level across much of the site would have been limited, and the ground cover on site may have obscured any UXB entry holes for a large period of the war.

A view of the wider area is located in **Annex O3**.

13.10. 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

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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.

13.11. 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 Limited will be advised.

13.12. 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 Hampstead was subject to a **Moderate** density of bombing with 166 bombs recorded per 1000 acres. The site was situated approximately 4.5km north-west of the centre of London, which experienced very high levels of bombing throughout WWII. London bomb census mapping and incident records indicate the presence of bombing incidents 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 site was split in two during WWII, and was occupied by both the grounds of number 73 & 75. Number 75 appears to have survived the war, and the grounds associated with this house appear well maintained. Number 73 appears to have been cleared, most likely due to bomb or fire damage. The grounds of this house do not appear to be well maintained, and signs of UXB's could have been missed in this area.
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.*	Number 75, in the northern half of the site, sustained serious blast damage during WWII. While the house was probably occupied for most of the war, the damage sustained may have reduced the access level as any occupants may have sought shelter elsewhere while the house was being repaired. The access level would have been even less frequent in the southern half of the site, where the building on site was cleared, most likely due to bomb or fire damage. This area would not have received a good level of access for a significant period of the war.

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*	The London County Council Bomb Damage Maps record that number 75, in the northern half of the site area, sustained blast damage. They also record that number 73, in the southern half of the site area, was cleared. It has not been possible to confirm when exactly number 73 was cleared, but it is considered likely that the house was either destroyed by bombing or burnt down by fires caused by a number of nearby Incendiary Bomb showers. 1946 aerial photography shows that number 75 survived the war, and any damage sustained may have already been repaired or may simply not be visible from a top-down view. Further redevelopment appears to be taking place on the grounds of number 73. This work appears to be in a very basic stage and it is not clear whether this work is the clearance of the previous structure or the construction of a new structure on site.
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.

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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. 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 a 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 2.4km north-east in the vicinity of Hampstead Heath.

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

14.4. 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.

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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 yet 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.

Some redevelopment appears to have occurred within the site boundary. The southern house, no. 73, has not been rebuilt, but extensions appear to have been made to the northern house, no. 75. The extensions have been made to the rear of the property, extending into the west of the site, and part way to the south-east to the side of the property. Additionally, a swimming pool has been has been excavated into the ground, at the former location of no.73. These developments may have partially mitigated the risk of encountering items of unexploded ordnance, though only at the locations and down to the depths of post-war foundations.

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 Bomb Damage Maps, Hampstead Bomb Incident Records, in-house data and post WWII era aerial photographs for the site. The record is of good quality, with incidents recorded across multiple sources and in detail. Incidents have been accounted for in written records and their locations confirmed/corroborated between different record sets.
The Risk that the Site was Contaminated with UXO	After considering the following facts, 1st Line Defence believes that there is a **Medium Risk** that unexploded high explosive bombs fell unnoticed and unrecorded within the site boundary. • The Metropolitan Borough of Hampstead was subject to a **Moderate** density of bombing with 166 bombs recorded per 1000 acres. The site was situated approximately 4.5km north-west of the centre of London, which experienced very high levels of bombing throughout WWII. • The Metropolitan Borough of Hampstead was predominantly a residential borough during WWII with few significant targets of note. Despite this, the borough was located in close proximity to the centre of London and other boroughs that were heavily hit, most notably the borough of St. Pancras and the borough of Marylebone, which bordered Hampstead to the east and south respectively. The relative inaccuracy of bombing and the Luftwaffe's indiscriminate bombing of London meant that Hampstead received a medium bomb density. • London bomb census mapping and incident records indicate the presence of bombing incidents within the site boundary. A bomb is recorded on the northern boundary of the site, noted as being 'outside number 75' in incident records and a number of incendiary bomb strikes are recorded within the immediate area. • London bomb damage mapping records 'general blast damage' to number 75 in the north of the site area, but also that number 73, in the southern half of the site, was cleared. It has not been possible to confirm the exact date of cause of the clearance of this house, but it is considered likely to have been due to damage caused by bombing or fire damage, as the site was in the close vicinity of both HE bomb strikes and Incendiary Bomb showers. • The access level throughout the site would not have been comprehensive. While the access level in the grounds and house no. 75 in the northern half of the site is likely to have been good, it would have been reduced when the house was damaged by the bomb strike that fell outside of the house. (See section 13.7 of this report for more information) The access level within the southern half of the

	site area would not have been comprehensive. • The ground cover within the northern half of the site area appears to have been good, as this part of the site was occupied by number 75 and attached grounds, which appear to have been well maintained. The southern half of the site was occupied by grounds that were not well maintained and a house that was cleared. This type of ground cover would have not been conductive to the observation of UXB's. • 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. • Through the research process every effort is made to reduce the risk and 'zone' the site in question, but given the nature of the ground cover, the anticipated low/ irregular level of access, and the small site area; when accounting for the risk of 'J-curve', it has not been possible to zone this site.
The Risk that UXO Remains on Site	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. Some redevelopment appears to have occurred within the site boundary. The southern house, no. 73, has not been rebuilt, but extensions appear to have been made to the northern house, no. 75. The extensions have been made to the rear of the property, extending into the west of the site, and part way to the south-east to the side of the property. Additionally, a swimming pool has been has been excavated into the ground, at the former location of no.73. These developments may have partially mitigated the risk of encountering items of unexploded ordnance, though only at the locations and down to the depths of post-war foundations.
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 73 – 75 Avenue Road, 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 **Medium Risk** from unexploded ordnance on the site of proposed works.

Medium Risk

The southern half of the site was partially occupied by a house that was cleared and ground that was not well maintained. The house may have been cleared due to bomb or fire damage, and thus would have presented an area of land in which UXB's could have gone unnoticed. The northern half of the site was, in contrast, well maintained and would have been accessed frequently for most of the war. However, the house on site did sustain blast damage, and this would have reduced the access level. It has not proved possible to 'zone' the site area into areas of low and medium risk due to the small size of the site area and the risk of 'J-curve'.

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

1ST LINE DEFENCE

Detailed Unexploded Ordnance Threat Assessment
73 – 75 Avenue Road
GEA Limited

17. Proposed Risk Mitigation Methodology

17.1. General

The following risk mitigation measures are recommended to support the proposed works at 73 – 75 Avenue Road:

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 2007. 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.
Shallow Intrusive Works/Open Excavations	• **Unexploded Ordnance (UXO) Specialist Presence on Site to support shallow intrusive works:** When on site the role of the UXO Specialist would include; monitoring works using visual recognition and instrumentation and immediate response to reports of suspicious objects or suspected items of ordnance that have been recovered by the ground workers on site; providing UXO Awareness briefings to any staff that have not received them earlier and advise staff of the need to modify working practices to take account of the ordnance threat, and finally to aid Incident Management which would involve liaison with the local authorities and Police should ordnance be identified and present an explosive hazard.
Borehole/Piles	• **Intrusive Magnetometer Survey of all Borehole and pile locations down to a maximum bomb penetration depth:** 1st Line Defence can deploy a range of intrusive magnetometer techniques to clear ahead of all the pile locations. The appropriate technique is governed by a number of factors, but most importantly the site's ground conditions. The appropriate survey methodology would be confirmed once the enabling works have been completed.

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 **3rd February 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.

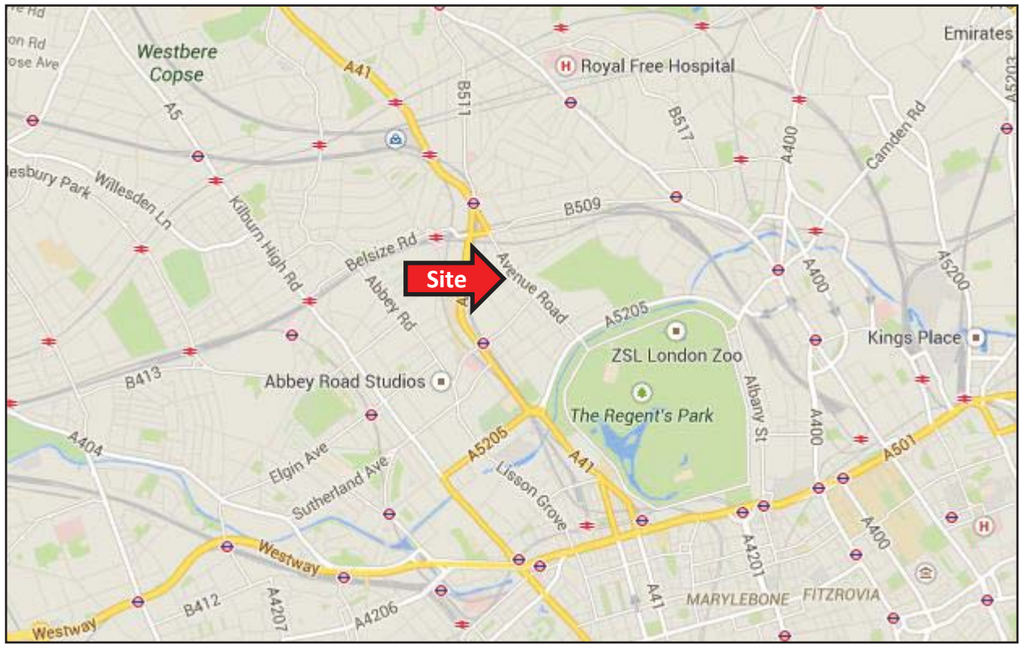
Bibliography

The key published documents consulted during this assessment are listed below:

- Bates, H. E., *Flying Bombs over England*, Frogletts Publications Ltd., 1994
- 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
- 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
- Wade, C. , *Hampstead at War 1939 – 1945*, Camden History Society, 1978
- Whiting, C., *Britain Under Fire: The Bombing of Britain's Cities 1940-1945*, Pen & Sword Books Ltd., 1999

Site Location Maps

Annex: **A**



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Tel: +44 (0)1992 446 974

Client: **GEA Limited**
Project: **73 – 75 Avenue Road**
Ref: **OPN2111**
Source: Google Maps

