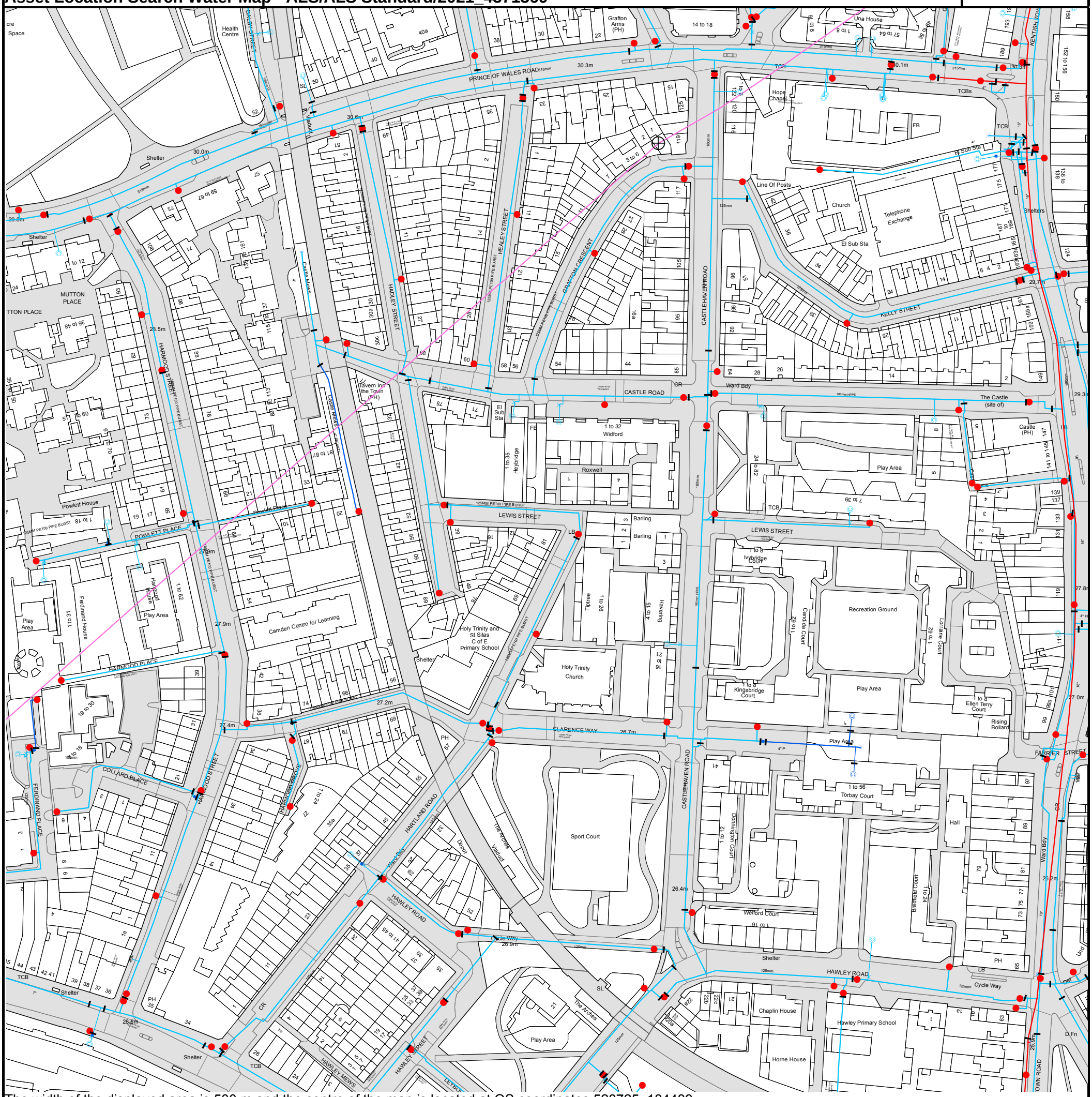
Asset Location Search Water Map - ALS/ALS Standard/2021_4371369



The width of the displayed area is 500 m and the centre of the map is located at OS coordinates 528725, 184489.

The position of the apparatus shown on this plan is given without obligation and warranty, and the accuracy cannot be guaranteed. Service pipes are not shown but their presence should be anticipated. No liability of any kind whatsoever is accepted by Thames Water for any error or omission. The actual position of mains and services must be verified and established on site before any works are undertaken.

ALS Water Map Key

Water Pipes (Operated & Maintained by Thames Water)

4"

Distribution Main: The most common pipe shown on water maps. With few exceptions, domestic connections are only made to distribution mains.

16"

Trunk Main: A main carrying water from a source of supply to a treatment plant or reservoir, or from one treatment plant or reservoir to another. Also a main transferring water in bulk to smaller water mains used for supplying individual customers.

3" SUPPLY

Supply Main: A supply main indicates that the water main is used as a supply for a single property or group of properties.

3" FIRE

Fire Main: Where a pipe is used as a fire supply, the word FIRE will be displayed along the pipe.

3" METERED

Metered Pipe: A metered main indicates that the pipe in question supplies water for a single property or group of properties and that quantity of water passing through the pipe is metered even though there may be no meter symbol shown.

Transmission Tunnel: A very large diameter water pipe. Most tunnels are buried very deep underground. These pipes are not expected to affect the structural integrity of buildings shown on the map provided.

Proposed Main: A main that is still in the planning stages or in the process of being laid. More details of the proposed main and its reference number are generally included near the main.

