

BRIMSTONE

DETAILED UXO RISK ASSESSMENT

STAGE 2 DETAILED UXO RISK ASSESSMENT

Client:	Environmental Engineering Partnership Limited		
Project Ref:	E3PL277R		
Site Name:	Land at Hinchley Road, Charlestown		
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EXECUTIVE SUMMARY

RESULT: Brimstone concludes that unexploded ordnance (UXO) poses a **LOW RISK** to the proposed works.

THE SITE: The Site is located in Charlestown, within Greater Manchester, approximately 855m north-west of Moston railway station. It comprises entirely undeveloped ground with no immediately obvious purpose, with mature vegetation present along the northern border, as well as intermittently across the eastern and western extents. A series of accessways are also encompassed across the Site.

The Site is bound to the north by Caspian Drive and residential structures on Northwold Drive, to the east by Hinchley Road and residential structures on Caspian Drive, to the south by Hinchley Road, and to the west by the Co-op Academy North Manchester grounds.

Grid Reference: SD 87823 03137 **What3Words:** birds.roses.bulb

THE PROPOSED WORKS: Client-provided documentation indicates that Site investigation (SI) works have previously been completed, comprising 10 dynamic sampling boreholes to 4.45m – 5.45m below ground level (bgl) and 23 trial pits to 1.10m – 3.50m bgl undertaken spatially across the Site in January 2024, as well as an additional four rotary boreholes in February 2024 to 30m – 40.50m bgl.

Development works will comprise low-rise residential properties with piled foundations, as well as associated hardstanding roadways and landscaping. The precise depths of associated intrusions were not provided at the time of writing.

UXO RISK ASSESSMENT:

German UXO:

- Greater Manchester was the 11th most heavily bombed British conurbation during World War II (WWII). Analysis of Luftwaffe target photography indicates that the A.V. Roe & Co. Ltd aircraft factory, approximately 735m north-east, was the closest primary bombing target to the Site. Railway infrastructure approximately 825m east may also have been identified as a target of opportunity.
- No bombing incidents were recorded within the Site boundary or in the immediate surrounds within consulted sources. A Manchester bomb plot and damage map records one high-explosive (HE) bomb strike within an approximate 500m radius, plotted approximately 500m south-east. However, no damage is recorded in the vicinity within this mapping; note, the Site's undeveloped composition means any damage occurring specifically on Site will have not been recorded in this particular source. Similarly, no casualties were identified within the aforementioned radius within a civilian fatalities map; although, this source cannot be considered comprehensive due to only recording incidents where fatalities occurred.
- No immediately obvious evidence of bomb damage, such as cratering, is visible within the undeveloped land on Site or in the vicinity within post-WWII aerial photography dated 1948. Similarly, no such evidence of structural damage, such as ruins, is visible on Site or in the surrounds within post-WWII OS mapping.
- As mentioned, at the onset of WWII, the Site largely comprised undeveloped ground; the eastern extent encompassed a playing field associated with a school, while the western extent appeared to comprise agricultural land. Therefore, it is anticipated that these areas experienced an infrequent level of access, although this would have depended on the landowner(s) and seasonal usage. Nonetheless, infrequent access reduces the likelihood that evidence of an unexploded bomb (UXB) strike would have been observed and dealt with at the time, especially if the ground cover became unmaintained at any point during WWII.

- In contrast, given the seeming lack of damage occurring in this location, any UXB strike to the structures in the southern extent of the Site will have caused incontrovertible evidence of its occurrence and would have been reported at the time. Additionally, the presence of these structures may have added a degree of access / monitor to the undeveloped areas of the Site in close proximity, although this could not be confirmed.
- In conclusion, no bombing incidents are recorded on Site or in close proximity, and no evidence of bomb damage occurring on Site / immediately adjacent has been identified. Despite the majority of the Site presenting conditions unconducive to the visual detection of UXBs, given the abovementioned lack of bombing / damage occurring, a **Low Risk** of encountering German UXBs has been assessed.

British / Allied UXO:

- No evidence of historic military activity specifically on Site has been found and it is considered unlikely that any has occurred. Therefore, the risk of encountering associated Allied UXO has been assessed as **Low**.
- 31 permanent heavy anti-aircraft (HAA) batteries were active within range of the Site during WWI; the closest was located approximately 650m south-east. Light anti-aircraft (LAA) guns likely defended vulnerable points within the region also. Luftwaffe activity was relatively frequent over the wider area and therefore these guns would have expended a considerable quantity of ammunition. However, no such strikes have been identified in the vicinity; as such, the risk of encountering an unexploded anti-aircraft (AA) shell is considered analogous to German UXBs, and a **Low Risk** has been assessed.

Likelihood of UXO Remaining and UXO Encounter:

- No significant post-conflict ground works have occurred across the majority of the Site. The southern structures appear to have been cleared by 1952, with a hardstanding accessway appearing to have been laid across the southern extent of the Site boundary by 2005. The remainder of the Site still comprises undeveloped land as per recent satellite imagery.
- General maintenance and laying of hardstanding on previously undeveloped ground will have disturbed WWII-era soil to very shallow (>1m bgl) depths across the Site. Clearance of the pre-WWII structures in the southern extent will have disturbed WWII-era to shallow (1-2m bgl) depths in their footprints. No deep (>2m bgl) intrusions are anticipated to have occurred across the Site.
- The risk associated with any very shallow buried UXO will have been largely mitigated across the Site. The risk associated with any shallow buried UXO may have been partially mitigated in the footprints of the cleared structures in the south. The risk associated with any deep buried UXO almost certainly remains unmitigated.
- Please note, the risk of a UXO encounter can be considered mitigated in the exact locations and down to the exact depths of any post-WWII intrusive works.

RECOMMENDED RISK MITIGATION MEASURES: The measures detailed below are recommended to mitigate the risk to ALARP level.

Risk Mitigation Measure	Recommendation
UXO Safety Awareness Briefings	Prior to all intrusive works commencing.

CONTENTS

EXECUTIVE SUMMARY ..... **ii**
QUALITY POLICY **2**
1 INTRODUCTION **3**
1.1 Background 3
1.2 Legislation 3
1.2.1 Construction Design and Management Regulations (CDM) 2015 3
1.2.2 The Health and Safety at Work Act 1974 3
1.3 Commercial Contractor and the Authorities 3
1.3.1 Commercial Contractors 3
1.3.2 UK Authorities 4
1.4 UXO Risk in the UK 4
1.5 UXO Detonations 4
2 ASSESSMENT METHODOLOGY **5**
2.1 Introduction 5
2.2 Source, Pathway, Receptor, Consequence Risk Model 5
2.3 Assessment Structure 6
2.4 Information Sources 6
2.5 As Low as Reasonably Practicable Principle 6
2.6 Risk Tolerances 7
2.7 Mapping/Imagery Accuracy Disclaimer 7
2.8 Reliance and Limitations 7
3 THE PROJECT **7**
3.1 The Site 7
3.2 The Proposed Works 7
4 SITE HISTORY **8**
4.1 Site Introduction 8
4.2 Mapping 8
4.3 Photography/Aerial Photography 9
4.4 Additional Site-Specific History 9
5 UXO RISK - GERMAN BOMBING **9**
5.1 WWI Bombing History 9
5.1.1 Britain during WWI 9
5.1.2 Site Specific 9
5.2 WWII Bombing History 10
5.2.1 Greater Manchester 10
5.2.2 Site Specific 10
5.2.3 Bombing Decoy Sites 10
5.3 WWII Bombing Records 10

5.3.1 Introduction 10
5.3.2 Bombing Density Statistics 11
5.3.3 Manchester Bomb Plot and Damage Map, 1940-1941 11
5.3.4 Manchester Civilian Fatalities Map 12
5.3.5 Abandoned Bomb Register 12
5.3.6 Secondary Source / Anecdotal Evidence 12
5.4 Likelihood of UXB Contamination 13
5.5 Likelihood of Subsequent UXB Detection 14
6 WWII GERMAN BOMBS 15
6.1 Bombs Dropped on the UK 15
6.2 Bomb Failures 15
6.3 Bomb Ground Penetration 16
6.3.1 Introduction 16
6.3.2 The J-Curve Effect 16
6.3.3 Site Specific Geology 17
6.3.4 Site Specific Maximum Bomb Penetration Depth 17
7 UXO RISK - BRITISH/ALLIED ACTIVITY 17
7.1 Introduction 17
7.2 Potential Sources of UXO 17
7.2.1 Introduction 17
7.2.2 WWII Anti-Aircraft Fire 18
8 UXO RISK MITIGATING CIRCUMSTANCES 19
8.1 Introduction 19
8.2 Explosive Ordnance Clearance Tasks 19
8.3 Ground Works 19
8.4 Deductions 19
9 CONCLUSION 20
9.1 Accuracy of Historical Records 20
9.2 The Risk of UXO Contamination on Site 20
9.2.1 Key Findings – German UXO Risk 20
9.2.2 Key Findings - British UXO Risk 20
9.3 Site-Specific UXO Hazards 21
9.4 The Likelihood of UXO Encounter 21
9.4.1 Introduction 21
9.4.2 German UXBs 22
9.4.3 British / Allied UXO 22
9.4.4 Deductions 22
10 OVERALL RISK RATING 23
11 RISK MITIGATION RECOMMENDATIONS 23

FIGURES

FIGURE 1: Site Location Maps

FIGURE 2: Proposed Site Plan

FIGURE 3: Historical OS Mapping

FIGURE 4: Historical Aerial Photography

FIGURE 5: Manchester Bomb Plot Mapping

APPENDICES

APPENDIX 1: Recent UXO Incidents and Historical Analysis

APPENDIX 2: Data Sheets - German WWII Air-Delivered Munitions

APPENDIX 3: Data Sheet - British WWII Anti-Aircraft Munitions

APPENDIX 4: Glossary

APPENDIX 5: Bibliography

QUALITY POLICY

Brimstone Site Investigation Ltd, known as Brimstone, is committed to the delivery of unexploded ordnance (UXO) risk mitigation services, including safe removal and disposal of explosive ordnance, in the UK and overseas. Since our incorporation in 2016 it has been our goal to provide unsurpassed and unbiased UXO risk mitigation services. Brimstone is a client-centric organisation, with the aim to provide the client the services they need, to the agreed requirement, in accordance with national and international standards or standard operating procedures.

We are committed to providing a safe, cost-effective, and quality service, underpinned by our core values:

- **Integrity:** We are unwavering in our commitment to providing pristine, unbiased counsel and superior services. Our ethical compass guides every interaction, ensuring we maintain the highest standards of conduct in all our endeavours.
- **Professionalism:** We embody professionalism at every level, conducting our business with unparalleled excellence. Our commitment to quality guarantees top-tier service and a seamless experience for every client.
- **Knowledge:** We are devoted to perpetual growth, consistently expanding our expertise to stay at the forefront of industry innovation and strategy. Our thirst for knowledge ensures we are equipped to lead and succeed in an evolving marketplace.
- **Innovation:** We champion innovation, continuously advancing our services and processes. Our pursuit of inventive strategies and pioneering solutions ensures we not only meet but exceed the evolving needs of our clients and the industry.

We are committed to the applicable requirements of the ISO 9001:2015 standards. We set and review quality monitoring objectives using the plan, do, check, act cycle to measure the performance of our quality management system. Brimstone wholly endorses the ethos of 'continual improvement efforts' and allocates resources to meet this requirement.

This policy applies to the whole of the Brimstone services and involves all personnel including the managing director. All personnel are responsible for helping manage quality, seeking improvement through constant review, and by encouraging supplier and subcontractor involvement. We are committed to achieving customer satisfaction using quality procedures, which will be operated to meet or exceed the applicable requirements of ISO 9001.