Approximate site boundary

N

Recent Aerial Photography

Annex: **B**

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Client: **GEA Limited**

Project: **73 – 75 Avenue Road**

Ref: **OPN2111**

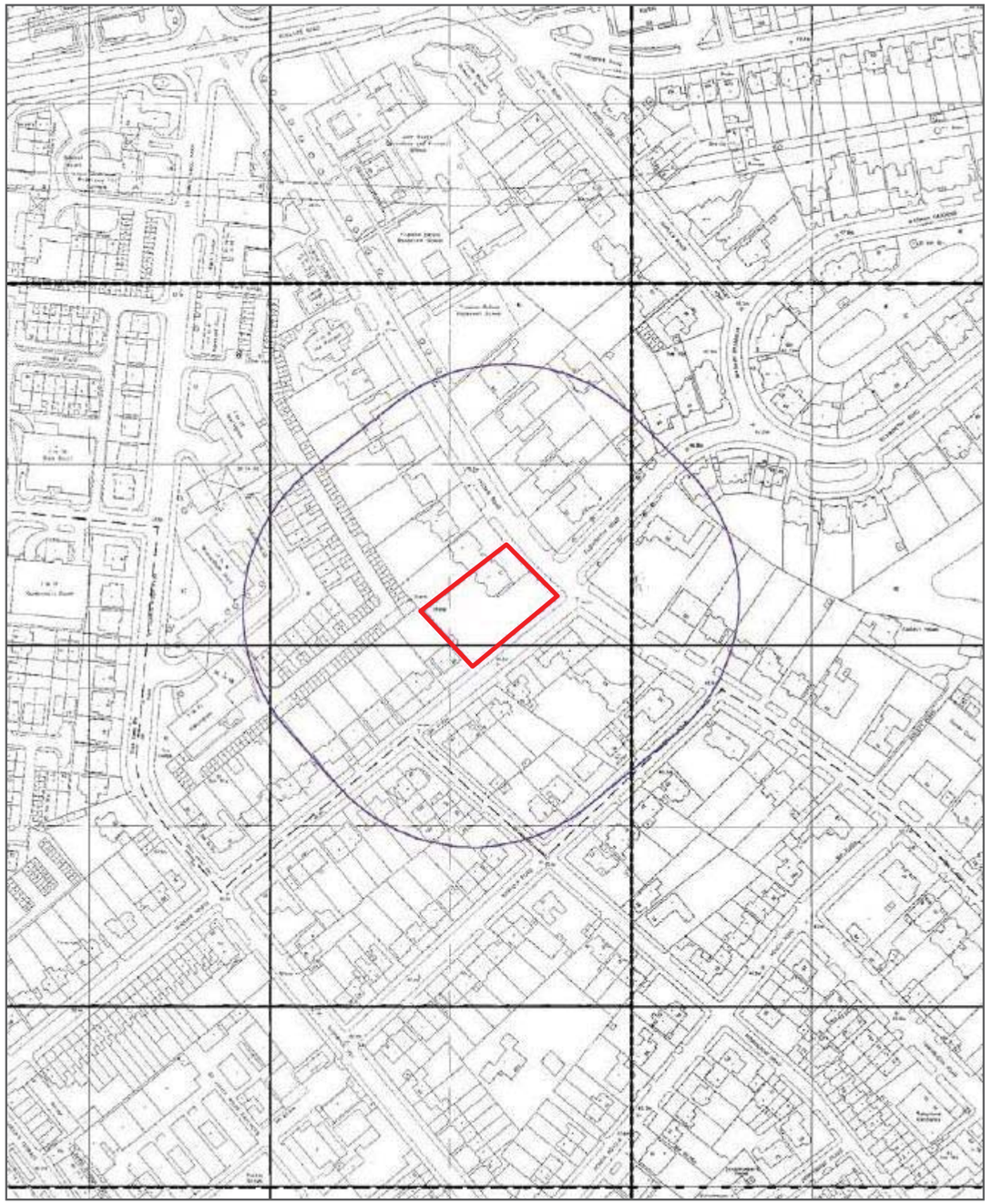
Source: Google Earth ™ Mapping Services

Approximate site boundary

N

Site Plan

Annex: **C1**



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Client: **GEA Limited**

Project: **73 – 75 Avenue Road**

Ref: **OPN2111**

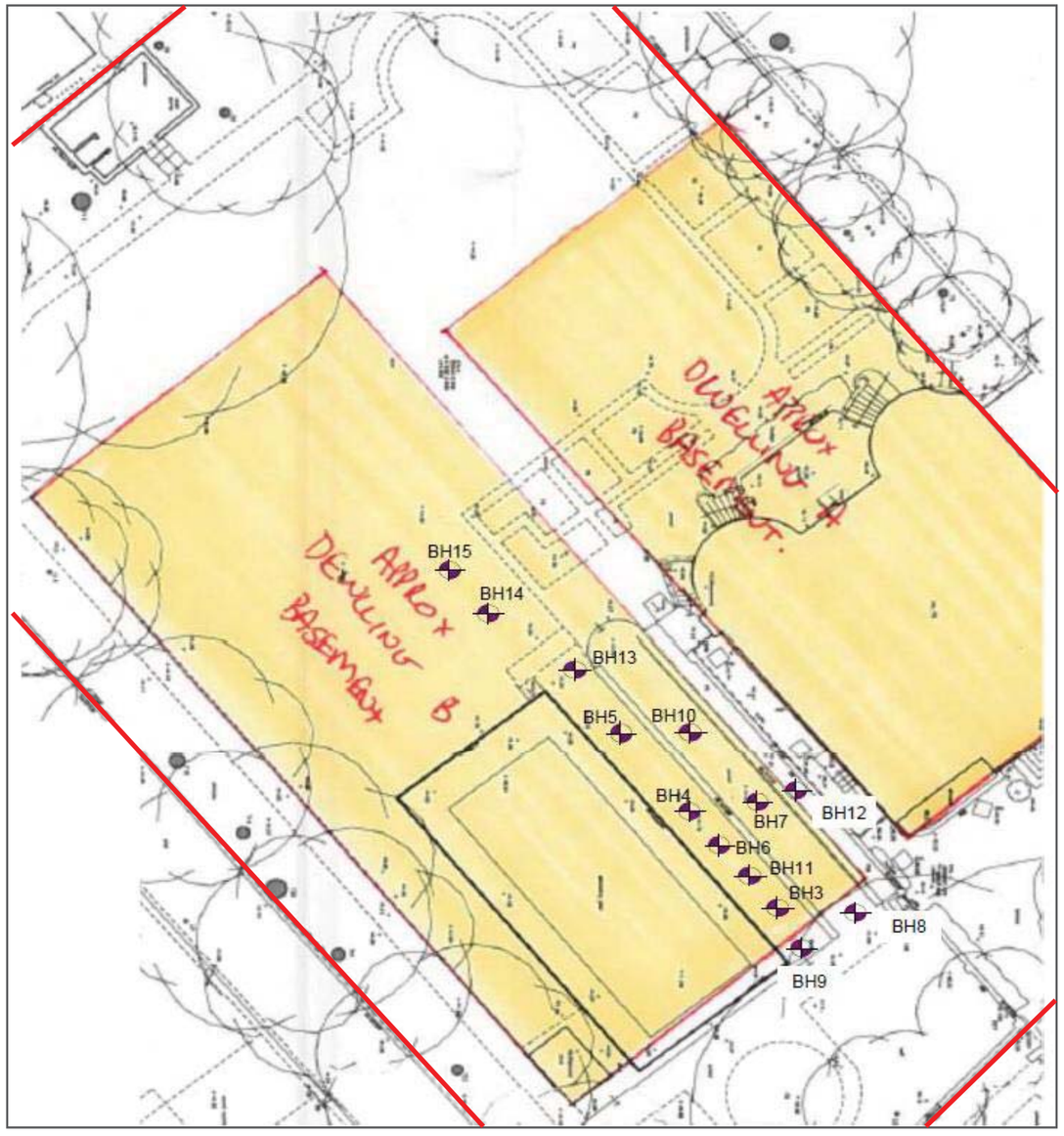
Source: GEA Limited

Approximate site boundary

N

Site Plan – Exploratory Hole Plan

Annex: **C2**



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Client: **GEA Limited**

Approximate site boundary

Project: **73 – 75 Avenue Road**

N

Ref: **OPN2111**

Source: GEA Limited

Borehole Log

Annex: **D**

GEA Geotechnical & Environmental Associates
Tyttenhanger House
Coursers Road
St Albans
AL4 0PG

Site 73 - 75 Avenue Road, London, NW8 6HP			**Number** BH9
Excavation Method Drive-in Window Sampler	**Dimensions**	**Ground Level (mOD)**	**Client** Deroda Investments Limited	**Job Number** J14383
	Location	**Dates** 14/01/2015	**Engineer** Heyne Tilett Steel	**Sheet** 1/1

Depth (m)	Sample / Tests	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water
					(0.20) 0.20	Topsoil		
					(0.65) 0.85	Made ground: Soft dark brown slightly sandy slightly gravelly clay. Gravel is fine to coarse angular to subrounded brick, flint and concrete.		
					(0.15) 1.00	Made ground: Cobble sized brick fragments.		
					(0.80) 1.80	Made ground: Brown sand and gravel. Gravel is fine to coarse angular to subangular brick.		
			At 2.05m PP: 0.5, 0.5, 0.75		(0.20) 2.00	Made ground: Soft brown sandy clay with occasional fine to medium angular to subangular gravel sized brick fragments.		
			At 2.40m PP: 1.5, 1.75, 1.5		(0.30) 2.30	Made ground: Soft brown slightly sandy clay with occasional fine subangular brick gravel. (Reworked London Clay)		
			At 2.80m PP: 3.5, 3.5, 3.5		(0.70) 3.00	Soft brown CLAY with occasional fine to medium subrounded flint gravel. Rare fine roots. (Weathered LONDON CLAY)		
						Complete at 3.00m		