Valves

- General Purpose Valve
- Air Valve
- Pressure Control Valve
- Customer Valve

Hydrants

- Single Hydrant

Meters

- Meter

End Items

Symbol indicating what happens at the end of a water main.

- Blank Flange
- Capped End
- Emptying Pit
- Undefined End
- Manifold
- Customer Supply
- Fire Supply

Operational Sites

- Booster Station
- Other
- Other (Proposed)
- Pumping Station
- Service Reservoir
- Shaft Inspection
- Treatment Works
- Unknown
- Water Tower

Other Symbols

- Data Logger

PIPE DIAMETER	DEPTH BELOW GROUND
Up to 300mm (12")	900mm (3')
300mm - 600mm (12" - 24")	1100mm (3' 8")
600mm and bigger (24" plus)	1200mm (4')

Other Water Pipes (Not Operated or Maintained by Thames Water)

Other Water Company Main: Occasionally other water company water pipes may overlap the border of our clean water coverage area. These mains are denoted in purple and in most cases have the owner of the pipe displayed along them.

Private Main: Indiates that the water main in question is not owned by Thames Water. These mains normally have text associated with them indicating the diameter and owner of the pipe.

Terms and Conditions

All sales are made in accordance with Thames Water Utilities Limited (TWUL) standard terms and conditions unless previously agreed in writing.

1. All goods remain in the property of Thames Water Utilities Ltd until full payment is received.
2. Provision of service will be in accordance with all legal requirements and published TWUL policies.
3. All invoices are strictly due for payment 14 days from due date of the invoice. Any other terms must be accepted/agreed in writing prior to provision of goods or service, or will be held to be invalid.
4. Thames Water does not accept post-dated cheques-any cheques received will be processed for payment on date of receipt.
5. In case of dispute TWUL`s terms and conditions shall apply.
6. Penalty interest may be invoked by TWUL in the event of unjustifiable payment delay. Interest charges will be in line with UK Statute Law 'The Late Payment of Commercial Debts (Interest) Act 1998'.
7. Interest will be charged in line with current Court Interest Charges, if legal action is taken.
8. A charge may be made at the discretion of the company for increased administration costs.

A copy of Thames Water's standard terms and conditions are available from the Commercial Billing Team (cashoperations@thameswater.co.uk).

We publish several Codes of Practice including a guaranteed standards scheme. You can obtain copies of these leaflets by calling us on 0800 316 9800

If you are unhappy with our service you can speak to your original goods or customer service provider. If you are not satisfied with the response, your complaint will be reviewed by the Customer Services Director. You can write to her at: Thames Water Utilities Ltd. PO Box 492, Swindon, SN38 8TU.

If the Goods or Services covered by this invoice falls under the regulation of the 1991 Water Industry Act, and you remain dissatisfied you can refer your complaint to Consumer Council for Water on 0121 345 1000 or write to them at Consumer Council for Water, 1st Floor, Victoria Square House, Victoria Square, Birmingham, B2 4AJ.

Ways to pay your bill

Credit Card	**BACS Payment**	**Telephone Banking**	**Cheque**
Call **0800 009 4540** quoting your invoice number starting CBA or ADS / OSS	Account number **90478703** Sort code **60-00-01** A remittance advice must be sent to: **Thames Water Utilities Ltd., PO Box 3189, Slough SL1 4WW.** or email **ps.billing@thameswater.co.uk**	By calling your bank and quoting: Account number **90478703** Sort code **60-00-01** and your invoice number	Made payable to '**Thames Water Utilities Ltd**' Write your Thames Water account number on the back. Send to: **Thames Water Utilities Ltd., PO Box 3189, Slough SL1 4WW** or by DX to **151280 Slough 13**

Leep Electricity Networks Ltd & Leep Utilities have no apparatus in this area.

Regards

Diane

From: Utility Reports <utility.reports@emapsite.com>
Sent: 18 February 2021 17:16
To: Leep Electricity Networks <lenl@leeputilities.co.uk>
Subject: Plant Location Request GRS08957 Site at Castle Road (Heybridge), N/A, N/A

RE: Castle Road (Heybridge), N/A, N/A

Location: OSGB: 528745.800,184498.200
Our Reference: GRS08957

Our Company is currently undertaking a utility survey of the site indicated by the co-ordinates detailed above and the attached plan/map.

As part of this survey we are required to indicate positions and descriptions of all main statutory services and wayleaves on site and in the adjoining roads where applicable.

We therefore request that you supply us with relevant plan information at your earliest convenience.

Thanking you in advance of your co-operation.

Yours faithfully

Stephen Sawyer
Utility Report Administrator

For and on behalf of Technics Group

Please visit our new website **www.technicsgroup.com**

T: 01483 230 080
E: **utility.reports@technicsgroup.com**

Technics Group is the trading name of Sitechnics Limited & Subtechnics Limited
Subtechnics Limited Registered in England No. 3668620 Sitechnics Limited Registered in England No. 3236243
Registered Office: Technics House, Merrow Business Park, Guildford, GU4 7WA

END USER LICENCE AGREEMENT

1 Introduction

By accessing this DATA the End User agrees to abide by the Terms and Conditions of Licence contained herein.