Aaron Florence
Founder and Managing Director
Brimstone Site Investigation Ltd.

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1 INTRODUCTION

1.1 Background

Environmental Engineering Partnership Limited (the Client) has commissioned Brimstone to carry out a Stage 2 Detailed Unexploded Ordnance Risk Assessment (DRA) of the proposed redevelopment works at the Land at Hinchley Road, Charlestown site (the Site).

1.2 Legislation

There are no regulations that specifically govern the UXO risk mitigation industry in the UK. However, there are two pieces of legislation that require consideration. It is industry best practice (and common sense) to frame your site in the context of UXO, and to put in place measures to protect people from risks. In 2009, CIRIA published Unexploded Ordnance (UXO) - A Guide for the Construction Industry C681. This publication, though not legally binding, provides the gold-standard framework to which UXO and construction companies operate.

1.2.1 Construction Design and Management Regulations (CDM) 2015

The regulations identify the client, the CDM coordinator, the designer, and the principal contractor as responsible parties. Under the regulations, responsible parties are held accountable for the way a construction project is managed and for the health and safety of workers. Responsible parties must:

- Provide an appropriate assessment of potential UXO risks, or ensure an assessment is completed by another party.
- Put in place appropriate risk mitigation measures if necessary.
- Supply all parties with information relevant to the risks.
- Ensure the preparation of an emergency response plan.

1.2.2 The Health and Safety at Work Act 1974

The Health and Safety at Work Act 1974 had a transformative impact on health and safety, saving thousands of lives since its enactment. Employers must consider their employees, workers not in their employment, and members of the public. The act places a duty on every employer 'as far as is reasonably practicable' to protect workers from risks. It also says that information must be provided about aspects of health and safety that affect their role.

1.3 Commercial Contractor and the Authorities

1.3.1 Commercial Contractors

If your site has been given a moderate or high-risk rating, then control measures will be recommended. The measures will be specific to the scope of works on site, usually in relation to the depth and extent of excavations, piling and similar activities. There are a range of different methods at Brimstone's disposal, including:

- Non-intrusive surveying (including drone surveying)
- Intrusive surveying
- Search and clear
- Watching brief
- Support to geotechnical investigations
- Target investigation
- Site-specific training packages
- Site safety briefings

Our UXO Engineers can assess suspicious items on site when they are found. This will avoid unnecessary site evacuations. If our engineer(s) decide the item is UXO, they will coordinate with the authorities, manage disruptions, and advise on control measures, such as evacuations and a cordon.

1.3.2 UK Authorities

If Brimstone is not on site and a suspicious item is found, the local police must be immediately called on the non-emergency number. Police will visit the site. They will then inform the Joint Services Explosive Ordnance Disposal (JSEOD) office, which will coordinate the callout of an army or navy response team.

A precautionary cordon will initially be put into effect, with possible evacuation of homes and businesses, road and rail closures. The cordon may be extended following the advice from JSEOD's response team.

To manage their resources, JSEOD triages incidents. A consideration of the type, size and location of the UXO is made. If an incident is not given a high priority rating, a team may not be available for up to two days following the initial report.

The use of JSEOD is under the Military Aid to Civil Authorities (MACA) framework, therefore the budget and personnel is limited, and there are no statutory obligations made of the MOD. Often the MOD will recommend involvement of a commercial UXO contractor to manage the ongoing risk – this is especially true of former airfields and training areas where contact with land service ammunition can be frequent.

1.4 UXO Risk in the UK

Fortunately, to the best of our knowledge, there has not been a single post-war incident in the UK where a construction worker has been killed or injured because of an item of UXO exploding. There have been cases in mainland Europe where UXO had been struck and then exploded, killing workers. In 2019, a WWII general purpose bomb spontaneously detonated in a field north of Frankfurt, Germany.

However, the incident in Frankfurt is not comparable to the UK, due to the way different countries manufactured ordnance. Bombs made in different countries have different associated hazards. British WWII bombs, for example, have a fuzing system which uses chemicals which makes them very unsafe. Please see **APPENDIX 1** for recent examples of UK UXO incidents.

Between 2013 and 2016 JSEOD responded to 7,500 callouts. These callouts range from falsely identified objects, inert objects, small items of UXO and large WWII German unexploded bombs (UXBs). Each year the construction industry inadvertently unearths UXO; often this goes unreported. UXO contamination comes from three main sources:

- **Enemy action:** during WWI and WWII the air forces of Germany, and to a lesser extent Italy, bombed targets throughout the UK. The German navy bombarded several coastal targets in eastern England during WWI and then in WWII German long-range artillery on the French coast bombarded parts of Kent.
- **Allied military activity:** during WWI and WWII several Allied nations used the UK as a staging area for military action in the European Theatre; predominantly the US and Canada.
- **UK military activity:** domestic British Army, Royal Air Force (RAF) and Royal Navy (RN) training activities during peacetime and conflict as well as anti-aircraft gun and rocket batteries during WWI and WWII.

1.5 UXO Detonations

A detonation is a violent chemical reaction which creates a huge volume of gas. This reaction appears to happen instantaneously – the velocity of the shockwave moving is up to 9,000m per second. This chemical reaction is started using a small amount of very sensitive explosives called primary explosives. These types of explosives are highly sensitive to shock, friction, heat, and spark. As the explosive charge undergoes high order decomposition (detonation), the brisance, or shattering effect, causes the casing to splinter, projecting razor-sharp shrapnel across long distances.

The blast wave effect and the shrapnel effect can cause significant damage. Calculating safety distances is a complex process. As a rule of thumb, in open ground, a 250kg explosive charge (as would be found inside a typical 500kg bomb) would require an omnidirectional safety distance of at least 1.6km.

Bombs work by amplifying the explosive charge from the sensitive primary explosive through to the main charge or fill of the item. This process is called an explosive train, if any link in that chain is broken, the item will fail to function as intended. This can be due to mechanical, electrical, or manufacturing tolerances or faults. Amongst other reasons, detonation of UXO could occur under the following circumstances:

- **UXO body impact:** A substantial impact onto the main body of a UXO; borehole rigs, piling rigs, jack hammers and mechanical excavator buckets.
- **Fuse impact:** Environmental conditions during decades of burial can result in the primary explosives located in the fuse pocket to crystallise and become shock sensitive. It would then take a relatively small impact or friction impact to cause the fuse to function and detonate the UXO.
- **Re-starting a timer:** A small proportion of German WWII bombs used clockwork fuses. In 2002, an Army EOD Engineer reported that the clockwork fuse in a UXB re-started. Decades of burial causes substantial corrosion in WWII German UXBs and therefore an incident such as this is extremely rare.

2 ASSESSMENT METHODOLOGY

2.1 Introduction

This assessment has been produced in accordance with the relevant CIRIA guidelines; *Unexploded Ordnance (UXO) - A Guide for the Construction Industry C681* (published in 2009). CIRIA C681 is a publication which originated from round table best practice discussions from industry leaders.

2.2 Source, Pathway, Receptor, Consequence Risk Model

The Source, Pathway, Receptor, Consequence (SPRC) risk model can be applied to buried UXO as follows:

- **Sources:** UK and Allied UXO sources include military firing ranges, bases, storage depots, munitions factories, anti-aircraft batteries, amongst others. There are many wartime causes of UXO contamination. The source for enemy contamination is overwhelmingly from WWII German air raids.
- **Pathways:** the pathway describes how the UXO reaches receptors. Usually, UXO is buried and therefore pathways can be any activity which involve breaking ground. Examples include ground investigation works, site enabling works and excavations.
- **Receptors:** receptors are the people, assets and infrastructure that can be adversely affected by UXO exposure. This includes site personnel, plant, equipment, buildings, the general public, and the environment.
- **Consequence:** the consequences of an inadvertent UXO detonation are catastrophic. They include injury and loss or life, as well as damage to property. Fortunately, the likelihood of UXO detonating is low, even when it is uncovered during works. However, another consequence to consider is delays to works, which itself can be a risk.

2.3 Assessment Structure

In accordance with CIRIA C681 this assessment addresses the following considerations in the appropriate order:

- The likelihood that the site was contaminated with UXO.
- The type of UXO that could have contaminated the site, and their associated hazards.
- The likelihood that UXO remains on the site.
- Theoretical bomb penetration depths.
- The likelihood that UXO will be uncovered during the proposed works.
- Risk rating and risk mapping (as appropriate).
- Risk mitigation recommendations.

2.4 Information Sources

To complete this risk assessment, Brimstone has gathered information from a wide range of sources. Brimstone's research team has completed detailed historical research, including access of original archived records. The list below is a general list of information sources that are consulted during the research process. For Site-specific sources consulted for this risk assessment, please refer to **APPENDIX 5**.

- The National Archives,
- Local archive centres,
- Ministry of Defence,
- The Council for British Archaeology,
- Groundsure mapping services,
- Historical aerial photography (Historic England, Britain from Above, NCAP),
- Google open-source mapping,
- The British Geological Survey,
- Open sources; published book, articles, web resources,
- Site-specific information supplied by the Client,
- Brimstone's library and historical database, and
- Brimstone's former armed forces employees.

2.5 As Low as Reasonably Practicable Principle

The ALARP (as low as reasonably practicable) principle corresponds to the actions that should be taken to reduce risks. The term 'ALARP' is in the Health and Safety at Work Act 1974, which says that risks must be controlled in a reasonable way.

Infinite time, effort and money could be spent trying to eliminate risk entirely. HSE uses the example that spending £1m to prevent five employees bruising their knees is disproportionate, whereas spending the same amount to prevent an explosion which could kill 150 people is proportionate.

Using this principle, Brimstone aims to reduce client costs by recommending strategies that are proportionate to the assessed risks, if any elevated risk is found at all.

2.6 Risk Tolerances

The Brimstone risk assessment process divides UXO risk into two tolerances:

- **Tolerable:** Low Risk and Low-Moderate Risk ratings are tolerable. Where the risk cannot be completely discounted, it may be a useful strategy to opt for a low-cost measure, such as a UXO safety briefing from a qualified UXO engineer.
- **Intolerable:** Moderate, Moderate-High, and High-Risk ratings are intolerable. Proactive risk mitigation measures should be put in place. Various strategies are at Brimstone's disposal to meet your project-specific needs.

2.7 Mapping/Imagery Accuracy Disclaimer

The information presented in any drawings, maps, or images has been compiled from a variety of sources, where possible, and is provided for general reference only. While Brimstone makes every effort to ensure the accuracy and completeness of this information, it may contain errors or omissions and should not be relied upon as definitive. Brimstone disclaims any liability for the misuse or misinterpretation of the information and makes no warranties or representations, express or implied, regarding its accuracy, completeness, or suitability for any particular purpose. Please contact Brimstone for further information regarding a map or image and further information can be provided where possible.

2.8 Reliance and Limitations

This report has been prepared using published information and information provided by the Client. Brimstone is not liable for any information which has become available following the publication of this report. No third-party liability or duty of care is extended. Any third-party using information contained in this assessment do so at their own risk.

3 THE PROJECT

3.1 The Site

The Site is located in Charlestown, within Greater Manchester, approximately 855m north-west of Moston railway station. It comprises entirely undeveloped ground with no immediately obvious purpose, with mature vegetation present along the northern border, as well as intermittently across the eastern and western extents. A series of accessways are also encompassed across the Site.

The Site is bound to the north by Caspian Drive and residential structures on Northwold Drive, to the east by Hinchley Road and residential structures on Caspian Drive, to the south by Hinchley Road, and to the west by the Co-op Academy North Manchester grounds.