Remarks

Scale (approx) 1:20

Logged By AB

Figure No. J14383.BH9

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Client: **GEA Limited**

Project: **73 – 75 Avenue Road**

N

Ref: **OPN2111**

Source: GEA Limited

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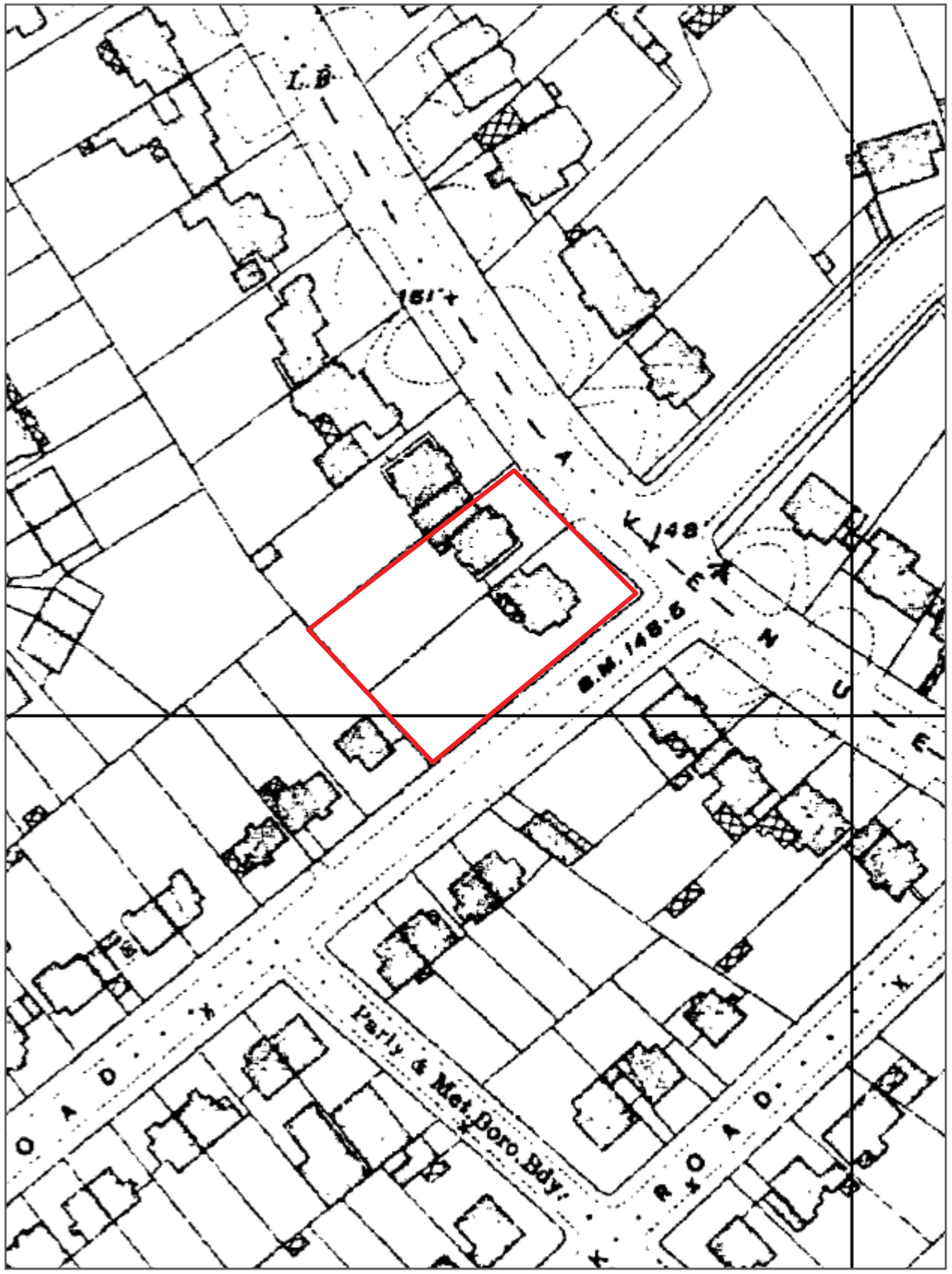
1916 Historical Map

Annex: **E1**



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Client: **GEA Limited**

Approximate site boundary

N

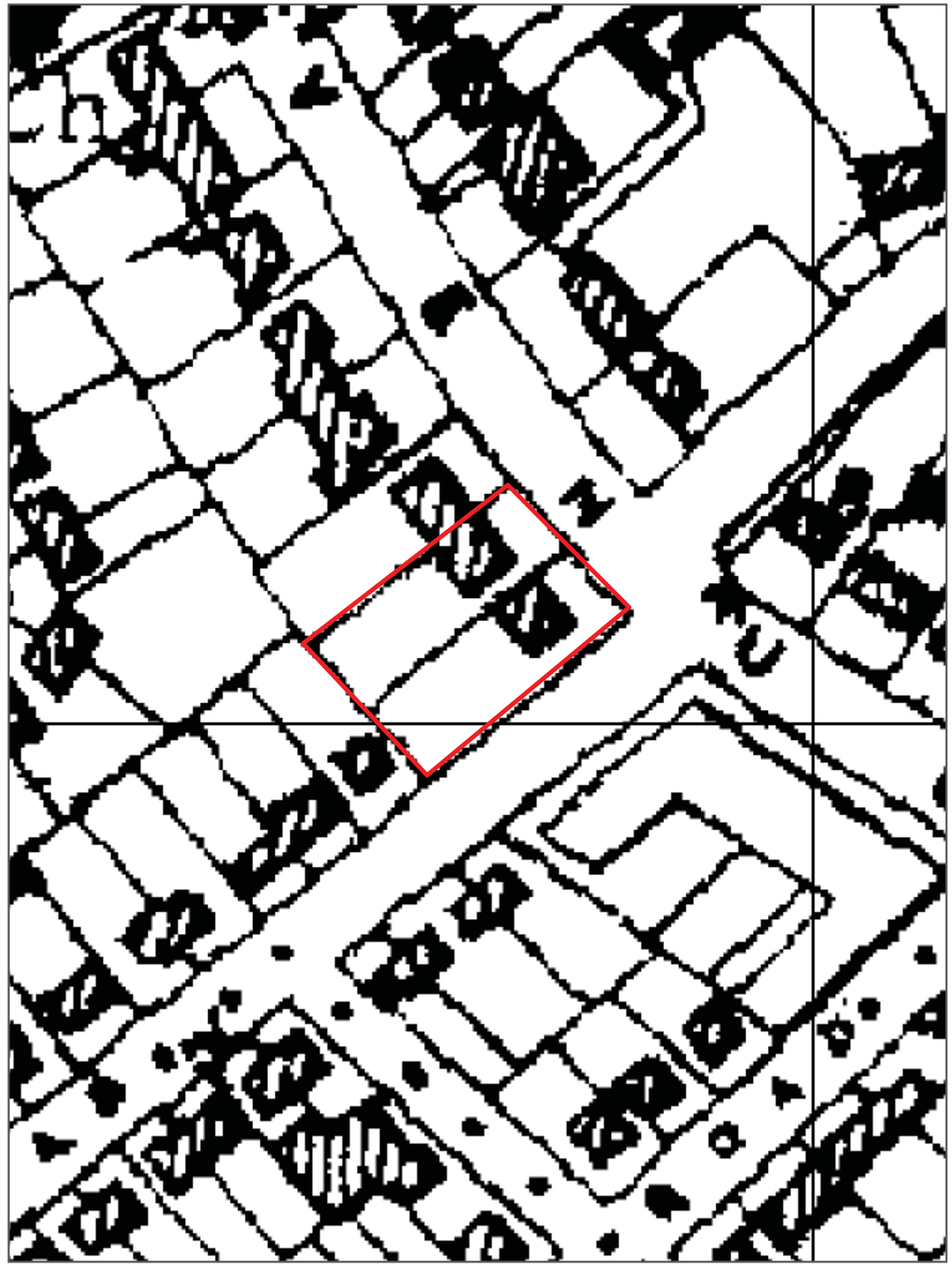
Project: **73 – 75 Avenue Road**

Ref: **OPN2111**

Source: Landmark Maps

1938 Historical Map

Annex: **E2**



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Client: **GEA Limited**

Approximate site boundary

N

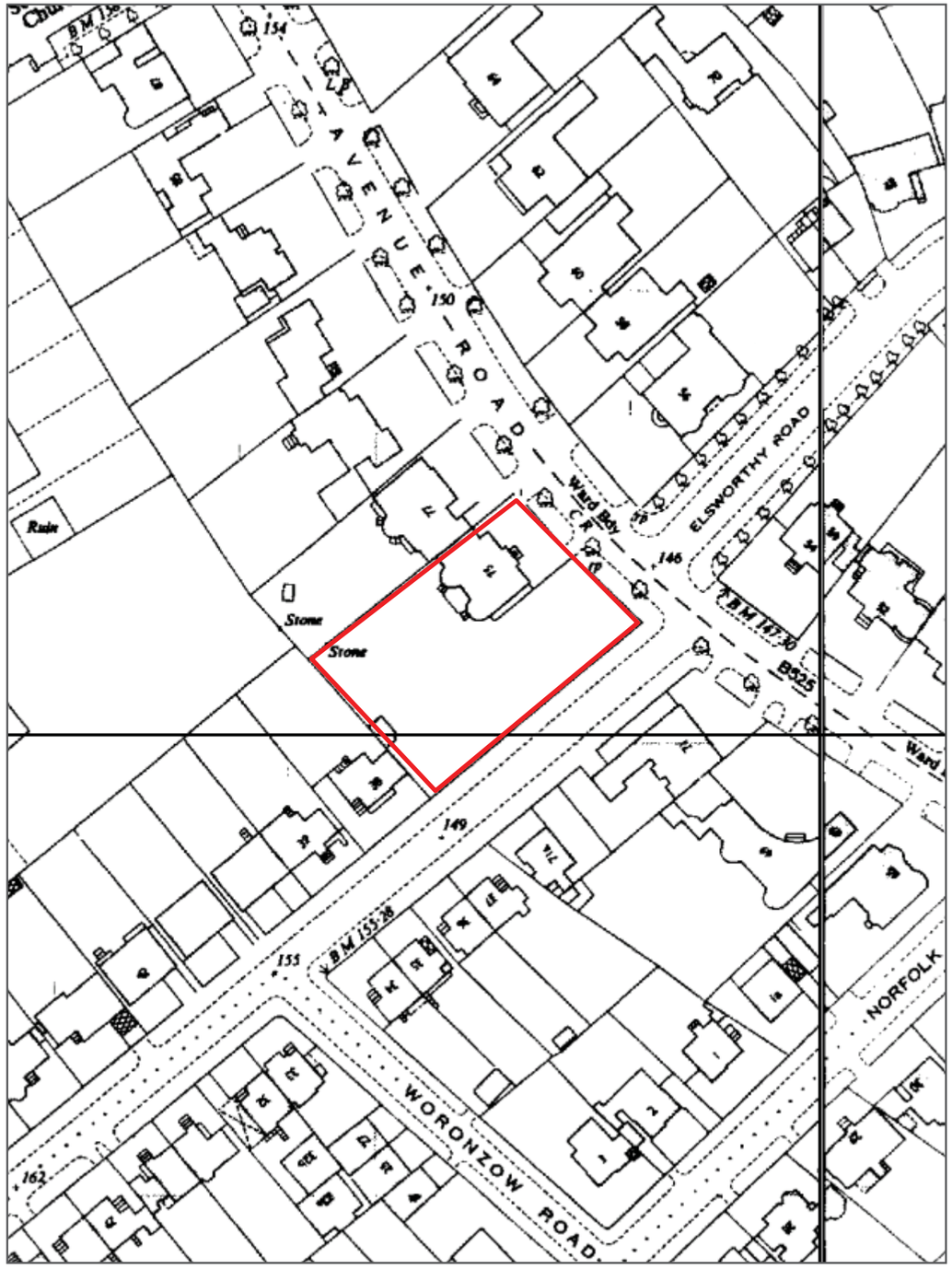
Project: **73 – 75 Avenue Road**

Ref: **OPN2111**

Source: Landmark Maps

1954 - 1955 Historical Map

Annex: **E3**



Client: **GEA Limited**	**Approximate site boundary**	N
Project: **73 – 75 Avenue Road**		
Ref: **OPN2111**	Source: Landmark Maps	