2 Definitions

- **LICENSOR** – emapsite.com Limited (Registered Number 3931726: MASDAR House, 1 Reading Road, Eversley, Hants RG27 0RP) who have been licensed to market the Intellectual Property Rights of others under these terms.
- **RESELLER** – Groundsure Limited and/or their own channel partners
- **END USER** – the person, organisation or company who is accessing the DATA, on the basis of these Licence terms, having been accepted as a Licensee by Licensor and paid the Price due to the Reseller in consideration for such Licence, and is identified as the person, organisation or company given on the corresponding invoice for this product from the Reseller.
- **DATA** - means the Products licensed and made available to the End User by the Licensor as a series of data sets which together provide indicative maps showing the underground assets of Utility Providers for England, Wales and Scotland and compiled by Subtechnics Limited.

3 Grant of licence

The licence granted to the End User is personal, revocable, non-exclusive and non-transferable, limited to Internal Use (as defined in clause 5 below) as the only Permitted Use by the End User and is for a period as specified in the corresponding order invoice from the Reseller. Save as expressly authorised to vary in accordance with clause 5 below, the End User shall be prohibited from:

modifying, translating, format-changing, enhancing, reproducing, copying (except where strictly necessary for system back up), redistributing, disseminating, selling, dealing with, licensing, encumbering, reverse engineering, disassembling or decompiling the DATA, or any part of thereof, except to the extent permitted by law;

using the DATA in any manner for the creation of products or services for Distribution;

using DATA otherwise than for Internal Use;

assigning or dealing with in any way its rights under the End User Contract;

putting, or allowing the DATA (or any Derived Data) to be put on any free, open or public access website; and

distributing or granting licences of the DATA (in whatever form) or material derived from DATA (including interrogating DATA), save as expressly varied by relevant part of clause 5 below.

4 Intellectual Property and Copyright

4.1 The End User must acknowledge and agree that all Intellectual Property Rights in the DATA are the absolute property of the Utility Providers (or where relevant Subtechnics Limited or the licensor). Material which is derived, developed or copied from DATA shall be deemed assigned to the relevant Utility Provider as legal and beneficial owner at creation, except as provided in this paragraph. However, where that material is created by End User under relevant Permitted Use by End User authorised by Licensor in accordance with the Agreement, the Intellectual Property in that material shall belong to the End User.

4.2 Copyright statements must be used with DATA as follows:

© Utility Provider (named as applicable) and Subtechnics Limited

5 Permitted use

5.1 PERMITTED USE BY END USER SHALL BE LIMITED TO INTERNAL USE. COMMERCIAL USE SHALL BE PROHIBITED. The meanings of such phrases are set out below.

5.2 Internal Use means the following internal uses by the End User: Without compromising the prohibitions contained in clause 3 above, analysing the DATA against a location or a series of locations to obtain information derived from the DATA such as proximity to underground assets and use of and sharing such information/results of such analysis internally within the End User's legal entity only.

5.3 Commercial Use means use that does not fall under Internal Uses (as above) and involves the provision or any form of Distribution to any third party of the DATA or any material derived from DATA (including Derived Data or Static Data) in connection with, expectation of or anticipation of any direct or indirect commercial benefit or commercial relationship (including a service, broker or agency agreement) and whether or not in return for any consideration (including direct or indirect fee, payment or other benefit), free of charge or for no consideration.

5.4 Derived Data means any material derived from or created using DATA, including where DATA is manipulated, aggregated, integrated, combined, merged, modelled, transformed or processed in or with other data or facilities;

5.5 Static Data means DATA and any data (including Derived Data resulting from Internal Uses presented or included in static format in presentations or reports in hard copy, .pdf or similar format. Static Data does not allow for alteration of the data presented, nor enable any further analysis to be carried out against the data (including against the DATA).

6 Confidentiality

6.1 In this clause 6, 'Confidential Information' means all confidential information disclosed (whether in writing, orally or by another means and whether directly or indirectly) by a Party to the other Party whether before or after the date of this Agreement which might reasonably be considered confidential, including the DATA, information relating to the DATA, and information relating to any of the operations, plans or intentions, clients, contacts, product information, software, data, processes, methods, know-how, trade

secrets, market opportunities and business affairs of a Party.

6.2 Each Party shall treat the other Party's Confidential Information as confidential and shall protect it as such. It shall manage it with not less than the same degree of care as it does its own Confidential Information. In any event where Confidential Information is disclosed in any way by one Party ('Disclosing Party') to the other Party ('Receiving Party'), either before or during the Term of this Agreement or after its expiry or termination for any reason, the Receiving Party shall:

not use Confidential Information for a purpose other than the performance of its obligations under this Agreement;

not disclose Confidential Information to any person except with the prior written consent of the Disclosing Party; and

make every effort to prevent the use or disclosure of Confidential Information.

6.3 During the term of this Agreement the Receiving Party may disclose Confidential Information solely to the extent that such disclosure is necessary for the purposes of this Agreement, to any of its directors, other officers, employees, End Users, Affiliates, contractors or sub-contractors. Receiving Party shall ensure that persons to whom Confidential Information is disclosed are made aware of and comply with the Receiving Party's obligations of confidentiality as if they were the Receiving Party.

7 Information Access

7.1 In so far as the End User is, or is deemed to be, or acts for and on behalf of or on the authority of a Public Authority for the purposes of the Information Access Regimes:

End User acknowledges that the Utility Providers, Subtechnics Limited, Reseller and Licensor consider that DATA is exempted from disclosure because DATA is:

proprietary to the Utility Provider and disclosure would harm the interests of the Utility Provider (including its commercial interests);

protected by database rights and other Intellectual Property;

confidential and the disclosure of it by the End User would constitute a breach of confidence actionable by the Utility Provider, Subtechnics Limited and/or the Licensor; and

confidential commercial or industrial information protected by laws to protect a legitimate economic interest.