Grid Reference: SD 87823 03137 **What3Words:** birds.roses.bulb

FIGURE 1: Site Location Maps

3.2 The Proposed Works

Client-provided documentation indicates that Site investigation (SI) works have previously been completed, comprising 10 dynamic sampling boreholes to 4.45m – 5.45m below ground level (bgl) and 23 trial pits to 1.10m – 3.50m bgl undertaken spatially across the Site in January 2024, as well as an additional four rotary boreholes in February 2024 to 30m – 40.50m bgl.

Development works will comprise low-rise residential properties with piled foundations, as well as associated hardstanding roadways and landscaping. The precise depths of associated intrusions were not provided at the time of writing.

FIGURE 2: Proposed Site Plan

4 SITE HISTORY

4.1 Site Introduction

Site-specific history can be assessed by reviewing historical mapping, historical aerial photography and by carrying out additional Site-specific research where appropriate. Below are descriptions of a selection of records relevant to the Site:

4.2 Mapping

The below table describes the composition of the Site, structural changes in pre- and post-WWII Ordnance Survey (OS) editions, and relevant points of interest. All maps were retrieved from National Library Scotland (NLS) online database and the Landmark Promap OS database.

Period	Map Date	Map Scale	Review
Pre-WWI	1844-1845	1:10,560	The Site largely comprises undeveloped ground, likely utilised for agriculture, with two structures labelled 'Moss House' and 'Gulvert', as well as an unnamed roadway, encompassed in the southern extent. It is bound in each direction to further undeveloped ground, as well as to the east and west by the unnamed roadway.
	1889-1891	1:10,560	A small structure has been constructed in the southern extent of the Site, while the 'Moss House' structure appears to have extended over the Site boundary immediately west. No significant changes appear to have occurred across the remainder of the Site or in the vicinity.
	1906	1:10,560	No significant changes appear to have occurred on Site or in the vicinity.
Pre-WWII	1938	1:10,560	**FIGURE 3:** No significant changes appear to have occurred on Site. The eastern extent of the Site is now situated on a 'recreation ground' associated with North Manchester High School, constructed approximately 110m south-east. A row of residential structures has been constructed approximately 20m south-west of the Site on Manton Fay Avenue. Further residences have been constructed approximately 255m south-east and 160m south-west.
Post-WWII	1951-1952	1:2,500	**FIGURE 3:** The structures in the southern extent of the Site appear to have been cleared. No significant changes appear to have occurred across the remainder of the Site. An area of prefabricated structures has been constructed approximately 10m north of the Site.

4.3 Photography/Aerial Photography

The below table describes the composition of the Site visible in post-WWII aerial photography, including areas of possible structural clearance, damage and other possible features of note. All photographs were retrieved from Historic England's (HE) Royal Air Force (RAF) Photography Archive.

Period	Photo Date	Review
Post-WWII	**12th June 1948**	**FIGURE 4:** The composition of the Site appears to corroborate that visible within pre-WWII OS mapping, largely comprising undeveloped ground. The eastern extent comprised a playing field associated with the North Manchester High School, indicated by an encompassed running track. A border runs through the centre of the boundary south-east to north-west, separating the playing fields from the remainder of the Site. The southern structures remain extant on Site at this time and have not yet been cleared. No immediately obvious evidence of bomb damage, such as cratering, is visible on Site or in the vicinity. The structures in the south appear to have survived the war intact.

4.4 Additional Site-Specific History

Some sites will have been occupied by landmarks or significant buildings historically and in such cases specific written histories including significant wartime details are occasionally available in the public domain. No such information was available.

5 UXO RISK - GERMAN BOMBING

5.1 WWI Bombing History

5.1.1 Britain during WWI

During World War I (WWI), an estimated 9,000 German bombs were dropped on London, Eastern England and South-Eastern England during some 51 Zeppelin airship raids and 52 fixed-wing aircraft raids. London suffered the worst of the bombing with an estimated 250 tonnes of HE and incendiary bombs recorded across the Capital, over half of which fell on the City of London district.

The WWI bombing campaign waged by Germany was on a far smaller scale than the WWII campaign, in terms of the number of raids, the weight of ordnance dropped during each attack and the size of the bombs used. When coupled with the fact that most WWI-bombed locations have since been redeveloped, German WWI UXB finds are extremely rare. Furthermore, most air raids took place during daylight hours and as it was the first time Britain had experienced strategic aerial bombardment, the raids often attracted public interest and even spectators, increasing the chances of any UXBs being reported.

5.1.2 Site Specific

A collection of written reports describing each air raid in the region was reviewed.[1] No evidence that Manchester was targeted by enemy bombing during WWI was uncovered.

[1] ttps://www.iancastlezeppelin.co.uk/

5.2 WWII Bombing History

5.2.1 Greater Manchester

Greater Manchester was home to a number of vital wartime industries during WWII, many of which were located in Trafford Park. Infrastructure of strategic importance was also present in the form of Manchester Docks and the Manchester Ship Canal.

Between 29th July 1940 and 30th July 1942, Greater Manchester experienced 41 air raids, most of which were small in scale, often executed by a solitary bomber. At least nine relatively insignificant raids were carried out during the autumn of 1940, with the first medium scale raid affecting a wide area, occurring on 28th August, then on 1st October, a medium to heavy raid was executed.

The Luftwaffe mounted consecutive major attacks on the nights of 22nd – 24th December 1940 (the 'Christmas Blitz'). These left large areas of Manchester, Salford and Stretford devastated. NB: a major attack was a Luftwaffe designation for a raid delivering >100 tonnes of HE (in addition to incendiaries) to a target area.

In total, these two attacks involved 441 German bombers dropping 272 tonnes of HE on the first night and 195 tonnes of HE on the second night. Seven conflagrations and 600 smaller fires were reported, the result of tens of thousands of small incendiary bombs (IBs). The Christmas Blitz caused the total destruction of >4,000 houses as well as serious damage to a further 12,000. 805 HE bombs were reported across Manchester, Salford, Stretford and Manchester Docks, including 134 UXBs.

During 1941, two additional major* raids was launched on 9th January and 1st June. Although each involved half as many aircraft as 22nd December 1940 raid, they still delivered a further 208 tonnes of HE bombs and numerous IBs onto the city and surrounding area. Three medium scale raids were also mounted in 1941, during the spring.

*The fourth and final major raid actually only delivered 97 tonnes of HE. However, it is close enough to 100 tonnes to be considered 'major'.

5.2.2 Site Specific

Luftwaffe target photography identifies the A.V. Roe and Co. Ltd aircraft factory, approximately 735m north-east of the Site, as the closest primary bombing target. Railway infrastructure, approximately 825m east, may have been identified as a target of opportunity.

5.2.3 Bombing Decoy Sites

In mid-1940 bombing decoys were introduced. The decoys used either:

- A system of lighting to simulate an urban area or a military airfield's runway,
- Deliberately started fires to simulate a previously bombed target,
- Dummy buildings and vehicles to simulate a military facility.

792 static decoy sites were built at 593 locations in Britain. They were estimated to have drawn at least 5% of the total weight of bombs away from their intended targets. No decoys were operational within a significant radius of the Site during WWII. The closest was approximately 9.7km to the south-east.

5.3 WWII Bombing Records

5.3.1 Introduction

The bomb census recorded the location and type of bomb strikes to help with intelligence gathering and planning. It was compiled using information recorded by ARP wardens. These records were gathered by the Ministry of Home Security to calculate bombing density within administrative areas.

The bomb census was unreliable in the early stages of the war, though by 1941 procedures had been standardised. The quality of the census records also depended on where in the UK the records were produced. Some records are held at the National Archives and some are held at local borough archives.

Relevant records held at the National Archives and the Manchester Archives and Local Studies were obtained for this risk assessment.

5.3.2 Bombing Density Statistics

The table below records the Ministry of Home Security's bombing density calculation for the County Borough of Manchester. As the Site was located approximately 450m and 500m south-west of the administrative borders of the Urban District of Chadderton and Municipal Borough of Middleton, respectively, the statistics for these areas have also been included below. It gives a breakdown of the types of large German bombs reported and is understood to not include UXBs.

Admin Area	Manchester	Chadderton	Middleton
Area Acreage	27,255	3,013	5,172
High Explosive Bombs (all types/weights)	712	11	37
High Explosive Parachute Mines	18	1	0
Flam (Oil) Bombs	7	0	0
40kg Phosphorus Incendiary Bombs (IBs)	0	0	0
40kg 'Fire Pot' IBs	0	0	0
V1 Flying Bomb	1	0	0
V2 Long Range Rocket	0	0	0
Total (excluding V-Weapons and 1kg / 2kg IBs)	737	12	37
Bombs Per 1,000 Acres	**27.0**	**4.0**	**7.2**

1kg / 2kg incendiary bombs and 2kg anti-personnel (AP) bombs were often too numerous to record accurately and therefore are not included in the above figures.

5.3.3 Manchester Bomb Plot and Damage Map, 1940-1941

Brimstone has reviewed an original bomb plot and damage map for the wider study area. This map was produced by the Manchester City Council's Architects Department (Building Surveyor's Division) during the war and was updated throughout the conflict to reflect all raids on the city.

No original legend / key accompanies this map; however, a contemporary description does confirm some symbols. No symbol for unexploded bombs (UXB) was identified and any incendiary bomb (IB) strike symbol with a number written within it represents the number of individual IBs falling at that location.

Three categories of damage are illustrated on this map: solid red, hatched red and red outline. Whilst as above, no original key accompanies the map, these categories are considered likely to represent 'total damage or severe damage' (solid red), 'moderate damage' (hatched red) and 'minor blast damage' (red outline) respectively.

A section of the map covering the study area is presented in **FIGURE 5** and described below. Please note, due to the positioning of the mapping, two maps join at the centre of the Site; therefore, these maps have been merged, and mapping boarders are still visible.

- One high-explosive (HE) bomb strike is recorded within an approximate 500m radius, plotted approximately 500m south-east. However, no bombing incidents are recorded on Site.
- No bomb damage is recorded within an approximate 500m radius of the Site. Note, given that the Site primarily comprised undeveloped land, any damage occurring will have not been recorded within this source.

5.3.4 Manchester Civilian Fatalities Map

A contemporary digital map of Greater Manchester recording the locations of every Christmas Blitz bombing incident that resulted in at least one fatality, was reviewed. This map (published by the Manchester Evening News) was compiled using data from the Commonwealth War Graves Commission; however, it only covers the two heaviest raids on the city. Although a potentially significant source of bombing incident locations, many bombs did not cause a fatality and therefore this map should not be viewed as comprehensive.

No fatalities were recorded on Site or within an approximate 500m radius.

5.3.5 Abandoned Bomb Register

Due to the overstretched bomb disposal units during WWII, many bombs were intentionally left undisturbed. UXBs were triaged based on where they were and how big they were. If they didn't pose a significant risk, they were 'abandoned'. The locations of these bombs were recorded on the abandoned bomb register.

The abandoned bomb register is a public record document held at the Parliamentary Archives of the House of Commons, from which Brimstone has obtained a copy. The register should not be relied on for completeness or accuracy. The closest abandoned bomb is recorded approximately 8.2km south-west of the Site.

5.3.6 Secondary Source / Anecdotal Evidence

A search of online resources, as well as a review of local history publications was carried out with the intention of locating any eyewitness accounts of local bombing incidents. However, no such evidence was found.