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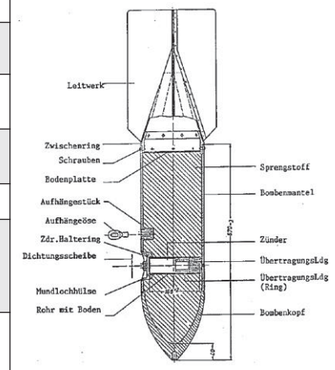
Common Types of German HE Air-Delivered Ordnance

Annex: **F1**

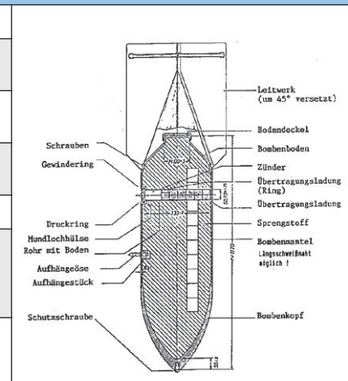
SC 50kg

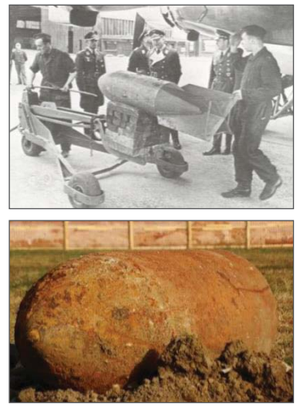
Bomb Weight	40-54kg (110-119lb)
Explosive Weight	c25kg (55lb)
Fuze Type	Impact fuze/electro-mechanical time delay fuze
Bomb Dimensions	1,090 x 280mm (42.9 x 11.0in)
Body Diameter	200mm (7.87in)
Use	Against lightly damageable materials, hangars, railway rolling stock, ammunition depots, light bridges and buildings up to three stories.
Remarks	The smallest and most common conventional German bomb. Nearly 70% of bombs dropped on the UK were 50kg.



SC 250kg

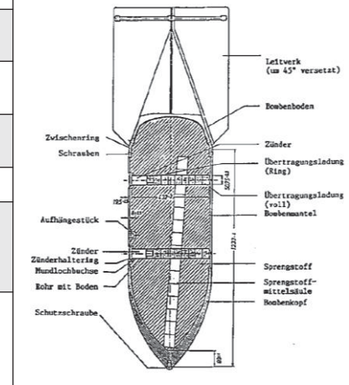
Bomb Weight	245-256kg (540-564lb)
Explosive Weight	125-130kg (276-287lb)
Fuze Type	Electrical impact/mechanical time delay fuze.
Bomb Dimensions	1640 x 512mm (64.57 x 20.16in)
Body Diameter	368mm (14.5in)
Use	Against railway installations, embankments, flyovers, underpasses, large buildings and below-ground installations.
Remarks	It could be carried by almost all German bomber aircraft, and was used to notable effect by the Junkers Ju-87 Stuka (Sturzkampfflugzeug or dive-bomber).

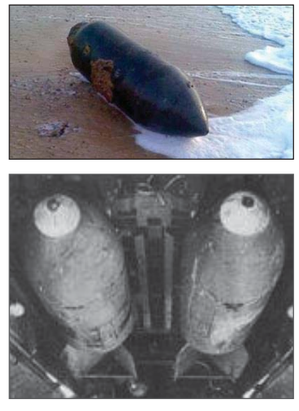




SC 500kg

Bomb Weight	480-520kg (1,058-1,146lb)
Explosive Weight	250-260kg (551-573lb)
Fuze Type	Electrical impact/mechanical time delay fuze.
Bomb Dimensions	1957 x 640mm (77 x 25.2in)
Body Diameter	470mm (18.5in)
Use	Against fixed airfield installations, hangars, assembly halls, flyovers, underpasses, high-rise buildings and below-ground installations.
Remarks	40/60 or 50/50 Amatol TNT, trialene. Bombs recovered with Trialen filling have cylindrical paper wrapped pellets 1-15/16 in. in length and diameter forming





Client: **GEA Limited**		
Project: **73 – 75 Avenue Road**		
Ref: **OPN2111**	Source: Various sources	

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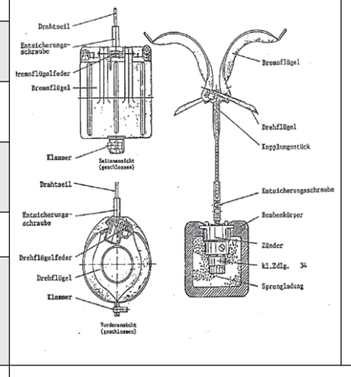
Common Types of German HE Air-Delivered Ordnance

Annex: F2

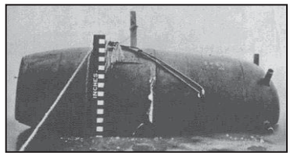
SD2 Butterfly Bomb

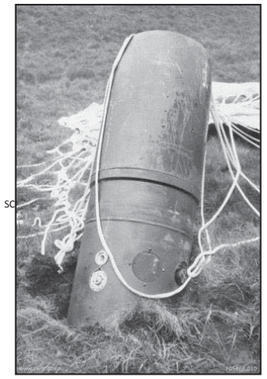
Bomb Weight	2kg (4.41lb)
Explosive Weight	7.5oz (212.6 grams) of TNT surrounded by a layer of bituminous composition.
Fuze Type	41 fuze (time) , 67 fuze (clockwork time delay) or 70 fuze (anti-handling device)
Bomb Dimensions	Length 240 mm Width 140 mm Height 310 mm
Body Diameter	3in (7.62 cm) diameter, 3.1in (7.874) long
Use	It was designed as an anti-personnel/fragmentation weapon. They were delivered by air, being dropped in containers that opened at a predetermined height, thus scattering the bombs.
Remarks	The smallest and most common conventional German bomb. Nearly 70% of bombs dropped on the UK were 50kg.



Parachute Mine (Luftmine B / LMB)

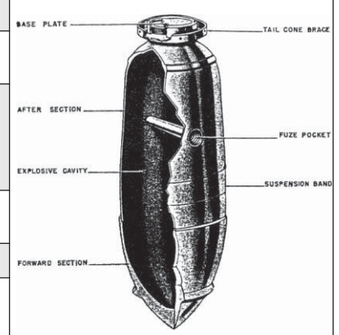
Bomb Weight	987.017kg (2176lb)
Explosive Weight	125-130kg (276-287lb)
Fuze Type	Impact/ Time delay / hydrostatic pressure fuze
Bomb Dimensions	1640 x 512mm (64.57 x 20.16in)
Body Diameter	368mm (14.5in)
Use	Against civilian, military and industrial targets. Designed to detonate above ground level to maximise damage to a wider area.
Remarks	Parachute Mines were normally carried by HE 115 (Naval operations), HE 111 and JU 88 aircraft types. Deployed a parachute when dropped in order to control its descent.

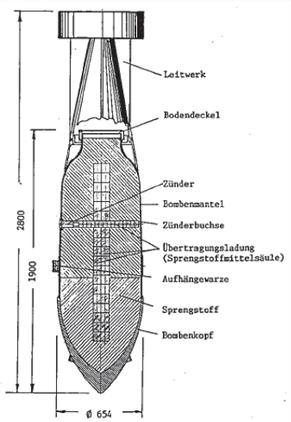




SC 1000kg

Bomb Weight	996-1061kg (1,058-1,146lb)
Explosive Weight	530-620kg (551-573lb)
Fuze Type	Electrical impact/mechanical time delay fuze.
Filling	Mixture of 40% amatol and 60% TNT, but when used as an anti-shipping bomb it was filled with Trialen 105, a mixture of 15% RDX, 70% TNT and 15% aluminium powder.
Bomb Dimensions	2800 x 654mm (77 x 25.2in)
Body Diameter	654mm (18.5in)
Use	SC type bombs are General Purpose Bombs used primarily for general demolition work. Constructed of parallel walls with comparatively heavy noses. They are usually of three piece welded construction



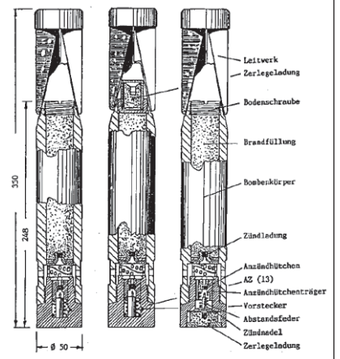


German Incendiary Bombs

Annex: F3

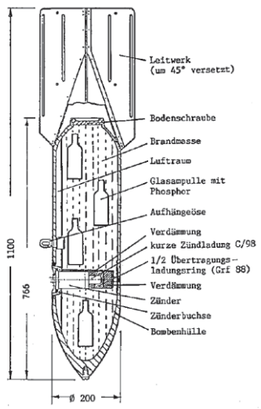
1kg Incendiary Bomb

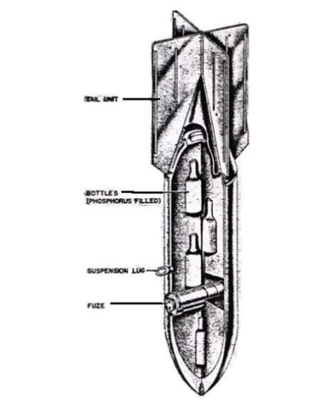
Bomb Weight	1.0 and 1.3kg (2.2 and 2.87lb)
Explosive Weight	680gm (1.3lb) Thermite
Fuze Type	Impact fuze
Bomb Dimensions	350 x 50mm (13.8 x 1.97in)
Body Diameter	50mm (1.97in)
Use	As incendiary – dropped in clusters against towns and industrial complexes
Remarks	Magnesium alloy case. Sometimes fitted with high explosive charge. The body is a cylindrical alloy casting threaded internally at the nose to receive the fuze holder and fuze.