7.2 End User shall, in the event it receives a request for information ('Access Request') under the Information Access Regimes pursuant to which the DATA might be disclosed:

immediately notify the Reseller of the Access Request and provide the Reseller with full and complete details of the Access Request and the DATA that may be disclosed, together with any other information the Reseller may request;

consult, as soon as possible within receipt of Access Request, with the Reseller as to whether the DATA constitutes information which is exempt from disclosure or publication pursuant to the Information Access Regimes and/or pursuant to the matters set out above;

notify the Reseller immediately of any final decision as to disclosure of the DATA and no less than 72 hours before any proposed disclosure, as to what if any of the DATA (or any Derived Data) is proposed to be disclosed and

co-operate fully and at End User's sole cost with the requirements set out in this paragraph.

7.3 End User shall not disclose the DATA in any publication scheme maintained pursuant to any Information Access Regime without first notifying the Reseller in advance of disclosure in accordance with this paragraph.

7.4 Where the End User is, or is deemed to be, or acts for and on behalf of or on the authority of a Public Authority under the Information Access Regimes and the End User seeks to make disclosure or discloses DATA under the Information Access Regimes without the consent of the Reseller, such disclosure shall entitle the Reseller and/or the Licensor and/or Subtechnics Limited to terminate the End User Contract with immediate effect and without liability on their part.

7.5 The Contracts (Rights of Third Parties) Act 1999 shall apply for the benefit of Subtechnics Limited and the Licensor and the Reseller that Subtechnics Limited and/or the Licensor and/or the Reseller may (but shall have no obligation to) enforce any of the terms in the End User Contract which relate to disclosure under the Information Access Regimes, limitation on liability, use of DATA or infringement of Intellectual Property Rights in the DATA.

8 Termination

8.1 The licence must terminate automatically in the event that the End User materially breaches any of the requirement / obligations set out in this End User Licence Agreement. All use of DATA and material derived from DATA shall cease promptly in such event, except as follows:

• Following expiry of the End User Contract, the End User may continue to use limited material created using DATA during the term of its End User Contract. Such material is limited to that which is both properly authorised as relevant Permitted Use by the End User and is in static form, i.e. such that after termination it is not changed, added to, updated, modified in any other way or used in or to create any new, updated, supplemented or modified product, tool, analysis or material.

• Material which is not in static form (including probabilistic modelling and models and output therefrom, which is automatically deemed to be not static) shall not be used after termination of the End User Contract.

• the End User must be prohibited from using DATA (including in Reseller's Product/Service), and from deriving any new, updated, supplemented or modified product, tool or material from DATA, after the date of termination of its End User Contract.

8.2 The invalidity or unenforceability of any part of this Agreement shall not prejudice or affect the validity or enforceability of the remainder of the Agreement, which shall remain in full force and effect. If any provision of this Agreement is found to be invalid, illegal or unenforceable but would cease to be so if some part of the provision were deleted or modified, the provision in question shall apply with such minimum modification as may be necessary to make it

valid, legal and enforceable and still give effect to the commercial intention of the Parties in this Agreement.

9 Fees

9.1 The End User must acknowledge its obligation to pay licence fees to the Reseller. The total price of the Products shall be the Reseller's written quoted price as varied from time to time. The price is exclusive of any applicable Value Added Tax, which the End User shall be additionally liable to pay to Licensors.

9.2 End User shall pay in full on order or shall pay within 30 days of the date of invoice, if accepted for an account with the Reseller. The time of payment shall be of the essence of the Contract. All payments shall be made in full without deduction in respect of any set-off or counterclaim. If the End User fails to make any payment on the due date then without prejudice to any other right or remedy available to Licensors, Licensors shall be entitled to:

cancel the Contract or suspend any deliveries to the End User;

appropriate any payment made by the End User to the DATA; and

charge the End User interest (both before and after any judgment) on the amount unpaid, at the rate of 4 per cent per annum over the base rate for the time being of Barclays Bank PLC.

Licence to DATA is not deemed to commence until payment has been made of the Price in full to Licensors.

10 Liability

10.1 Licensors warrant that the DATA will correspond with its specification at the time of delivery. The above warranty does not extend to any defect resulting from use of the DATA with materials or equipment not supplied by Licensor. The above warranty is given by Licensors subject to the following conditions:

Neither Licensor nor Reseller shall be under any liability in respect of any defect in the DATA arising from any drawing, design or specification supplied by the End User or in respect of any defect arising from failure to follow Licensors' guidance, misuse or alteration of the DATA without Licensors' approval;

Neither Licensor nor Reseller shall be under any liability under the above warranty (or any other warranty, condition or guarantee) if the total price for the DATA has not been paid by the due date for payment; and Except in respect of death or personal injury caused by Licensor or Reseller's negligence, neither Licensor nor Reseller shall be liable to the End User for any consequential loss or damage (whether for loss of profit or otherwise), costs, expenses, or other claim for consequential compensation whatsoever which arises out of or in connection with the supply of the DATA, except as expressly provided in these Conditions.

Except in respect of injury to or death of any person Licensor's and Reseller's aggregate liability for breach of contract, negligence or other default shall not exceed the value of the Contract.