5.4 Likelihood of UXB Contamination

Where detailed bombing records exist, it is possible to predict whether any UXBs could be found on a site. This likelihood is discussed in the following table:

Density of Bombing	
Number of Air Raids in the Vicinity:	A comparison of the bombing incident records confirms that at least one air raid affected the study area.
Intensity of these Air Raids:	The bomb dropped in the local area appears to have been part of a small-scale raid, although it is also feasible that the Site area was affected by the large-scale raids targeting Manchester.
Bomb Strike Positions	
Closest Bomb Strikes	HE bombs: Approximately 500m south-east. 1kg / 2kg IBs: None.
Alignment of recorded Bomb Strikes:	It has not been possible to identify any potential bomb sticks (individual aircraft bombloads) in the local area due to the limitations of available record sets For most small IB spreads (covering a wide area) it is impossible to correctly identify the aircraft's flightpath and thus bomb stick alignment. Furthermore, such bombs were significantly affected by the wind, further hampering analysis.
Bomb Failure Rate	
Evidence to suggest that the generally accepted failure rate of 10% differs in the vicinity of the Site:	None.
UXBs recorded in close proximity to the Site:	No UXBs recorded within a significant distance of the Site.

5.5 Likelihood of Subsequent UXB Detection

A range of circumstances determine whether a UXB strike location would have been identified, during and after the war. This is discussed in the following table. This includes level of access to the Site during WWII, bomb damage, as well as the ground cover during WWII. This is discussed in the following tables.

Historic Access
A UXB falling on a site which was frequently accessed would have had a better chance of being found. ARP Wardens actively searched for UXBs in heavily bombed residential areas. The importance of a site or nearby buildings and infrastructure was also a factor. Many industrial facilities had fire watchers tasked with extinguishing incendiary bombs and reporting UXBs.
If the air raid recorded in the vicinity occurred during the hours of darkness, there is a greater probability that any UXB strike to the Site could have occurred unobserved as residents / employees were inside. Furthermore, no evidence of fire watchers providing night-time observation in the vicinity was found. These factors decrease the likelihood that any UXB fall would have been witnessed and reported. As the Site comprised largely undeveloped ground, it is anticipated that areas access levels were infrequent; however, this would have depended on the landowner(s) and seasonal agricultural usage. While the eastern extent of the Site was associated with a school structure approximately 110m south-east, this is understood to have been evacuated, decreasing the level of access / monitor over this area for that period.[2] The structures in the south do not appear to have been subject to any damage. As such, it is thought that these would have been subject to a frequent level of access throughout WWII.

Bomb Damage
As the bombing campaign continued, damaged areas became vulnerable to unreported UXBs. Bomb site wreckage or soil disturbance at a bomb crater could obscure evidence of a subsequent UXB strike.
No immediately obvious evidence of bomb damage, such as cratering or structural clearance, has been identified on Site or in the vicinity within consulted post-WWII aerial photography or OS mapping.

Ground Cover Type
A UXB which falls on open field could easily go unnoticed, whereas a UXB dropped on a hard-surfaced car park would have been easily observed.
The majority of the Site comprised undeveloped ground; while the western extent appears agricultural in nature, the eastern extent was encompassed by a school playing field. Such ground cover could have presented conditions unconducive to the visual detection of UXBs, i.e., overgrown and unmaintained vegetation. Visual evidence of a UXB strike, such as a small entry hole, could have become obscured within such conditions. In contrast, any UXB strike to the undamaged structures in the south of the Site would have caused incontrovertible evidence of its incidence as it passed through the structures and into the ground beneath.

[2] https://www.mgs-life.co.uk/article/hoots-from-the-archive-the-history-of-primary-education-at-mgs?ref=63

6 WWII GERMAN BOMBS

6.1 Bombs Dropped on the UK

Nazi Germany used different types of ordnance against the UK for different effects. Some types were designed to cause fires, others for their destructive blast effect and other for their penetration capability. Each type of ordnance was fitted with at least one fuze. For some bombs multiple fuzes were used. Many different types of fuzes were available for use – each with its own set of associated hazards.

Data sheets on those bombs most likely to be encountered today are included at **APPENDIX 2**.

- **HE bombs – moderate NEQ (net explosive quantity):** the most common types of HE bombs dropped were the SC (general purpose - GP) and SD (semi-armour piercing - SAP) series of bombs. The NEQ is between 30-50%. SAP bombs are engineered to attack light fortifications, whereas GP bombs are used in a mixed destructive blast and anti-personnel fragmentation role. 70% of bombs dropped on the UK were the 50kg type.
- **HE bombs – high NEQ:** blast bombs and parachute mines have bodies made of thin steel, allowing for larger HE charges. These were designed to detonate above ground, maximising the blast effect. Parachute mines were weapons slowed by parachutes and designed to detonate without penetrating the ground. Although, in some marshland areas, partially buried parachute mines have been observed. Consequently, it is highly unlikely that any unexploded blast bombs remain buried in the UK today.
- **HE bombs – low NEQ:** The PC series were armour piercing bombs used against heavy fortifications and reinforced bunkers. They were not commonly used over the UK.
- **Small incendiary bombs:** The 1kg and 2kg incendiaries were the most dropped bomb. Up to 620 x 1kg incendiaries could be packed into the largest container unit, which opened at a pre-determined height scattering its payload over a wide area. These small bombs could fully penetrate soft ground due to their small diameter. Variants of the 1kg and 2kg incendiary bombs contained a small HE charge designed for an anti-personnel role, and to increase its incendiary effect.
- **Large incendiary bombs - Thick skinned:** The C50 has a thick body and contained a mixture of incendiary liquids and white phosphorus. Another version of the C50 had a white phosphorus fill. The C50 'firepot' contained thermite incendiary containers (aka firepots) and a small HE charge.
- **Large incendiary bombs - Thin skinned:** The Flam 250 and Flam 500 models had thin steel bodies designed to break up on impact, spreading their oil-incendiary mixture, which was ignited by a small HE charge. Consequently, it is highly unlikely that any unexploded Flam bombs remain buried in the UK today. Their unreliability meant withdrawal from frontline use by January 1941.
- **Submunitions:** The SD2 'butterfly' bomb was a 2kg submunition dropped on several British cities and towns. It contained a 225gram HE charge. SD2s had no ground penetration ability so the vast majority were recovered at the time. However, SD2s are still found across Britain today.
- **V1 flying bombs and V2 rockets:** In the final year of WWII Germany began using pilotless weapons against England. Both V Weapons had 1,000kg HE warheads. Due to their light-body construction, they had no penetration ability, and any impact left a noticeable debris field. As such, there is negligible risk from unexploded V Weapons today.

6.2 Bomb Failures

Records from September 1940 to July 1941 show that an average of 84 UXBs were dropped on civilian targets each day. Around 8% of these were time delay bombs – designed to strike the ground and start a predetermined countdown which could last days.

There is a generally accepted 10% failure rate for WWII German HE bombs. This is estimated from records gathered by bomb disposal units. These statistics do not account for UXBs that went by unnoticed.

Failures can happen for different reasons, including:

- Equipment or human error in arming the bombs before release,
- Failure of a mechanism within the fuze (out of tolerance),
- Jettisoning payloads if the bomber was under attack or crashing, or
- Partially functioned bombs (e.g. cracks in the cast TNT).

6.3 Bomb Ground Penetration

6.3.1 Introduction

Using data gathered during WWII by the Ministry of Home Security, estimations can be made about how deep a bomb is likely to penetrate the ground. Over one thousand incidents were reported by the bomb disposal units to support this research. Further tests were carried out, dropping bombs of different sizes into chalk and measuring the depths they reached. This research is held at the National Archives. The estimates are:

Bomb weight (kg)	Ground Type (m)									
	Sand		Gravel		Chalk		Clay		Sandstone	
	Average	Max.	Average	Max.	Average	Max.	Average	Max.	Average	Max.
50	2.8	7.8	2.8	7.8	3.5	7.7	4.0	9.1	2.7	6.0
250	4.8	13.7	4.8	13.7	6.0	13.1	6.8	15.8	4.6	10.4
500	6.0	17.3	6.0	17.3	7.6	16.4	8.7	19.8	5.8	13.1
1,000	7.6	21.9	7.6	21.9	9.6	20.7	10.9	24.9	7.3	16.5

Different layers of geology affect penetration depths. For example, 1m of made ground, then 1m of gravel before reaching clay – as is many areas of London – is not easily calculated from the data above.

When calculating how deep a bomb could have reached, we must make three assumptions:

- **Impact velocity:** German bombing raids were carried out at altitudes in excess of 5,000m. The velocity of impact is roughly 313ms^{-1} (not accounting for resistance). It is the same velocity regardless of mass.
- **Impact angle:** strike angles of 10 to 15 degrees to the vertical. It must be assumed that the bomb was stable at the moment of ground penetration.
- **Bomb design:** Some larger German bombs were occasionally fitted with 'kopfrings' - a metal ring, triangular in cross section, fitted around the nose of the bomb to help prevent penetration. It must be assumed that no 'kopfrings' were fitted.

6.3.2 The J-Curve Effect

During WWII, Bomb Disposal Units (BDUs) reported that most buried UXBs were found horizontal or upturned. This observation confirmed the 'J-curve effect'. As an HE bomb penetrates the ground, slightly offset from the vertical, its passage underground creates a 'J' shape.

This is relevant because the J-curve effect results in a horizontal offset between the buried UXB and its point of entry. This distance is estimated to be one third of the theoretical penetration depth. A low altitude attack, meaning a low impact angle, could produce an even greater offset, of up to 15m.

6.3.3 Site Specific Geology

BGS Mapping	**Superficial Deposits:** Till, Devensian – Diamicton Peat – Peat	**Bedrock Deposits:** Pennine Middle Coal Measures Formation – Mudstone, Siltstone, Sandstone

6.3.4 Site Specific Maximum Bomb Penetration Depth

During WWII, the Luftwaffe dropped many different types of HE bomb. The SC (general purpose) series was by far the most numerous and of this series, the SC 500 model (weighing 500kg) was the largest of the most commonly deployed and therefore this will be used as the benchmark weapon for the Site-specific bomb penetration depth calculations.

For a Site assessed as presenting a **Low Risk** of German UXB contamination, a calculation of maximum bomb penetration depth is not required.

7 UXO RISK - BRITISH/ALLIED ACTIVITY

7.1 Introduction

The table below lists potential sources of UXO (excluding enemy action). Those which are potentially relevant to the Site are discussed in the subsequent section(s).

Potential UXO Source	Potentially Significant
Army or RAF training areas / ranges	×
Military bases and other installations	×
Munitions and explosives factories	×
Military storage depots	×
Defensive fortifications	×
Wartime site requisitions	×
WWII defensive mining (landmines)	×
WWII Home Guard activity	×
Wartime anti-aircraft fire	✓

7.2 Potential Sources of UXO

7.2.1 Introduction

Research has not located any evidence of significant British or Allied army, RAF or Royal Navy activity specifically on Site and none is likely to have occurred historically. Additionally, while the North Manchester High School approximately 110m south-east, with which the eastern extent of the Site was associated, was evacuated during WWII, no explicit evidence to suggest the school and its grounds were requisitioned has been identified. The only likely potential source of British UXO contamination is therefore WWII AA artillery fire.

7.2.2 WWII Anti-Aircraft Fire

Anti-Aircraft (AA) Command was a British Army command established in 1939 to defend the UK during the anticipated German bombing campaign. It controlled the Territorial Army AA artillery and searchlight units. From 1940 to 1945 BDUs dealt with 7,000 unexploded AA shells in Britain. There were three main types of AA battery used for home defence (see below). Data sheets on these AA defences are included at **APPENDIX 3**.

- **Heavy Anti-Aircraft (HAA):** large-calibre guns (3.7" and 4.5") for engaging high-altitude bomber formations. Hundreds of permanent batteries were constructed in and around major cities and military bases during the 1930s. Some 2,000 of these guns were available during the Blitz. Each gun could fire between 10 and 20 rounds per minute and consequently HAA batteries could expend large quantities of shells during each engagement.