C50 A Incendiary Bomb

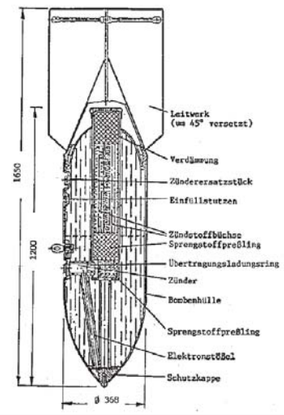
Bomb Weight	c41kg (90.4lb)
Explosive Weight	0.03kg (0.066lb)
Incendiary Filling	12kg (25.5lb) liquid filling with phosphor igniters in glass phials. Benzine 85%; Phosphorus 4%; Pure Rubber 10%
Fuze Type	Electrical impact fuze
Bomb Dimensions	1,100 x 280mm (43.2 x 8in)
Use	Against all targets where an incendiary effect is to be expected
Remarks	Early fill was a phosphorous/carbon disulphide incendiary mixture

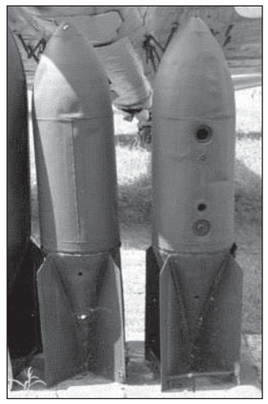




Flam C-250 Oil Bomb

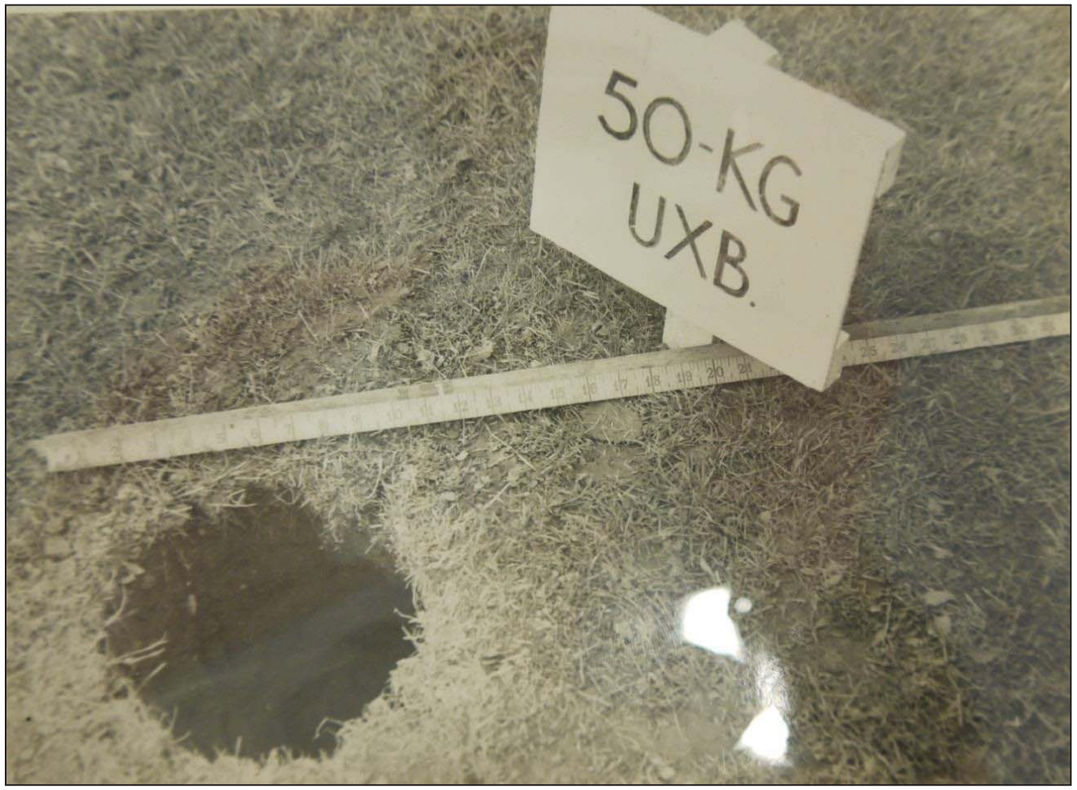
Bomb Weight	125kg (276lb)
Explosive Weight	1kg (2.2lb)
Fuze Type	Super-fast electrical impact fuze
Filling	Mixture of 30% petrol and 70% crude oil
Bomb Dimensions	1,650 x 512.2mm (65 x 20.2in)
Body Diameter	368mm (14.5in)
Use	Often used for surprise attacks on living targets, against troop barracks and industrial installations. Thin casing – not designed for ground penetration





50kg Bomb Entry Hole

Annex: G



German 50kg HE Bomb Entry Hole

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Ref: **OPN2111**

Source: Archive sources

Examples of UXO incidents in the UK

Annex: H1

LIVE BBC NEWS CHANNEL

Page last updated at 14:45 GMT, Friday, 22 May 2009 15:45 UK

E-mail this to a friend Printable version

Building site WWII bomb exploded

A controlled explosion has been carried out on a World War II bomb found on a building site in East Sussex.

The 110lb (50kg) SC50 bomb, thought to have been dropped from a German aircraft in 1940 or 1941, was found at the Hollenden House site in Bexhill.

Children at St Peter and St Paul Primary School next door in Buckhurst Road were sent home early after the discovery on Thursday.

Police said a 160ft (50m) cordon was put round the site during the blast.

Breaking News: UXB in Beckton - controlled explosion ends the drama

Colin Grainger , Editor
Sunday, December 19, 2010
9:32 AM

The World War Two bomb that was found on the 2012 Olympic site in Stratford back in 2009. Picture: Steve Poston

Recommend 0 Tweet 3

+1 Recommend this on Google

Bomb disposal experts carried out a controlled explosion last night on a 250kg World War II shell discovered at Britain's largest sewage works.

Bomb disposal experts carried out a controlled explosion last night on a 250kg World War II shell discovered at Britain's largest sewage works.

The bomb was found at Beckton sewage works off Jenkins Lane after surveyors preparing the site for a £200m expansion detected an unusual magnetic force underground on Saturday morning.

The Thames Water workers immediately alerted police and army ordnance experts, who attended the site and confirmed it was an unexploded German warhead.

A 400-metre exclusion zone was set up before the bomb was destroyed at the works under controlled conditions at 9pm on Saturday.

Second World War bomb which caused commuter chaos has been diffused

By DAILY MAIL REPORTER
Last updated at 4:42 PM on 06th June 2008

Comments (0) Share +1 0 Tweet 0 Like 3

An unexploded Second World War bomb which forced the closure of a number of transport routes in the capital was defused today.

Army experts worked to disarm the 2,000lb UXB faced delays after discovering metal used to make the Second World War device was thicker than expected.

This morning, however, military engineers managed to cut through the casing of the bomb, which measures 5ft by 2ft, enabling them to begin 'steaming' the explosive inside to make it safe.

Effort: Army experts' machines and the unexploded bomb in East London

Commuters faced the prospect of more Tube chaos, however, as lines near the danger area were closed.

The bomb, which is lying on a gas main just 50 yards from the main sewage pump for east London, was unearthed by a mechanical digger on Monday in the banks of the Lea in Bromley-by-Bow near the Olympic site.

Construction workers made the discovery while widening the bank to take barges for the 2012 Games village construction.

It had lain dormant there for more than 60 years.

Holiday beach cordoned off after landslip sends more than a THOUSAND Second World War bombs and rockets tumbling onto the sands

- **Bad weather led to ground movement which exposed the huge arsenal at Mappleton, East Riding**
- **A dog walker stumbled across the deadly find on Saturday and 15 controlled explosions were carried out**
- **Rockets, mortar bombs and 25-pounder bombs were recovered after they were fired into the cliffs by RAF aircraft during the war**
- **Most of the devices were dummy rounds used for bombing practice but contain enough explosives to cause terrible injuries**

By EMILY ALLEN and MARK BRANAGAN

PUBLISHED: 08:11, 23 July 2012 | **UPDATED:** 02:42, 24 July 2012

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Source: Various news sources

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Examples of Unexpected Detonation of WWII Bombs

Annex: H2

BASF has confirmed that an explosive device, most likely a World War II-era bomb, caused the blast that left one person injured Tuesday at a plant construction site in Germany.

The explosion was reported at BASF's Ludwigshafen toluene diisocyanate (TDI) plant, which recently broke ground for a 300,000 metric tons per year TDI production plant and other construction to expand its facilities.

1st March 2013

BASF is expanding their its Ludwigshafen location by expanding several plants and building a TDI plant, which was the site of an explosion on Tuesday (Feb. 26). One person was injured in the blast, which BASF believes was caused when excavation work detonated a bomb.

Early reports had speculated that excavation work had detonated a bomb from World War II. While the age of the bomb has not been confirmed, BASF has said that an explosive device was detonated.

BASF Provides Some Details

Responding to a request from *PaintSquare News* for more information on Wednesday (Feb. 27), BASF's manager of media relations and corporate communications Europe, Ursula von Stetten, wrote in an email, "So here [are] the facts: The detonation took place at 10:00 a.m. One person was injured; the injury is not serious. He will be kept in the hospital for some days.

"Cause of the detonation was an explosive device, presumably a bomb deriving from the Second World War. The device detonated when grounding work was done. No details on [a] delay [are] available. At the moment, the exact circumstances of the incident are [being] evaluated."

World War II Bomb Explodes on German Motorway

A highway construction worker in Germany accidentally struck an unexploded World War II bomb, causing an explosion which killed him and wrecked several passing cars.

Tweet 0 Recommend 1

23rd October 2006

AP

A cutting machine lies wrecked by the side of the A3 motorway next to a small crater left by the explosion.

A World War II bomb has exploded during construction work on a German highway, killing one worker and injuring several motorists who were driving past, police said.

The worker had been cutting through the road surface near the south-western town of Aschaffenburg when his machine struck the bomb and triggered it. Police said they weren't sure yet what type of bomb it was. "The explosion seems to have been too small for it to have been an aircraft bomb," a police spokesman said.

The A3 Autobahn linking the cities of Frankfurt and Würzburg has been blocked in both directions.

More than 60 years since the end of World War II, construction workers still frequently unearth unexploded bombs and it is not uncommon for whole city districts to be cordoned off and even evacuated while bomb disposal experts defuse them.

Indeed, just last week, some 22,000 people were evacuated from their homes in Hanover when three World War II bombs were discovered.

Allied pilots rained nearly 2 million tons of explosives on Germany during the war. Landmines, hand grenades, mortar bombs and anti-tank devices from the fighting on German soil at the end of the war are also found, and authorities say it will take decades before the country is cleared of duds.

Between 400 and 600 bombs are discovered a year in the state of North Rhine-Westphalia alone, where the heavily industrialized Ruhr region was a major target for Allied bombers.