Except as expressed here all warranties, conditions or other terms implied by statute or common law are excluded to the fullest extent permitted by law.

11 Governing Law and Jurisdiction

The End User Contract and any matter, dispute or claim arising from or in connection with the End User Contract in so far as it applies to DATA and its use (including non-contractual disputes or claims) shall be governed by and construed in accordance with English law. The End User must submit to the mediation process prescribed in the Agreement and, subject to that, to the exclusive jurisdiction of the English court.

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BRIMSTONE
SITE INVESTIGATION

DETAILED
UXO RISK ASSESSMENT

INTEGRITY | PROFESSIONALISM | KNOWLEDGE

STAGE 2 DETAILED UXO RISK ASSESSMENT

Client:	Campbell Reith	
Project Ref:	CAMP06R	
Site:	Site 4 Heybridge, Camden	
Report Ref:	DRA-21-1242-CAMP06R-Site4Heybridge,Camden	
Revision:	1	
Status:	Final	
Release Date:	22nd March 2021	
Written By:	IA	Researcher
Reviewed By:	WH	Researcher
Authorised By:	AF	Managing Director

EXECUTIVE SUMMARY

RESULT: Brimstone Site Investigation concludes that UXO poses a **LOW RISK** and **MODERATE RISK** to the proposed works.

THE SITE: The Site (centred on the National Grid Ref: TQ 28695 84532) is located in the Kentish Town area of the London Borough of Camden, approximately 520m east of Chalk Farm Underground Station. The Site is bound to the west by Hadley Street, to the north by Castle Road, to the south by Lewis Street and to the east by a residential apartment block.

The Site is occupied by a single storey concrete covered car park associated with the adjacent residential development. The north-east corner occupies the sloped vehicular entrance to the car park and the south and west extents encroach into adjacent pavement and road. The car park level appears to be lower than street level.

THE PROPOSED WORKS: It is understood that the Site will be redeveloped for residential use. However, at the time of writing, most details regarding the developmental ground works were unavailable. NB: it was noted that the new structure(s) will require a piled foundation solution.

UXO RISK ASSESSMENT:

German UXO:

- London was the most frequently and heavily bombed British city during WWII, with most damage being sustained by the central and eastern boroughs (including Camden). The study area experienced a very high bombing density, the result of at least six (likely more) large-scale air raids.
- The original bombing incident records plot approximately 65 HE bombs within 400m of the Site boundary, the closest of which appears to have landed approximately 50m south-east of the Site. However, a HE bomb strike to the southern extent of the Site appears to be missing from the historic record. This bombing incident caused the destruction of four houses on Site. NB: 1kg / 2kg IBs are unlikely to have struck the Site.
- It has been possible to identify the flightpath orientations of a few aircraft that bombed the local area, but probably did not fly over the Site. These bombloads are insignificant, however multiple local bombloads could not be analysed. The precise date of the bomb damage on Site is not known, however there is a good chance that it occurred during the first month of the Blitz. If this were the case, then the study area will have been bombed several times following this damage, raising the possibility of a UXB (unobserved and unplotted) strike to ruins on Site.
- Most local air raids occurred at night. Consequently, there is a greater risk of UXBs falling to the ground unwitnessed.
- Following the destruction on Site, the ruins will have been abandoned, probably for the remainder of the war. This raises the possibility that any UXB entry hole could have persisted here unseen for a significant period of time. Even if this bombsite was accessed, evidence of a UXB strike could have easily been overlooked, obscured by rubble / debris (houses in ruin) or overgrown vegetation that likely occupied the neglected back gardens / yards.
- The majority of the Site area was occupied by residential properties that survived the war largely intact. Any UXB strike to these structures (or the road / pavement surfaces) would have caused incontrovertible evidence of its incidence. The residential back gardens / yards were probably accessed frequently during the Blitz and their very small size suggests a low likelihood of dense vegetation (risk elevating ground cover). A large UXB entry hole within one of these small plots will have been easily recognisable.

British / Allied UXO:

- Numerous (>30) permanent HAA batteries were active within range of the Site during WWII. Luftwaffe activity was frequent and intense over the wider area and therefore these guns would have expended

a vast quantity of ammunition. Consequently, it is quite possible that an unexploded AA shell struck the Site. For the same reasons as above, any such UXO could conceivably have gone unreported within the abandoned back yards / gardens and could have penetrated to shallow depths within soft ground.

- No evidence of historic military activity within the Site boundary has been found and it is highly unlikely that any has occurred historically. Consequently, the risk from associated UXO is low.

Likelihood of UXO Remaining and UXO Encounter:

- The risk associated with any very shallow buried UXO (smalls German IBs) will have almost certainly been mitigated. It is likely that any shallow buried unexploded British HAA shell was encountered and removed during post-war excavations. Any deep buried German HE UXB contamination of the Site is unlikely to have been mitigated to any significant degree.
- At the time of writing, the layout of the proposed development was not known and therefore no specific comments relating to the likelihood of a UXO encounter during specific intrusive methodologies at specific locations, can be made.
- As deep intrusions (piling) are planned, a risk pathway may exist between these works (in the south of the Site) and deep buried (large) German UXBs. NB: piling is the engineering activity most at risk of initiating a large German UXB, due to the forces involved and the 'blind' nature of the intrusion. It is also conceivable that an unexploded British HAA shell or 50kg German HE UXB could be encountered during shallow mechanical excavations below WWII ground level in this part of the Site.