  British time fuses were poorly manufactured during WWII, and this led to high failure rate for HAA shells, up to 30%. Unexploded HAA shells had the potential to land up to 27km from their battery, although more typically landed within a 15km radius.

- **Light Anti-Aircraft (LAA):** smaller calibre guns for engaging dive bombers and low altitude intruders. As such, they were mostly used to defend specific industrial and military targets which were subject to precision bomber attack. LAA guns were either .303" calibre machine guns or 20mm and 40mm calibre cannon. The latter were fitted with simply impact fuses and small incendiary or HE bursting charges.

  The 40mm Bofors gun could fire 120 x HE shells / minute to a ceiling of 1,800m. Each shell was designed to self-destruct if it didn't strike an aircraft, however, inevitably some failed and fell back to earth.

- **Z (Rocket) Batteries**: a Z-Battery comprised a grid formation of 64 rocket projectors which fired 2" and later 3" Unrotated Projectile (UP) rockets to a maximum altitude of 5,800m; a ground range of some 9,000m. They were deployed in cities all around the UK from 1941 and proved to be an effective addition to the existing AA guns.

  The rockets measured 0.9m (2") and 1.8m (3") in length with four stabilising fins at the base and were fitted with 3.5kg or 8.2kg HE warheads. The larger warhead had an effective airborne blast radius of up to 20m. Some variants deployed a form of aerial mine described as a "small yellow bomb" which was designed to detach from the rocket at height and descend on a parachute with the objective of becoming snagged on target aircraft and then detonating.

Unlike bombs which were designed to strike the ground, AA projectiles and rockets were designed to function in the air. Due to their shape, and centre of gravity they would often not strike the ground nose first. This coupled with the lower mass of AA UXO resulted in shallower ground penetration depths, compared to UXBs. Although, in very soft conditions, unexploded AA projectiles have been found deeper than 1.5m bgl.

31 permanent HAA batteries were active within range of the Site during WWII; the closest emplacement was recorded approximately 650m south-east. LAA guns likely defended vulnerable points within the wider borough. Luftwaffe activity was relatively frequent over the wider area and therefore these guns would have expended a considerable quantity of ammunition. Consequently, it is possible that an unexploded AA shell could have struck the Site; however, no evidence of such an occurrence has been identified during the production of this assessment.

8 UXO RISK MITIGATING CIRCUMSTANCES

8.1 Introduction

Works on a UXO contaminated site could result in the partial or complete removal of UXO risk. Construction or earthworks may have uncovered any UXO contamination, which would then have been reported and removed by the authorities. A site may have been subject to an explosive ordnance clearance (EOC) task conducted by the armed forces. EOC tasks involve surveying, subsequent target investigation and removal of UXO. Although the effectiveness of historic EOC tasks will have often been unsatisfactory.

8.2 Explosive Ordnance Clearance Tasks

The division of EOC tasks has been complex throughout British military history. It used to be the case that anything under the water level would be dealt with by navy units, and anything on land would be dealt with by army units. In recent years, RAF Explosive Ordnance Disposal (EOD) capability has been discontinued, and now only the Royal Navy and the British Army have EOD units. In the army, the Royal Logistics Corps and Royal Engineer EOD units have been amalgamated to form 29 EOD & Search Group. Often taskings are assigned to either the naval or army elements based on where in the country the threat is and the nature of the threat.

Brimstone has access to a database of historic EOC tasks. This database is only complete up until the early 2000s and therefore does not include recent EOC tasks. No such database for the RAF and Royal Navy EOD units is easily accessible. A search of this database has not resulted in any Army EOC tasks in the vicinity of the Site.

UXO encounters on civilian land are often reported in the media and therefore a web search of local media outlets was also carried out. One such incident occurred 12th January 2013 when an unexploded hand grenade was identified in a residential garden in White Moss Road, approximately 1.1km north-west of the Site.[3] An EOD team attended the scene and performed a controlled explosion in-situ. However, due to its distance removed, this incident is not considered significant regarding UXO contamination on Site.

8.3 Ground Works

No significant post-conflict ground works have occurred across the majority of the Site. The southern structures appear to have been cleared by 1952, with a hardstanding accessway appearing to have been laid across the southern extent of the Site boundary by 2005. The remainder of the Site still comprises undeveloped land as per recent satellite imagery.

General maintenance and laying of hardstanding on previously undeveloped ground will have disturbed WWII-era soil to very shallow (>1m bgl) depths across the Site. Clearance of the pre-WWII structures in the southern extent will have disturbed WWII-era to shallow (1-2m bgl) depths in their footprints. No deep (>2m bgl) intrusions are anticipated to have occurred across the Site.

8.4 Deductions

The risk associated with any very shallow buried UXO will have been largely mitigated across the Site. The risk associated with any shallow buried UXO may have been partially mitigated in the footprints of the cleared structures in the south. The risk associated with any deep buried UXO almost certainly remains unmitigated.

Please note, the risk of a UXO encounter can be considered mitigated in the exact locations and down to the exact depths of any post-WWII intrusive works.

[3] https://www.manchestereveningnews.co.uk/news/local-news/hand-grenade-detonated-in-garden-989945

9 CONCLUSION

9.1 Accuracy of Historical Records

Occasionally, the accuracy of some historical records can prove to be poor when compared with other sources of information. One significant consequence of this can be the possibility of unrecorded German bomb strikes in the study area. No such inconsistencies were noted within the records consulted for this report.

9.2 The Risk of UXO Contamination on Site

9.2.1 Key Findings – German UXO Risk

- Greater Manchester was the 11th most heavily bombed British conurbation during WWII. Analysis of Luftwaffe target photography indicates that the A.V. Roe & Co. Ltd aircraft factory, approximately 735m north-east, was the closest primary bombing target to the Site. Railway infrastructure approximately 825m east may also have been identified as a target of opportunity.
- No bombing incidents were recorded within the Site boundary or in the immediate surrounds within consulted sources. A Manchester bomb plot and damage map records one HE bomb strike within an approximate 500m radius, plotted approximately 500m south-east. However, no damage is recorded in the vicinity within this mapping; note, the Site's undeveloped composition means any damage occurring specifically on Site will have not been recorded in this particular source. Similarly, no casualties were identified within the aforementioned radius within a civilian fatalities map; although, this source cannot be considered comprehensive due to only recording incidents where fatalities occurred.
- No immediately obvious evidence of bomb damage, such as cratering, is visible within the undeveloped land on Site or in the vicinity within post-WWII aerial photography dated 1948. Similarly, no such evidence of structural damage, such as ruins, is visible on Site or in the surrounds within post-WWII OS mapping.
- As mentioned, at the onset of WWII, the Site largely comprised undeveloped ground; the eastern extent encompassed a playing field associated with a school, while the western extent appeared to comprise agricultural land. Therefore, it is anticipated that these areas experienced an infrequent level of access, although this would have depended on the landowner(s) and seasonal usage. Nonetheless, infrequent access reduces the likelihood that evidence of a UXB strike would have been observed and dealt with at the time, especially if the ground cover became unmaintained at any point during WWII.
- In contrast, given the seeming lack of damage occurring in this location, any UXB strike to the structures in the southern extent of the Site will have caused incontrovertible evidence of its occurrence and would have been reported at the time. Additionally, the presence of these structures may have added a degree of access / monitor to the undeveloped areas of the Site in close proximity, although this could not be confirmed.
- In conclusion, no bombing incidents are recorded on Site or in close proximity, and no evidence of bomb damage occurring on Site / immediately adjacent has been identified. Despite the majority of the Site presenting conditions unconducive to the visual detection of UXBs, given the abovementioned lack of bombing / damage occurring, a **Low Risk** of encountering German UXBs has been assessed.

9.2.2 Key Findings - British UXO Risk

- No evidence of historic military activity specifically on Site has been found and it is considered unlikely that any has occurred. Therefore, the risk of encountering associated Allied UXO has been assessed as **Low**.

- 31 permanent HAA batteries were active within range of the Site during WWI; the closest was located approximately 650m south-east. LAA guns likely defended vulnerable points within the region also. Luftwaffe activity was relatively frequent over the wider area and therefore these guns would have expended a considerable quantity of ammunition. However, no such strikes have been identified in the vicinity; as such, the risk of encountering an unexploded AA shell is considered analogous to German UXBs, and a **Low Risk** has been assessed.

9.3 Site-Specific UXO Hazards

Different types of UXO pose differing types of hazard, depending on their structural design, Net Explosive Quantity (NEQ), fill type and likely contamination depth. The table below lists the main types of UXO most often encountered on urban UK sites and their relative hazard levels.

UXO Type	NEQ (NEQ Range)	Likely Burial Depth	Hazard Posed
WWII German General Purpose HE Bombs	25kg - 220kg (most commonly deployed bomb weights)	Deep burial (>2m)	**HIGH**
WWII British Heavy Anti-Aircraft Shells (HAA Shells)	1.1kg - 1.7kg	Shallow burial (1-2m)	**MODERATE-HIGH**
WWII British Land Service Ammunition (LSA)	<2kg	Shallow burial (1-2m)	
WWII German 2kg Incendiary / HE Bombs (IBs)	680g incendiary hazard + ~500g explosive hazard	Shallow burial (1-2m)	
WWII German 1kg IBs	680g (incendiary, not explosive hazard)	Shallow burial (1-2m)	**MODERATE**
WWII British Light Anti-Aircraft Shells (LAA Shells)	4g - 70g	Very shallow burial (<1m)	**LOW-MODERATE**
Small Arms Ammunition (SAA)	<1g	Very shallow burial (<1m)	**LOW**
Inert/Practice Item	0g	Very shallow burial (<1m)	

9.4 The Likelihood of UXO Encounter

9.4.1 Introduction

This report assesses the risk of UXO in relation to the proposed works, not simply the risk that UXO remains buried on Site. The likelihood of UXO encounter during intrusive ground works will vary depending on the type of UXO and the type of construction methods employed during the project. With increased soil disturbance i.e. more excavations, the likelihood of encountering UXO increases.

Within an area of elevated UXO contamination likelihood, the sub-surface volume of potential UXO contamination will comprise the natural soil / geology in between WWII ground level and the maximum bomb penetration depth. Therefore, any intrusions into this layer will be at risk of UXO encounter.

Any post-WWII fill material deposited on a site is unlikely to be contaminated with UXO and therefore the risk of encountering UXO on such a site could vary with depth.

In the wake of the initial nine-month Blitz, many cities and towns were left with vast quantities of bomb site

rubble that required removal and relocation. This material was put to use for in a variety of ways, for example >750,000 tons of London's rubble was used to build runways for new RAF and USAAF airfields and much of Liverpool's rubble was used to create and maintain sea / flood defences throughout Merseyside.

It is quite possible that unexploded British AA projectiles and German 1kg incendiaries were overlooked during removal, resulting in UXO contaminated fill material ending up on otherwise low UXO risk sites, possibly many miles from any high bombing density areas.

9.4.2 German UXBs

Although most German UXBs came to rest several metres below WWII ground level, these weapons can be found at any level between just below WWII ground level and the maximum bomb penetration depth. There are a number of reasons why these heavy bombs might be found at surprisingly shallow depths.

- **Tip and run:** When enemy aircraft had to take evasive action to escape RAF fighter intercepts or AA defences, they often dropped their bomb loads from a reduced height, potentially resulting in extreme J-curve effect.
- **Deflection:** the shape of German bomb nose sections meant they were susceptible to deflection when striking surface or shallow sub-surface obstacles, occasionally resulting in shallow burial or even UXBs skidding across hardstanding.
- **Aircraft Crash Site:** if an aircraft was unable to dump its bomb load before impacting the ground, due to mechanical fault, any externally fitted bombs could have become buried on impact.