19th September 2013

WWII bomb injures 17 at Hattingen construction site

Published: 19 Sep 08 16:53 CET

Share +1 0 Tweet 0

Seventeen people were injured on Friday when a construction crew unwittingly detonated a buried World War II-era bomb in Hattingen.

- Liberals grit teeth ahead of May state election (17 Mar 12)
- Nazi death camp guard Demjanjuk dies (17 Mar 12)
- Stupid stunt causes bomb scare chaos (16 Mar 12)

An excavator apparently drove over a 250-kilogramme (550 pound) American bomb, damaging surrounding buildings. Most of the injured suffered auditory trauma from the blast, and the excavator operator suffered injuries to his hands, police in the German state of North Rhine-Westphalia said.

"The hole was astoundingly small for such a large bomb full of so many explosives," Armin Gebhard, head of the Arnsberg department for military ordnance removal, told The Local. "But of course it damaged all the surrounding buildings too. We are really happy it wasn't worse."

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2 June 2010 Last updated at 15:37

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World War II bomb kills three in Germany

Three people have been killed and six injured trying to defuse a World War II bomb in central Germany.

Workers building a sports stadium had earlier unearthed the bomb in the town of Goettingen.

It was not immediately clear why the bomb, reportedly weighing 500kg (1,100lb), had detonated.

Unexploded WWII bombs dropped by Allied planes are frequently found in Germany, though it is unusual for them to explode unexpectedly.

A special commission is investigating the causes of the explosion, while prosecutors are considering whether the team leader should face charges of manslaughter through culpable negligence, the BBC's Oana Lungescu reports from Berlin.

The blast happened an hour before the defusing operation was due to start.

Officials said the three men who died were experienced sappers, or combat engineers, who over 20 years had defused up to 700 bombs.

More than 7,000 people were immediately evacuated when the 500kg bomb was found. Several schools, a kindergarten and local companies remain closed.

2nd June 2010

AFP

All the victims were involved in an operation to defuse the bomb

June 2006

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Ref: **OPN2111** Source: Various news sources

Recent Example of UXB Detonation – January 2014

Annex: H3

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3 January 2014 Last updated at 16:25

Share

WW2 bomb blast kills digger driver in Germany

A World War Two bomb has exploded at a construction site near a west German town, killing a man and injuring eight others, police say.

The explosion occurred after a digger accidentally struck the device during excavation work in Euskirchen in the state of North Rhine-Westphalia.

The machine's operator died on the spot. Two of those hurt were critically wounded, the dpa news agency reports.

Police said the blast impact could be felt a kilometre (0.6miles) away.

The incident took place around 13.30 local time (12.30 GMT) in an industrial park on the edge of town.

The bomb blew up when it was disturbed by the digger, as the machine lifted up earth and debris.

The blast damaged nearby office buildings and cars. Police say the explosion also smashed the windows of some local shops and homes.

© AP

Risky business: There are still thought to be hundreds of undetonated bombs in the area following the Allied drops in 1944

REUTERS

Although WW2 bombs are regularly being found, it is rare that anyone is killed by a device going off

REUT

The impact of Friday's massive blast damaged cars parked near the site

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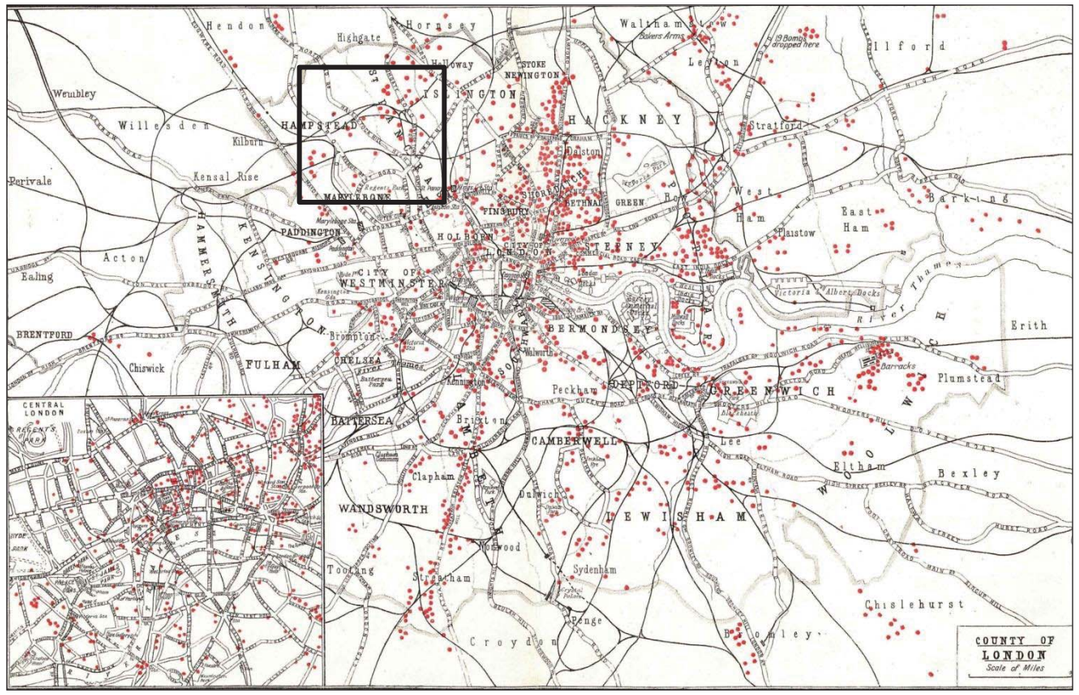
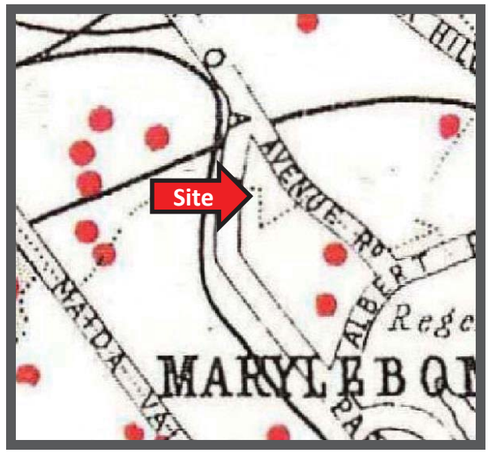
WWI Bomb Plot Map, London

Annex: I





Examples of 50 and 100kg German WWI bombs

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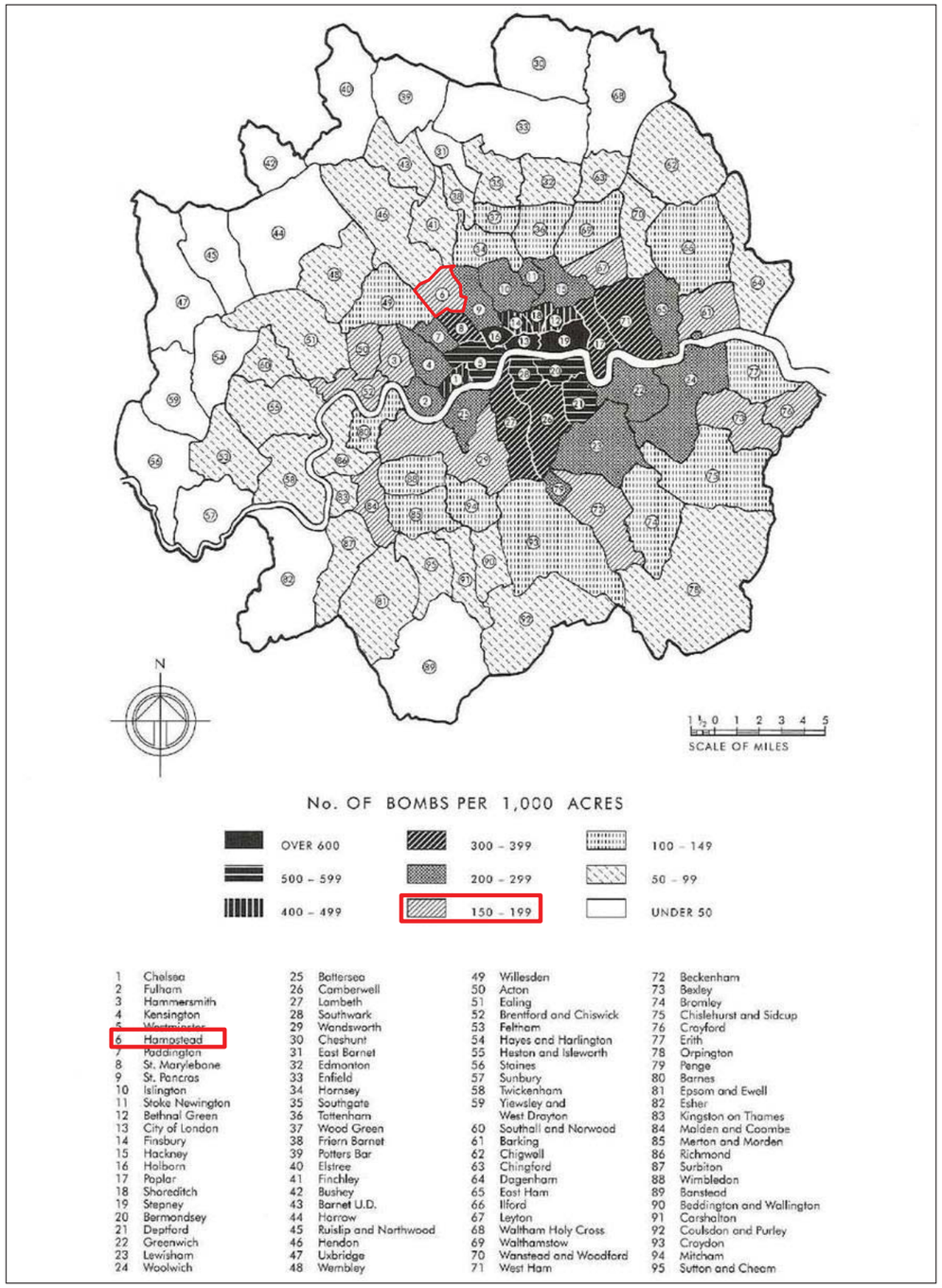
Source: The National Archives, Kew