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 within both risk zones.
EOD Engineer - On Site Supervision	Watching brief of all 'open' mechanical excavations and magnetometer survey of any borehole locations within the **Moderate Risk Zone** only.
Intrusive Magnetometer Probe Survey	Of all pile positions within the **Moderate Risk Zone** only.

RISK MAP:

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BRIMSTONE SITE INVESTIGATION LTD

Brimstone Site Investigation is committed to delivering bespoke UXO-risk mitigation strategies to a range of clients across a range of industries.

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

- **Integrity** in advice, information and the manner in which we conduct ourselves and our operations.
- **Professionalism** in the way we handle our operations, people, and processes.
- **Knowledge** in new skills and information, to ensure we remain at the forefront of innovation and strategy.

This report has been prepared with consideration to the site conditions at the time of report order confirmation. BSI Ltd cannot accept liability for any subsequent changes to the conditions on site which may influence the UXO risk. The report has been prepared in line with the relevant CIRIA guidance and UK legislation current at the time of report order confirmation. Changes to official guidance, legislation or technical risk assessment improvements could render parts of this assessment obsolete.

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1 INTRODUCTION

1.1 Background

Campbell Reith (the Client) has commissioned BSI to carry out a Stage 2 Detailed Unexploded Ordnance Risk Assessment (DRA) of the proposed redevelopment works at Site 4 Heybridge, Camden (the Site).

1.2 Legislation

There are no regulations that specifically govern the UXO risk mitigation industry in the UK. There are however 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 BSI'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 BSI 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 detonating 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 9000m 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 cause 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 SPRC 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. Another consequence to consider however 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 BSI has gathered information from a wide range of sources. BSI's research team has completed detailed historical research, including access of original archived records. The following is a general list of information sources that are consulted during the research process:

- 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, Bluesky),
- Google open source mapping,
- The British Geological Society,
- Open sources; published book, articles, web resources,
- Site specific information supplied by the Client,
- BSI's library and historical database, and
- BSI's former armed forces employees.

BSI cannot discount the possibility that pertinent records exist in private collections, not available in the public domain. BSI has made every effort to source those accessible records that could affect the assessment of UXO risk.

2.5 ALARP 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, BSI 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 BSI risk assessment process divides UXO risk into two tolerances:

- **Tolerable:** negligible risk or low risk ratings are tolerable. However, low risk does not mean no risk. 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 risk or high-risk ratings are intolerable. Proactive risk mitigation measures should be put in place. Various strategies are at BSI's disposal to meet your project-specific needs.

2.7 Reliance and Limitations

This report has been prepared using published information and information provided by the Client. BSI is not liable for any information which has become available following the publication of this report. BSI is not liable for any inaccuracies within the records obtained. NB: wartime recrods relating to bombing have been proven on many occasions to be incomplete / inaccurate. 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 (centred on the National Grid Ref: TQ 28695 84532) is located in the Kentish Town area of the London Borough of Camden, approximately 520m east of Chalk Farm Underground Station. The Site is bound to the west by Hadley Street, to the north by Castle Road, to the south by Lewis Street and to the east by a residential apartment block.

The Site is occupied by a single storey concrete covered car park associated with the adjacent residential development. The north-east corner occupies the sloped vehicular entrance to the car park and the south and west extents encroach into adjacent pavement and road. The car park level appears to be lower than street level.

FIGURE 1: Site Location Maps **FIGURE 2:** Recent Aerial Photograph

3.2 The Proposed Works

It is understood that the Site will be redeveloped for residential use. However, at the time of writing, most details regarding the developmental ground works were unavailable. NB: it was noted that the new structure(s) will require a piled foundation solution.

FIGURE 3: Current Site Plan

4 SITE HISTORY

4.1 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

Period	Map Date	Map Scale	Review
Pre-WWI	1896	1:1,056	The Site encompasses three rows of terraced houses (totalling 11 properties) each with a small rear yard / garden of varying size and shape. Like today, the Site is bound to the south, west and north by streets, however the eastern Site boundary abuts terraced housing.
WWI	1916	1:2,500	**FIGURE 4.1:** No significant changes on or adjacent to the Site.
Pre-WWII	1920	1:10,560	Although this map is of small scale and lacks detail, it can be said that the terraced properties on Site remain.
	1938	1:10,560	Although this map is of small scale and lacks detail, it can be said that the terraced properties on Site remain.
Post-WWII	1952	1:2,500	**FIGURE 4.2:** Three houses in the south of the Site have been cleared. The remainder have survived the war. A second example of clearance is visible just east of the Site, with two more, further away to the south. NB: such observations on early 1950s dated London OS maps are often indicative of severe WWII bomb damage.
	1966	1:1,250	No changes on Site visible.
	1974	1:10,000	The Site appears to be in its present-day configuration, with the clearance of all pre-war housing and construction of one large structure.
	1980	1:1,250	The Site is confirmed to be in its present-day configuration.