German 1kg / 2kg incendiaries were cylindrical and approximately 50mm in diameter. They had tail sections, and so landed nose first. Within soft ground this could result in full penetration of the bomb below the surface. Such UXBs are usually found close to the surface.

9.4.3 British / Allied UXO

The nature of British/Allied military activity involving LSA and SAA and the smaller size of these munitions (in relation to German HE bombs) indicates that any resulting UXO contamination on a site will be limited to shallow depths, usually within 1.5m of the surface, notwithstanding added material to raise the ground level.

Domestic military LSA and SAA contamination will either be the result of expending blinds (dud ammunition) which bury into the ground on impact or munitions purposefully buried, for a number of reasons. Either way, these types of UXO are all found at shallow depth.

9.4.4 Deductions

Research has concluded that there is not an elevated likelihood of UXO contamination on Site.

10 OVERALL RISK RATING

Ratings for the likelihood of UXO contaminating the Site, remaining within the Site up to the present day and being encountered during the proposed works, inform the overall risk rating. Please refer to the UXO hazard table presented in ***Section 9.3*** for a breakdown of the most common hazards and their associated risk. The colour of each respective type of hazard indicates the associated risk, as defined within the aforementioned table. The UXO risk to the proposed works has been assessed as **Low.**

Risk Table					
Risk Zone	**UXO Type (Hazard)**	**Likelihood of UXO Contamination**	**Likelihood of UXO Remaining**	**Likelihood of UXO Encounter**	**Overall Risk Rating**
Low Risk	**WWII German GP HE Bombs**	Low	n/a		**LOW**
	HAA Shells	Low	n/a		
	LSA	Low	n/a		
	German 2kg IBs	Low	n/a		
	German 1kg IBs	Low	n/a		
	LAA Shells	Low	n/a		
	SAA	Low	n/a		

11 RISK MITIGATION RECOMMENDATIONS

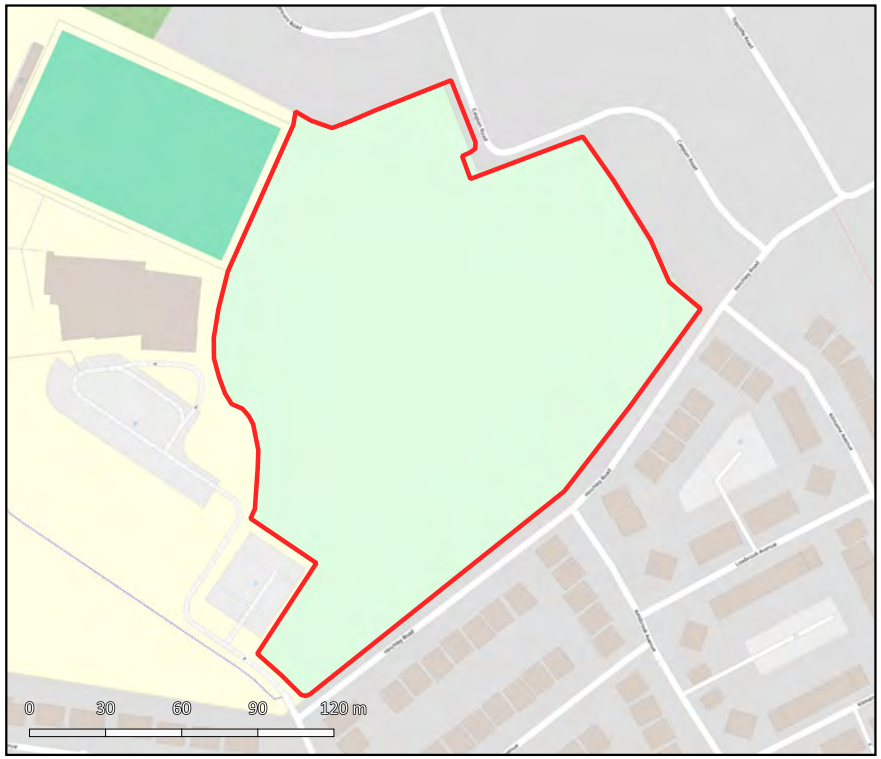
Brimstone has not identified an elevated UXO risk to the proposed works. The measures detailed below are recommended to mitigate the risk to ALARP level.

Risk Mitigation Measure	**Recommendation**
UXO Safety Awareness Briefings: To all personnel conducting intrusive works on Site. An essential part of the Health & Safety Plan for a site. Conforms to the requirements of CDM2015.	Prior to all intrusive works commencing.

FIGURES: 1 - 5

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DRA-25-1969

Project: Land at Hinchley Road, Charlestown

Client: Environmental Engineering Partnership Limited

Source: OpenStreetMap, Google Earth

Legend:

- Site Location
- Site Boundary

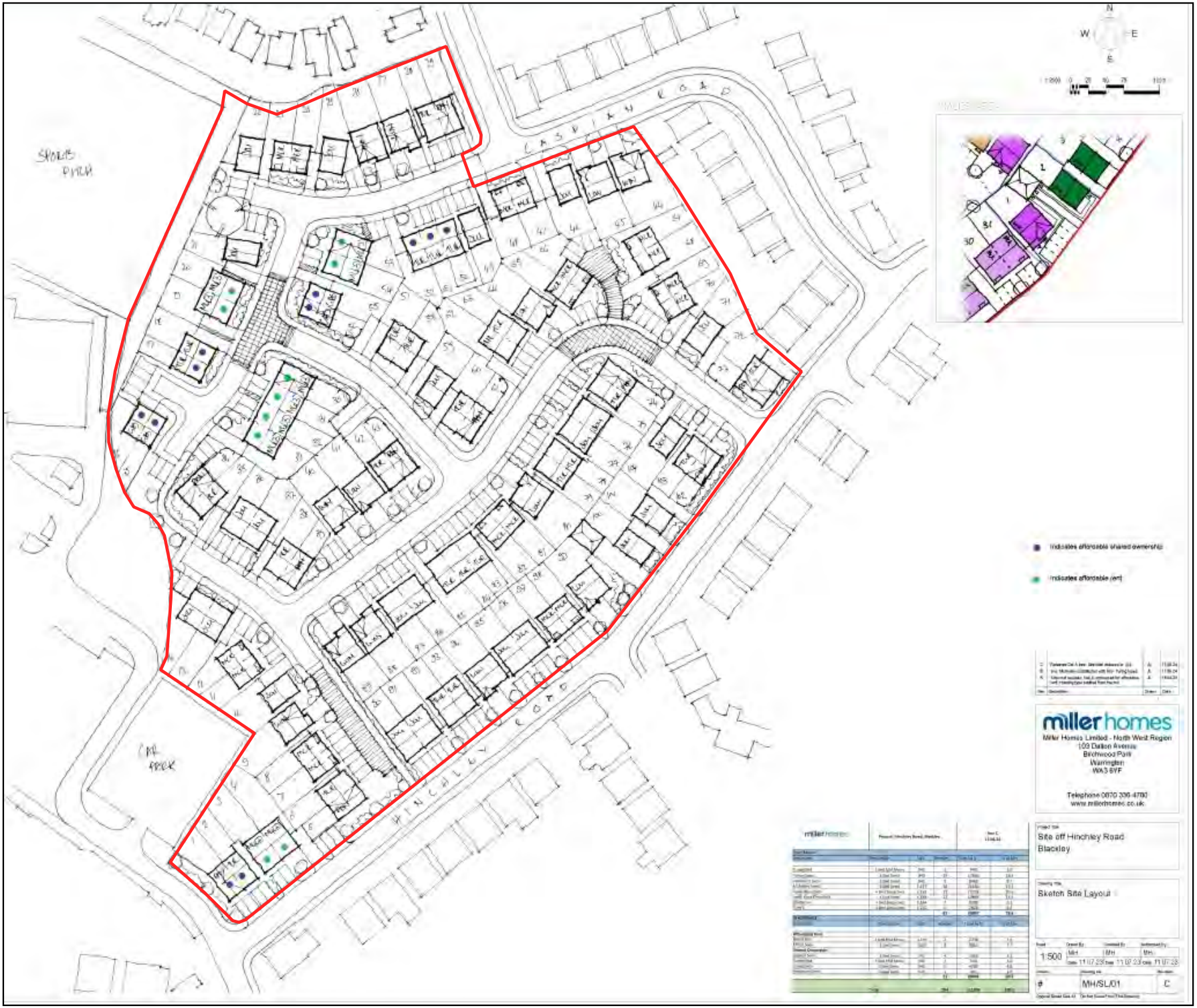
Notes:

Site Location

FIGURE: 1

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BRIMSTONE

DRA-25-1969

Project: Land at Hinchley Road, Charlestown

Client: Environmental Engineering Partnership Limited

Source: Environmental Engineering Partnership Limited

Legend:

Site Boundary

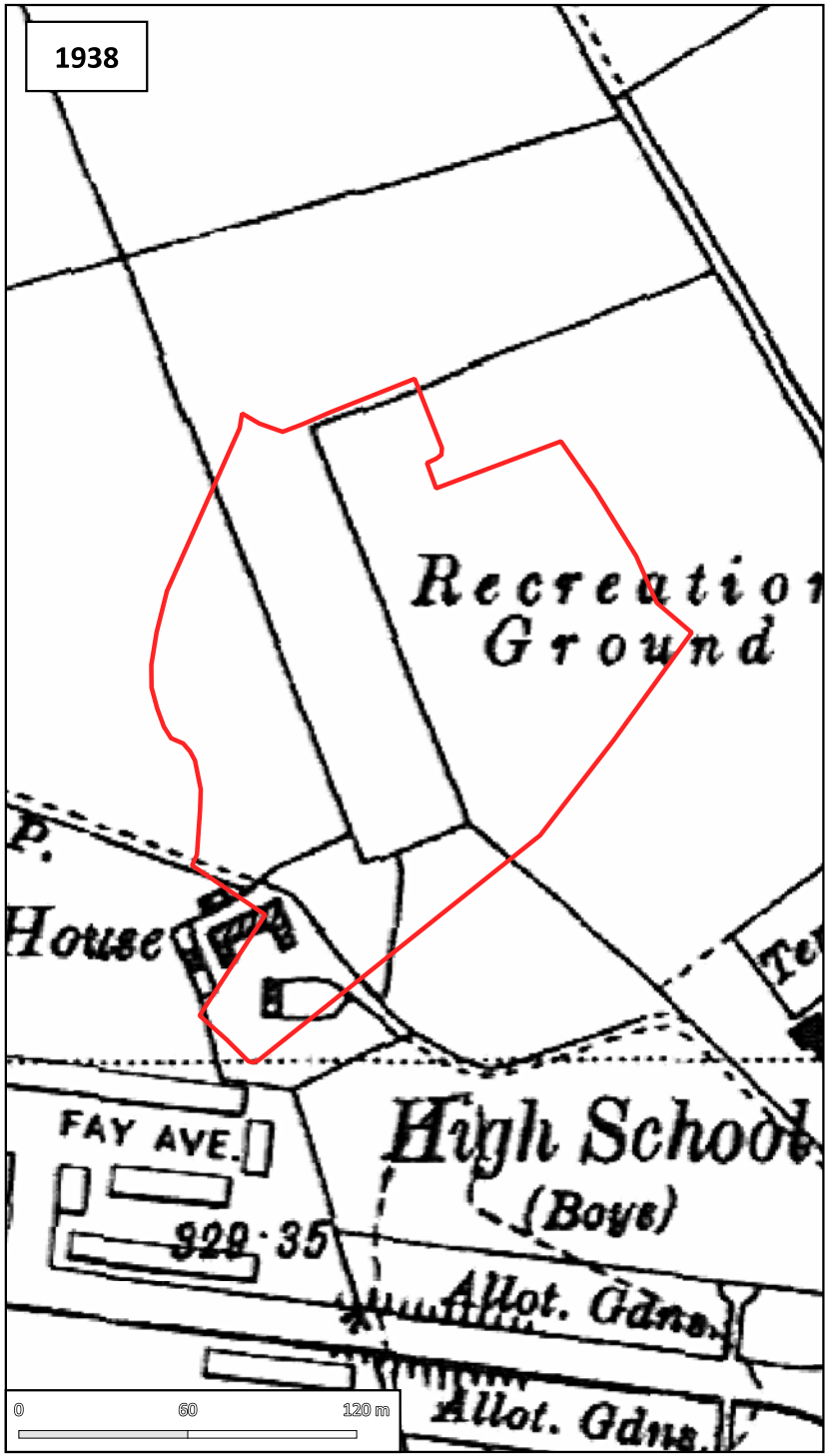
Notes:

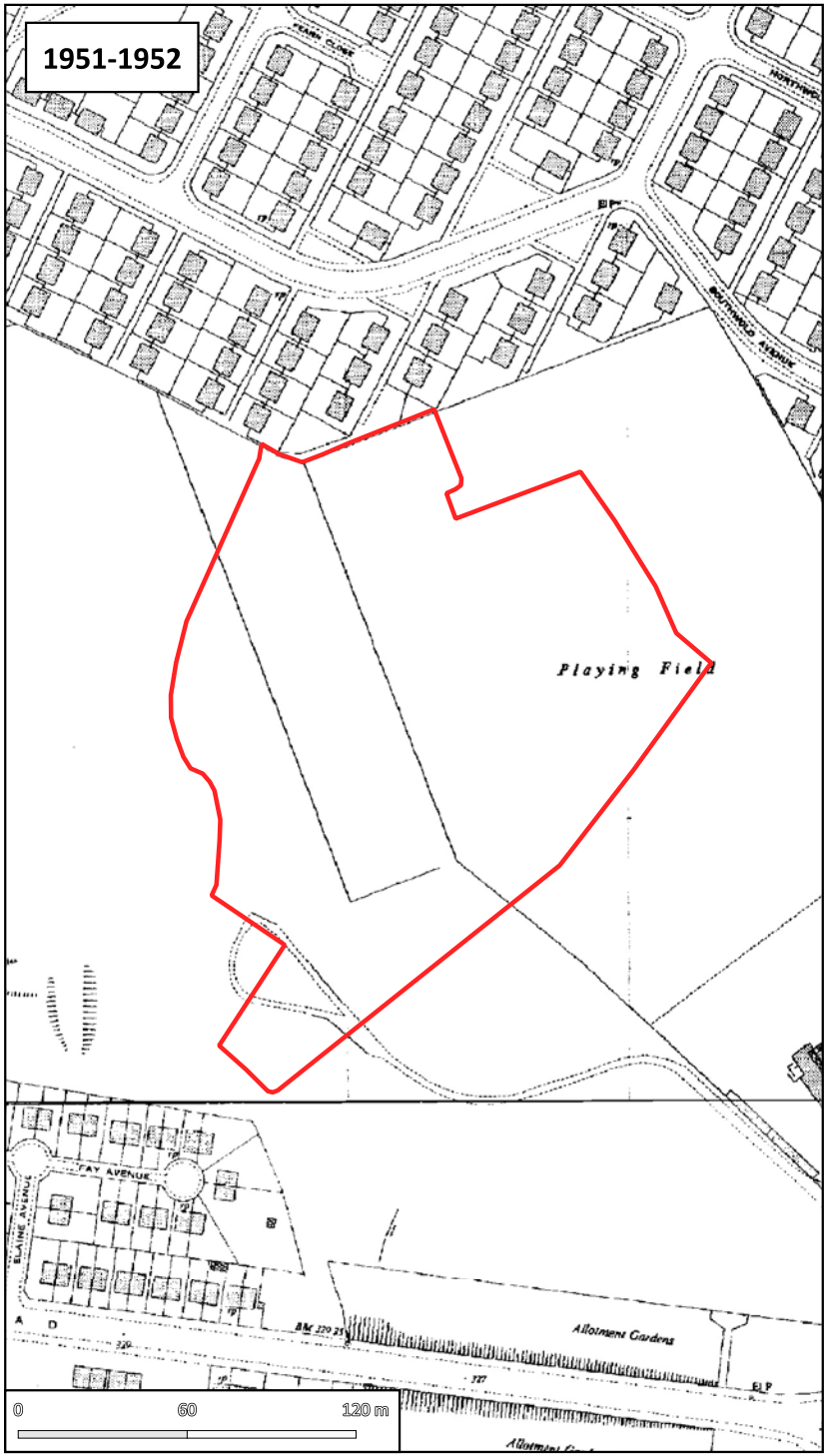
Proposed Site Plan

FIGURE: 2

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BRIMSTONE

DRA-25-1969

Project: Land at Hinchley Road, Charlestown

Client: Environmental Engineering Partnership Limited

Source: Promap

Legend:

Site Boundary

Notes:

Historical OS Mapping

FIGURE: 3

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DRA-25-1969

Project: Land at Hinchley Road, Charlestown

Client: Environmental Engineering Partnership Limited

Source: Historic England

Legend:

Site Boundary

Notes:

Photography date - 12th June 9148

Historical Aerial Photography

FIGURE: 4

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BRIMSTONE

DRA-25-1969

Project: Land at Hinchley Road. Charlestown

Client: Environmental Engineering Partnership Limited

Source: Manchester Archives and Local Studies

Legend:

- Site Boundary
- HE Bomb Strike

Notes:

Manchester Bomb Plot and Damage Map, 1940-1941

FIGURE: 5

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APPENDICES: 1 - 5

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Recent German UXB Finds in the UK + Historical Analysis

The Ministry of Defence (MOD) says that bomb disposal teams around the UK deal with approximately 60 German WWII-era UXBs per year.

- ***20th February 2024*** – An SC500 (standard 500kg HE bomb) was found during shallow excavations in a residential garden in Keyham, Plymouth. *Historical Analysis: The UXB landed in a small residential back garden belonging to an undamaged terraced house. It came to rest at approximately 1 to 2m bgl.*
- ***10th February 2023 –*** An SC250 (standard 250kg HE bomb) was dredged out of the River Yare in Great Yarmouth. The UXB detonated unexpectedly in situ during an attempt to disarm it. *Historical Analysis: The UXB landed in the River Yare; the precise location of its initial impact is unknown. UXBs in water are often affected by migration, whereby the item can travel along the riverbed.*
- ***26th February 2021 –*** An SC1000 (standard 1,000kg HE bomb) was discovered during shallow excavations in Exeter, adjacent to the University of Exeter. The item was detonated in situ and caused structural damage to nearby properties, leaving some inhabitable. *Historical Analysis: The UXB landed in undeveloped land of no obvious significance. It came to rest at approximately 2 to 3m bgl with its nose facing upwards, highlighting the potential of J-curve occurring.*
- ***23rd May 2019*** - An SC250 (standard 250kg HE bomb) was found during shallow excavations at a building site in Kingston upon Thames, London. *Historical Analysis: The UXB landed in a small residential back garden belonging to an undamaged terraced house. It came to rest approximately 3 to 4m bgl.*
- ***11th February 2018*** – An SC500 (standard 500kg bomb) was discovered in George V Dock in London during planned work at London City Airport. *Historical Analysis*: *George V Dock was identified as a primary target by the Luftwaffe during WWII and was bombed on multiple occasions.*
- ***15th May 2017 -*** An SC250 (standard 250kg HE bomb) was found during shallow excavations at a building site in Aston, Birmingham. *Historical Analysis: The UXB landed in a small back garden belonging to a terraced house, part of a row. It J-Curved under a neighbouring garden and came to rest at just 1.4m bgl. NB: These houses had not sustained bomb damage.*
- ***2nd March 2017 -*** A 250kg HE bomb was found during deep excavations at a building site in Brondesbury Park, London. *Historical Analysis: UXB landed in a large residential back garden. A single storey building was built on top of the UXB post-WWII.*

Recent Allied UXB finds in Europe

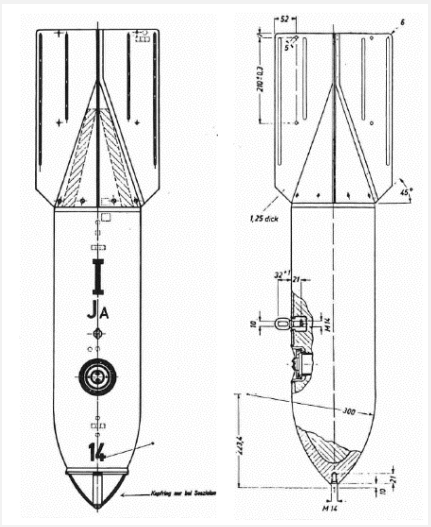
- ***27th June 2024*** – A 250kg HE UXB of Allied origin was discovered in a wooded area in Gruenheide (Germany).
- ***26th April 2024*** – A 500kg American HE UXB was discovered during construction work in Mainz (Germany), nearby the MEWA Arena stadium.
- ***3rd April 2024 –*** A 500kg UXB of Allied origin was discovered during construction work on a shipping channel in Deutz, Cologne (Germany). The device was defused in situ.
- ***28th March 2024*** – A 500lb American HE UXB was discovered during construction work in Aachen (Germany). The device was defused in situ.
- ***11th August 2023 –*** A 250kg HE UXB of Allied origin was discovered in Lublin (Poland). The device was discovered in an area where an aircraft factory had been located prior to WWII.
- ***8th August 2023*** – An unexploded "one-tonne shell" (1000kg HE UXB) of anticipated Allied origin was discovered near Dusseldorf city zoo (Germany).
- ***5th July 2023*** – A UXB of unspecified origin and calibre (alleged to have been Russian but no confirmation) was discovered on a construction site in Hohenschönhausen, Berlin (Germany). The device was defused in situ.
- ***17th March 2022*** – A farmer ploughing a field discovered a British INC30 (incendiary) bomb, which contained phosphorous, in Viersen (Germany). The plough became embedded in the device, which did not explode.

NB: Domestic UXO finds in the UK are too numerous to list. Between 2006 and 2009, over 15,000 items of British / Allied UXO (excluding small arms ammunition) were found on UK construction sites (CIRIA).

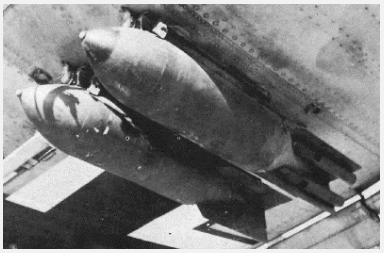
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SC 50

Bomb Weight:	40-54kg (110-119lb)
Explosive Weight:	25kg (55lb)
Filling:	TNT, Amatol or Trialen
Charge/Weight Ratio:	46%
Fuse Type:	Electrical impact fuse or mechanical delayed action fuse
Body Dimensions:	1,100mm length x 200mm diameter
Appearance:	Bomb body and tail painted grey/green with a yellow stripe on the tail unit. Steel construction.
Variants:	8 x variants. Additional fittings: Kopfring nose for limited penetration and Stabbo nose for dive-bombing.