N

London WWII Bomb Density Map

Annex: J



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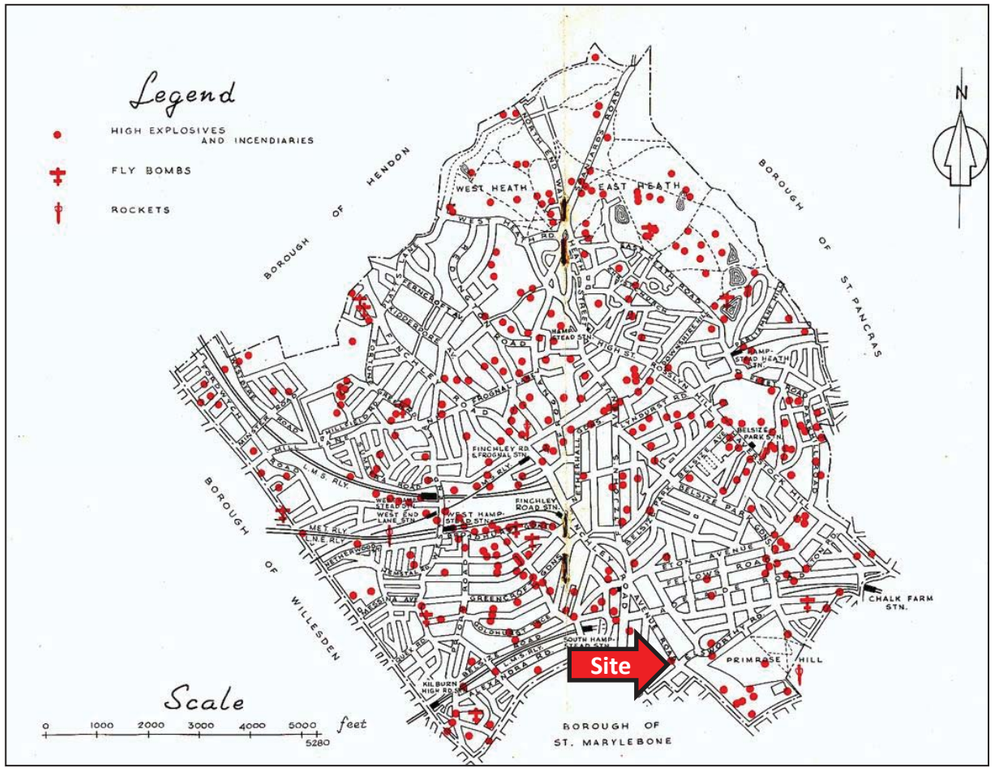
Source: The London Metropolitan Archives

N

Borough of Hampstead Bomb Map

Annex: K



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Source: 'Hampstead at War', Camden Archives

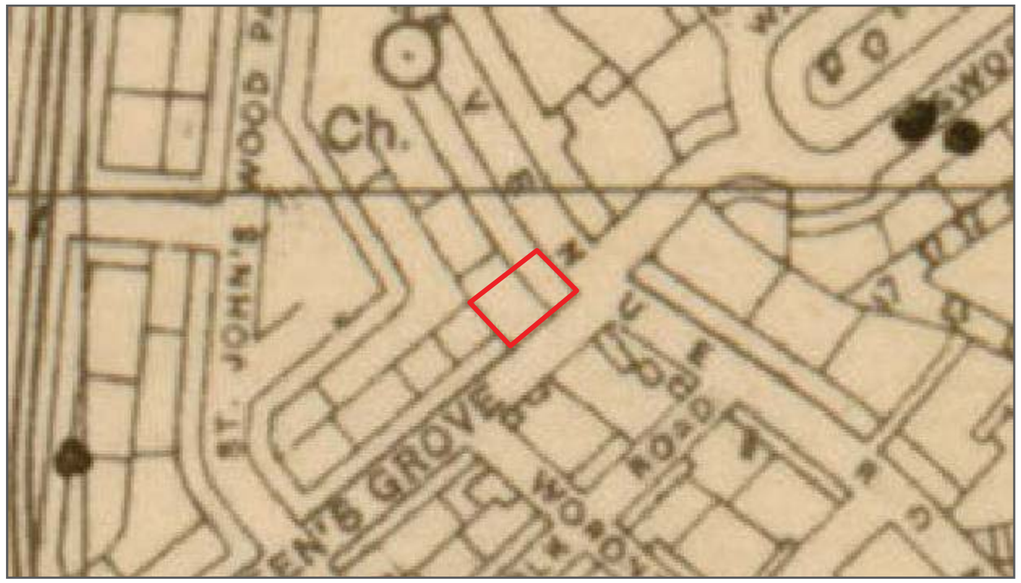
Approximate site boundary

N

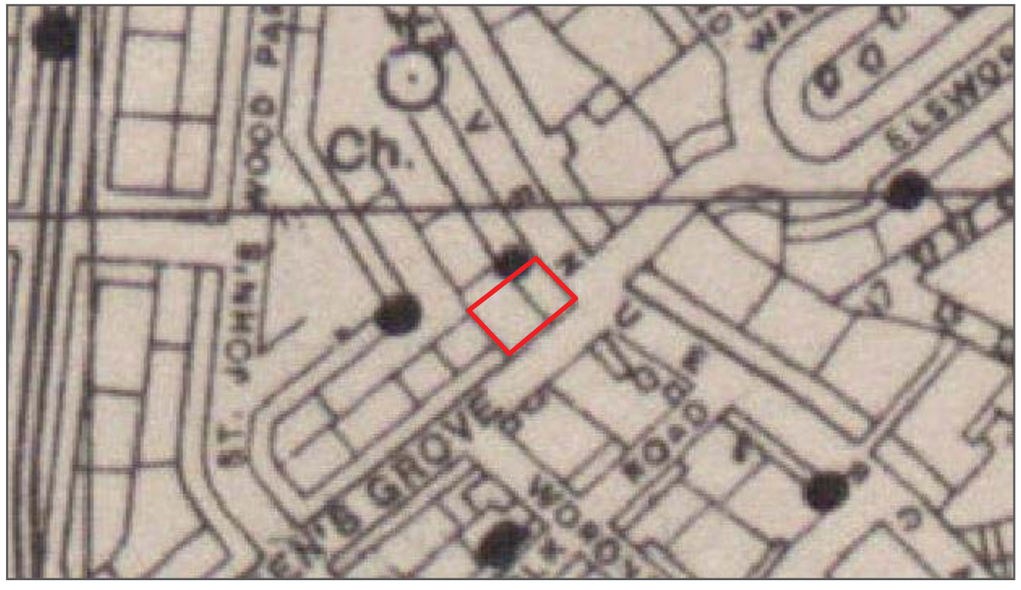
Consolidated London Bomb Census Mapping

Annex: L1

Night Bombing up to 7th October 1940



Night Bombing - 7th October 1940 to 28th July 1941



Recorded HE bomb strike

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Source: The National Archives, Kew

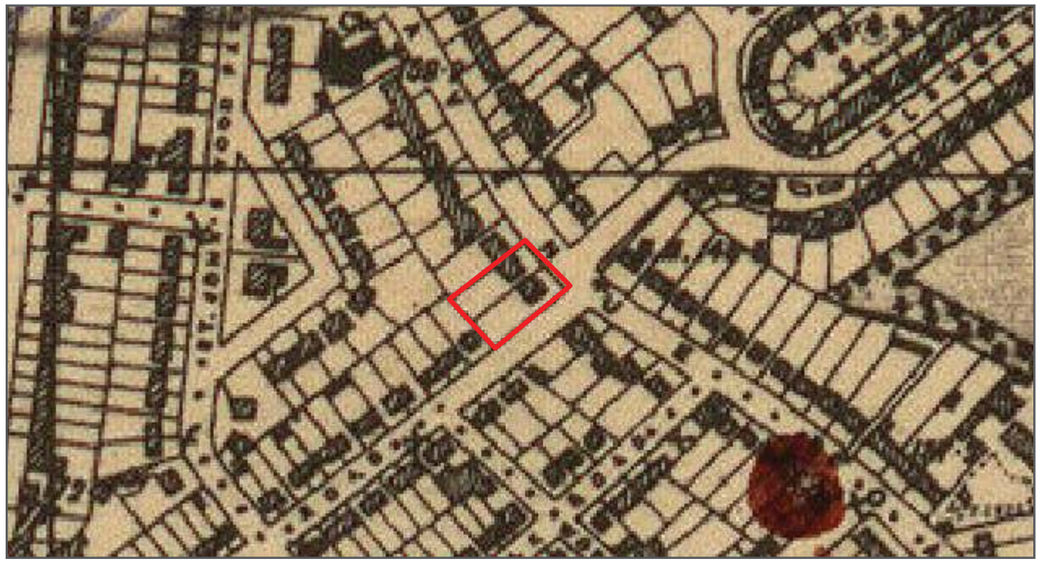
Approximate site boundary

N

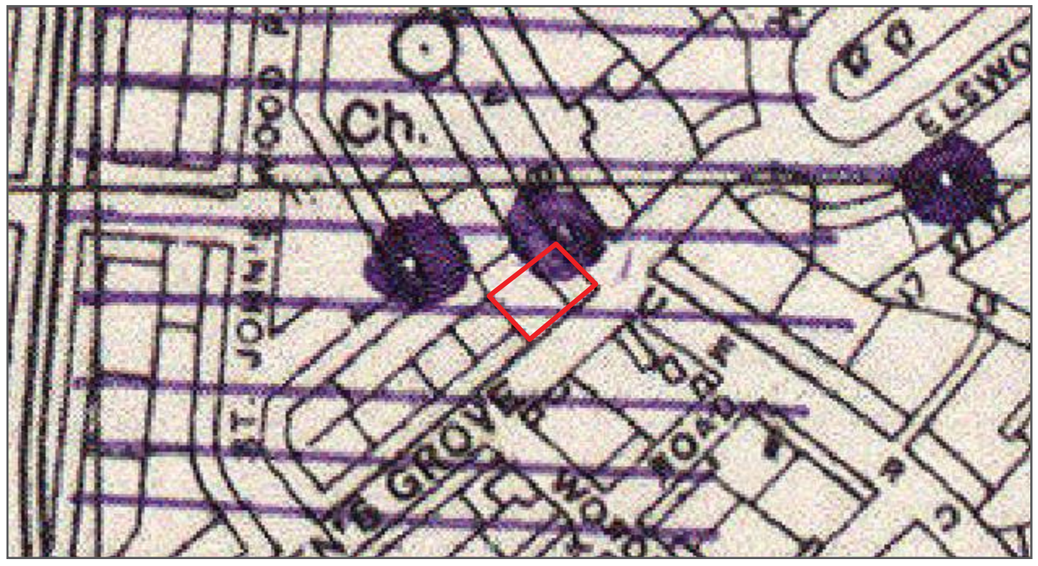
Weekly London Bomb Census Mapping

Annex: **L2**

Night Bombing 7th – 14th October 1940



Night Bombing 16th – 23rd December 1940



Recorded HE bomb strike

Incendiary bomb shower

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Source: The National Archives, Kew