4.3 Aerial Photography

Period	Photo Date	Review
Pre-WWII	May 1920	This oblique view photograph showing the Site from the west was taken approximately two years after the end of WWI and 20 years before the WWII Blitz. Although of relatively low resolution, it can be said that the Site is in the same configuration as the 1916 OS map. The houses on Site are all two storeys in height. The back yards / gardens are partly obscured from view and the quality of the image makes analysis of their composition impossible.
Post-WWII	May 1946	**FIGURE 5.1:** This oblique view photograph was taken approximately one year after the end of WWII (in Europe). It shows the Site from the south-west. Although of relatively low resolution, it can be said that the Site is in the same configuration as the 1952 OS map. NB: no analysis of any minor / moderate bomb damage or repair works can be made due to the quality of the image. The bombsite in the south has been entirely cleared of rubble / debris and again, the composition of the back yards / gardens on Site is unknown.
	Sep 1948	**FIGURE 5.2:** This higher resolution image shows the back yards / gardens to vary in appearance. However, some were probably occupied by small grass lawns and two or three small shrubs are visible. The rooves of those houses that survived appear to be uniform, with no obvious evidence of damage or repair works.

NB: at the time of writing, WWII dated high resolution aerial photographs of the Site were unavailable.

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 relevant Site-specific information was located.

5 UXO RISK - GERMAN BOMBING

5.1 WWII Bombing History of the Site

5.1.1 London

In the summer and autumn of 1940, the Luftwaffe targeted the RAF's airfields and support network with the intention of achieving air supremacy prior to a planned amphibious invasion of south-east England. The resulting Battle of Britain campaign (July to October) resulted in many air raids across England, although these were mainly concentred in the south-east. During this period a few small-scale raids affected the outer London boroughs.

Then in early September 1940, the Luftwaffe changed their tactics and commenced an indiscriminate carpet-bombing campaign against London. The resulting nine-month Blitz began on the 7th September 1940 and ended on the 12th May 1941 - the heaviest raid of the Blitz. The vast majority of the Luftwaffe units based in occupied Europe were then redeployed to the Russian front.

During 1943 a number of small-scale fighter bomber raids were carried out against the Capital. Then in 1944 the Luftwaffe commenced Operation Steinboch. This campaign comprised 31 major raids against London and other southern England targets, executed by inexperienced Luftwaffe crews, between January and May. However, poor navigation and improved defences resulted in unsustainable Luftwaffe losses, many formations being broken up by the RAF over the Home Counties. The final large-scale Luftwaffe raid on the Capital took place during May 1944, with all air raids ceased by the end of June.

Between 1940 and 1944 there were a total of 71 major air raids on Greater London resulting in some 190,000 bombs being dropped, killing over 29,000. In total some 50,000 tonnes of HE bombs and 110,000 tonnes of

incendiary bombs (mainly of the 1kg type) were dropped during the Blitz over Britain. The army BDUs successfully dealt with approximately 40,000 UXBs during the war.

Immediately following the final air raids on London, the Luftwaffe launched the V Weapons campaign, commencing in June 1944. The V1 (Flying Bomb or Doodlebug) and later the V2 (Long Range Rocket) were launched from occupied Europe. 2,419 of the former and 517 of the latter were recorded in the London Civil Defence region.

Both carried a large 1,000kg HE warhead and were constructed of thin sheet steel, rather than the thick steel used on the Luftwaffe's free fall bombs. V Weapons were designed to detonate on the surface (like parachute mines), as opposed to free fall bombs which were designed to have some penetration ability through multi-storey buildings.

Consequently, any V Weapons which failed to detonate broke up on impact, resulting in an easily identifiable debris field. Although there is a negligible risk from unexploded V Weapons on land today, they caused widespread destruction throughout London and therefore, at V Weapon impact sites, the assessment of pre-1944 UXB risk can be hampered.

5.1.2 Site Specific

The Luftwaffe's aiming points for indiscriminate raids (the City of London and East End Docks) are relatively close, to the south and south-east of the study area. All central London boroughs (including Camden) were subjected to large scale indiscriminate carpet-bombing raids and therefore the proximity of smaller targets is less relevant than in other parts of the country. Consequently, the study area experienced multiple large-scale raids. NB: Luftwaffe reconnaissance photographs highlight individual industrial targets within 5km of the Site, in Hackney, Stepney and Paddington.

By the end of the conflict, St Pancras Borough (within which the Site was historically located) had suffered 18,841 houses damaged (including 1,576 destroyed) and 5,440 casualties (including 957 fatalities).

5.1.3 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 14.1km south-west.

5.2 WWII Bombing Records

5.2.1 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 London Metropolitan Archives were obtained for this risk assessment. NB: Camden Local Studies and Archives Centre was experiencing long term closure at the time of writing, however it was confirmed that this archive does not hold a collection of bombing incident reports for, or a bomb plot map of, St Pancras Borough.

5.2.2 Bombing Density Statistics

The table below records the Ministry of Home Security's bombing density calculation for the Metropolitan Borough of St Pancras. The table gives a breakdown of the types of large German bombs reported and is understood to not include UXBs. 1kg / 2kg incendiary bombs (IBs) and 2kg anti-personnel (AP) bombs were often too numerous to record accurately and therefore are not included in the below figures.

Area Acreage	2,694
High Explosive Bombs (all types/weights)	641
High Explosive Parachute Mines	8
Flam (Oil) Bombs	14
40kg Phosphorus Incendiary Bombs (IBs)	11
40kg 'Fire Pot' IBs	0
V1 Flying Bomb	20
V2 Long Range Rocket	2
Total (excluding V-Weapons and 1kg / 2kg IBs)	674
Bombs Per 1,000 Acres	**250.1**

The table below records the St Pancras Civil Defence organisation's bombing density calculation for the borough. It provides a breakdown of the types of large German bombs reported and does not include UXBs.