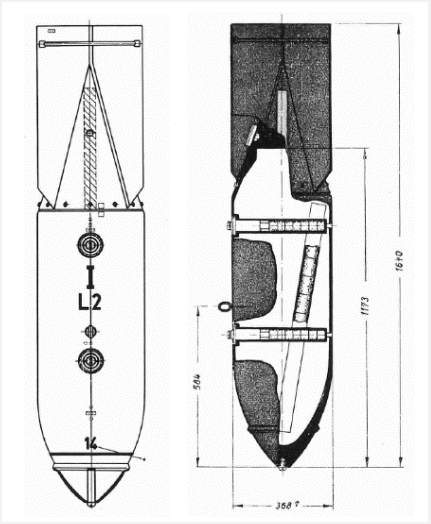






SC 250

Bomb Weight:	245-256kg (540-564lb)
Explosive Weight:	125-130kg (276-287lb)
Filling:	TNT, Amatol and Trialen mix
Charge/Weight Ratio:	44%
Fuse Type:	1 or 2 electrical impact fuse(s) or mechanical delayed action fuse(s)
Body Dimensions:	1,173mm length x 368mm diameter
Appearance:	Bomb body and tail painted grey/green with a yellow stripe on the tail unit. Steel construction.
Variants:	8 x variants. Kopfring nose for limited penetration. Stabbo nose for dive-bombing.

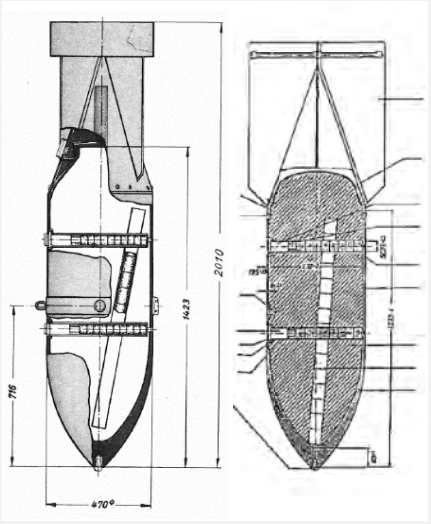






SC 500

Bomb Weight:	480-520kg (1,058-1,146lb)
Explosive Weight:	220kg (485lb)
Filling:	TNT, Amatol and Trialen mix
Charge/Weight Ratio:	44%
Fuse Type:	2 electrical impact fuses or mechanical delayed action fuses
Body Dimensions:	1,423mm length x 470mm diameter
Appearance:	Bomb body and tail painted grey/green or buff with a yellow stripe on the tail unit. Steel construction.
Variants:	3 x variants. Kopfring nose for limited penetration.



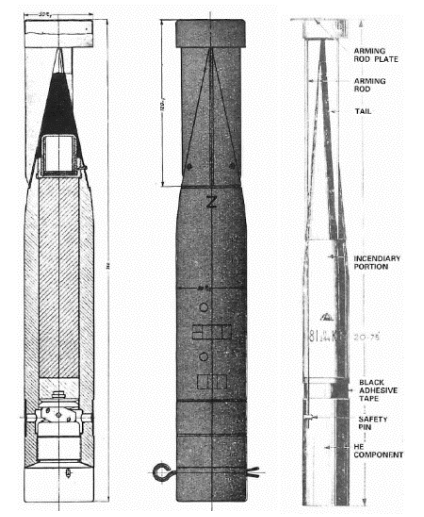




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B-1E Sub-Munition

Bomb Weight:	1-1.3kg (2.2-2.87lb)
Incendiary Weight:	680g (1.4lb)
Filling:	Thermite
Fuse Type:	Simple impact fuse
Body Dimensions:	247mm length x 50mm diameter
Appearance:	Grey body and dark green painted tail unit. Magnesium alloy case.
Operation:	Small percussion charge ignites Thermite (>1,000°C burn).
Variants:	Most common variant: B 2EZ (2kg) included a small HE charge
Remarks:	Drop containers varied in size. The smallest cluster bomb held 36 x B-1Es and the largest 620 x B-1Es.

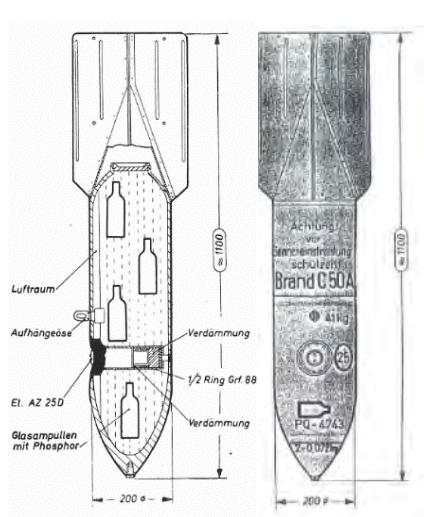






Brand C50

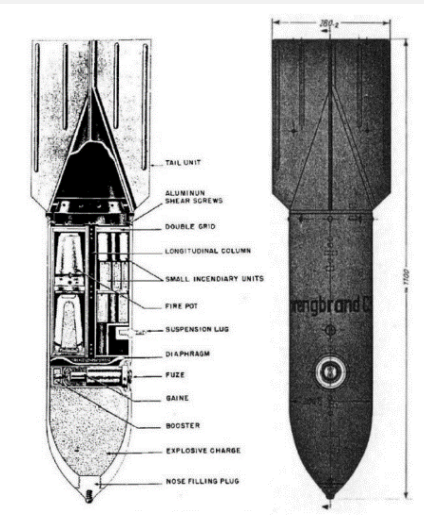
Bomb Weight:	41kg (90.4lb)
Incendiary Weight:	13kg (30lb)
Filling:	Main fill (86% Benzine, 10% Rubber) plus 4% Phosphorus in glass bottles
Fuse Type:	1 x electrical impact fuse
Bomb Dimensions:	762mm length x 203mm diameter
Appearance:	bomb body and tail painted grey or green with the rear of the bomb painted red and a red band around the centre of the body.
Variants:	C 50 B: 77% White Phos fill C 250 A: 87.7% Petroleum, 11.7% Polystyrene, 0.5% White Phos (185kg version)

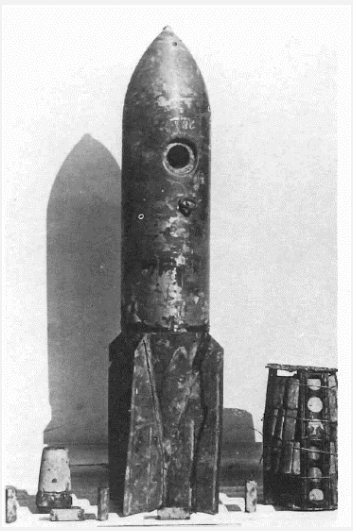




Spreng-Brand C50 - *Fire Pot*

Bomb Weight:	34kg (75lb)
Explosive Weight:	9kg (20lb)
Filling:	TNT burster charge, 6 x Thermite containers (fire pots) and 67 x small triangular incendiary elements.
Fuse Type:	1 x electrical impact fuses or aerial burst fuse
Bomb Dimensions:	711mm length x 203mm diameter
Appearance:	Bomb body and tail painted grey/green or pale blue with red base plug and red or green incendiary markings. Steel construction.
Operation:	A charge blows off the base plate, firing a plume of incendiary mixture 100 yds. Approx 1 second later the HE charge detonates.



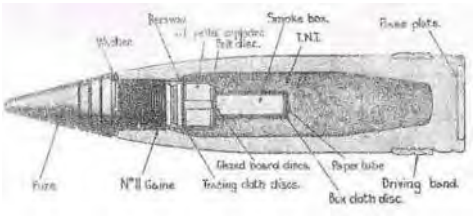


Project:	**Land at Hinchley Road, Charlestown**
Client:	**Environmental Engineering Partnership Limited**
Report Ref:	**DRA-25-1969**
Info Source:	*W, Ramsey.1988 / various news sources*

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HAA Battery - 3.7" QF Shell

Shell Weight:	12.7kg
Shell Dimensions:	94mm x 438mm
Fill Weight:	1.1kg
Fill Type:	TNT
Fuse Type:	Mechanical Time Delay fuse
Appearance:	Grey body, copper driving bands, brass neck
Rate of Fire:	10 - 20 rpm
Ceiling:	9,000 - 18,000m
Variants:	HE or shrapnel shells. Note, the 4.5" gun was also used in an HAA role throughout the UK.

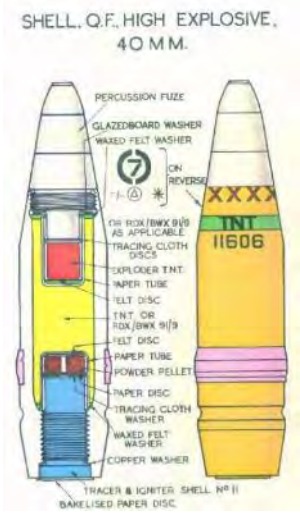






LAA Battery - 40mm Bofors Shell

Shell Weight:	0.84kg
Shell Dimensions:	40mm x 180mm
Fill Weight:	70g
Fill Type:	TNT
Fuse Type:	Impact fuse
Appearance:	Grey body, copper driving bands, brass neck
Rate of Fire:	120 rpm
Ceiling:	7,000m
Variants:	HE or AP shells. Both with rear tracer compartment



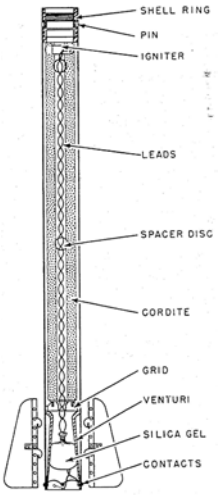






Z Battery - 3" U.P Rocket

Rocket Weight:	24.5kg
Warhead Weight:	1.94kg
Filling:	TNT warhead. Black Powder solid fuel rocket motor.
Fuse Type:	Mechanical Time Delay fuse
Rocket Dimensions:	1,930mm x 76mm
Ceiling:	6,770m
Operation:	Fired from single, tandem and (later) 36 x rail launchers (Z Batteries). Limited use throughout the UK.





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AA	*Anti-Aircraft (defences)*
AFS	*Auxiliary Fire Service*
AP	*Anti-Personnel*
ARP	*Air Raid Precautions*
ASW	*Anti-Submarine Warfare*
BDU	*Bomb Disposal Unit (historic term for EOD)*
Bgl	*Below Ground Level*
EOC	*Explosive Ordnance Clearance*
EOD	*Explosive Ordnance Disposal*
FP	*Fire Pot (German bomb)*
GI	*Ground Investigation*
HAA	*Heavy Anti-Air (gun battery)*
Ha	*Hectare (10,000m2)*
HE	*High Explosive*
IB	*Incendiary Bomb*
Kg	*Kilogram*
LAA	*Light Anti Air (gun battery)*
LCC	*London County Council*
LRRB	*Long Range Rocket Bomb (V2)*
LSA	*Land Service Ammunition*
Luftwaffe	*German Air Force*
OB	*Oil Bomb (German bomb)*
PM	*Parachute Mine (German bomb)*
RAF	*Royal Air Force*
RFC	*Royal Flying Corps*
RN	*Royal Navy (British)*
RNAS	*Royal Naval Air Service*
ROF	*Royal Ordnance Factory*
SAA	*Small Arms Ammunition*
SD2	*2kg AP bomb (German bomb)*
SI	*Site Investigation*
U/C	*Unclassified (German) bomb*
UP	*Unrotating Projectile (British 3" AA rocket)*
USAAF	*United States Army Air Force*
UX	*Unexploded*
UXB	*Unexploded Bomb*
UXO	*Unexploded Ordnance*
V1	*German Flying (pilotless) bomb - "Doodlebug"*
V2	*German LRRB - "Big Ben"*
WAAF	*Women's Auxiliary Air Force*
WWI	*World War One*
WWII	*World War Two*

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Manchester Archives and Local Studies

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