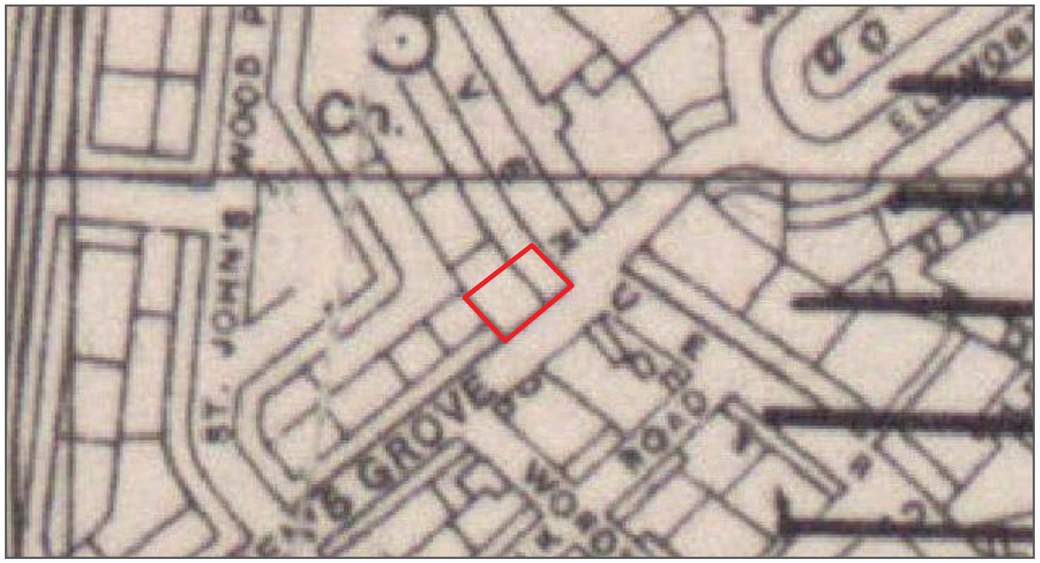
Approximate site boundary

N

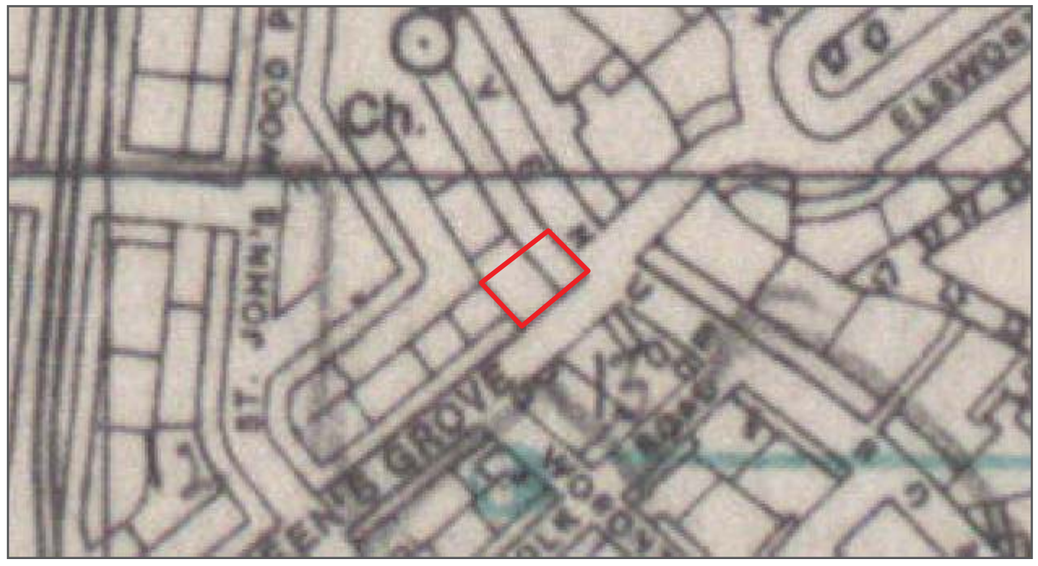
Weekly London Bomb Census Mapping

Annex: **L3**

Night Bombing 27tth January – 3rd February 1941



Night Bombing 14th – 20th February 1944



Phosphorus bomb strike

Incendiary bomb shower

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Source: The National Archives, Kew

Approximate site boundary

N

London V-1 Flying Bomb Map

Annex: **M**

V1 Flying Bomb

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Approximate site boundary

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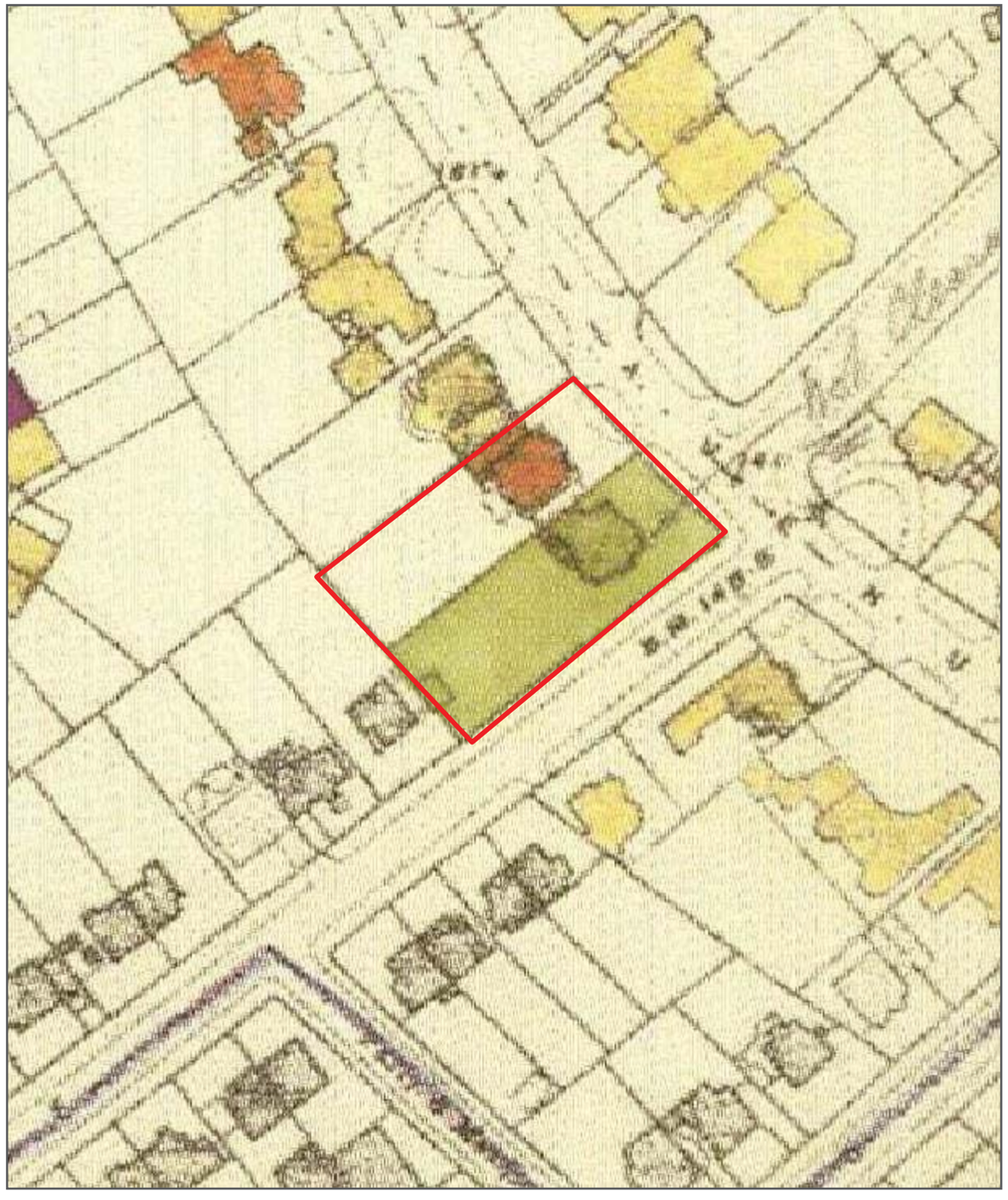
Project: **73 – 75 Avenue Road**

Ref: **OPN2111**

Source: The National Archives, Kew

London County Council Bomb Damage Map

Annex: **N**



Black	Total destruction	Orange	General blast damage; not structural
Purple	Damage beyond repair	Yellow	Blast damage, minor in nature
Dark Red	Seriously damaged; doubtful if repairable	Light Green	Clearance areas
Light Red	Seriously damaged, but repairable at cost		

V1 Flying Bomb

V2 Long Range Rocket

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Source: London Metropolitan Archives

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RAF Aerial Photography 10th May 1946

Annex: **O1**

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Source: National Monuments Record Office (English Heritage)

RAF Aerial Photography 10th May 1946

Annex: **O2**

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Source: National Monuments Record Office (English Heritage)

RAF Aerial Photography 10th May 1946

Annex: **O3**

Approximate site boundary

N

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Ref: **OPN2111**

Source: National Monuments Record Office (English Heritage)

Anti-Aircraft Projectiles

Annex: **P**

QF 3.7 Inch WWII Anti-Aircraft Projectile

Projectile Weight	28lb (12.6 kg)
Explosive Weight	2.52lbs
Fuze Type	Mechanical Time Fuze
Dimensions	3.7in x 14.7in (94mm x 360mm)
Rate of Fire	10 to 20 rounds per minute
Use	High Explosive Anti-Aircraft projectile. 4.5in projectiles were also used in this role.
Ceiling	30,000ft to 59,000ft

40mm Bofors Projectile

Projectile Weight	1.96lb (0.86kg)
Explosive Weight	300g (0.6lb)
Fuze Type	Proximity and Mechanical Time Fuze
Rate of Fire	120 rounds per minute
Projectile Dimensions	40mm x 310mm (1.6in x 12.2in)
Ceiling	23,000ft (7000m)

Unrotated Projectile (UP) – Z Battery

Projectile Weight	84lb (24.5kg)
Warhead Weight	4.28lb (1.94kg)
Warhead	Aerial Mine with a No. 700 / 720 fuze
Filling	High Explosive
Dimensions	1930mm x 82.6mm (76 x 3.25in)
Use	As a short range rocket-firing anti-aircraft weapon developed for the Royal Navy. It was used extensively by British ships during the early days of World War II. The UP was also used in ground-based single and 128-round launchers known as Z Batteries.

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Appendix E

Construction Management Plan