Area Acreage	2,694
High Explosive Bombs (all types/weights)	610
High Explosive Parachute Mines	14
Flam (Oil) Bombs	32
40kg Phosphorus Incendiary Bombs (IBs)	2
40kg 'Fire Pot' IBs	0
1kg / 2kg IB incidents (not total quantity of IBs)	427
V1 Flying Bomb	20
V2 Long Range Rocket	3
Total (excluding V-Weapons and 1kg / 2kg IBs)	658
Bombs Per 1,000 Acres	**244.2**

5.2.3 Bomb Census Maps

BSI has reviewed a collection of original consolidated and weekly bomb census maps for the wider study area. These small-scale maps cover the entire bombing campaign and record all types of bomb. Relevant maps are displayed at **FIGURE 6**.

- Approximately 65 large 'iron' bombs (including at least one UXB) are plotted within a 400m radius of the Site.
- The closest strikes are plotted approximately 50m east and south-east of the Site.
- At least one day time air raid affected the study area. NB: confusingly, these seven local bomb strikes are all replicated on the night time consolidated bomb plot map.
- One 1kg / 2kg IB shower is plotted within 400m of the Site (approximately 220m north). NB: no weekly

plot maps are available for the period up to 7th October 1940 period and therefore it is not known whether additional IB showers affected the Site during the first month of the Blitz.

5.2.4 V Weapons

BSI has reviewed a collection of original consolidated V1 Bomb Plot Maps, as well as a contemporary plot map of V2 Rocket incidents, produced using collections of original written incident reports.

No V1 or V2 strikes occurred on or adjacent to the Site. The closest V1 strike (15th June 1944) is plotted approximately 200m to the south-east and the closest V2 strike (21st March 1945) is plotted approximately 1.3km to the south-west.

Although the closest V1 strike occurred relatively close by, several blocks of buildings that survived the conflict intact will have shielded the Site from the 1,000kg HE blast. Therefore, this incident is insignificant.

5.2.5 Bomb Damage Map

BSI has reviewed an original war damage map covering the study area. The map was produced by the Engineer and Surveyors Department of the London County Council and was updated throughout the bombing campaign. A section of the map covering the study area is displayed at **FIGURE 7**.

Most of the houses on and immediately north of the Site have not been assigned any degree of bomb damage.

In the south-west, two houses have sustained 'serious damage'. In the south-east two houses have been 'totally destroyed' and a third has been 'seriously damaged'. The house at the north-east corner has sustained 'general blast damage'.

5.2.6 Abandoned Bomb Register

Due to the overstretched bomb disposal units during WW2, 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 BSI has obtained a copy. The register should not be relied on for completeness or accuracy. No abandoned bombs are recorded on or near the Site.

5.2.7 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 accounts of local bombing incidents. No such evidence relating to the study area was found. However, a publication (Newbury. 2006) states that on the night of the 27th September 1940, Kentish Town especially was badly hit with 21 HE bombs exploding. It is possible that this was the raid which resulted in bomb damage on Site.

Although none of the street names surrounding the Site are referenced within this publication, it only gives a brief description of each raid and noteworthy incidents.

5.3 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:	The bombing incident records show six air raids affecting the study area. However, this number is likely to be significantly higher as St Pancras Borough experienced at least 22 air raids during the first few weeks of the Blitz, for which weekly plot maps are unavailable.
Intensity of these Air Raids:	All bombs dropped locally were part of large-scale indiscriminate carpet-bombing raids, most of which were carried out at night.

Bomb Strike Positions	
Closest Bomb Strikes	HE bombs: closest confirmed strike is approximately 50m away. However, an unplotted HE bomb likely struck the Site. 1kg / 2kg IBs: these bombs are unlikely to have landed within the Site boundary. However, as records are incomplete, such bombs could have struck the Site during the first few weeks of the Blitz.
Alignment of recorded Bomb Strikes:	It has been possible to confirm or highlight as probable, three bomb-sticks (individual aircraft bombloads) in the local area. These are generally linear and therefore their flightpaths can be deduced. • None straddle the Site or its environs and none are generally aligned with (and resulted in bomb strikes near) the Site. • Due to the high bombing density created by the September 1940 raids, it has not been possible to identify most bomb-sticks in the local area. However, the pattern of local bombing shown on the first consolidated plot map does include potential bomb-sticks that align with the Site or its environs. • The aircraft flightpath associated with one local bombing incident cannot be identified due to that incident being a solitary bomb strike. • Small IBs have been dropped in the vicinity on at least one occasion. These bombs were significantly affected by the wind and therefore the flightpaths of the aircraft responsible cannot be easily deduced. In summary, although complete analysis is not possible, there were probably a number of occasions during which a UXB (unobserved and unplotted) could have been released over and landed within the Site boundary. NB: this analysis is less accurate for areas of high bombing density (such as the study area).
Bomb Failure Rate	
Evidence to suggest that the generally accepted failure rate of 10% differs in the vicinity of the site:	Local borough Civil Defence records list 157 confirmed HE UXB strikes on St Pancras. When combined with the number of HE bombs that functioned as designed, a local failure rate can be calculated: 20.4%. This rate is significantly higher than 10%.
UXBs recorded in close proximity to the site:	Closest plotted UXB strike to the Site is approximately 220m east.

5.4 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.

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.
The vast majority of local air raids occurred during the hours of darkness when residents would have been sheltering indoors. As such there is generally a lower chance of anyone witnessing any UXB strike to the Site as it fell / occurred. NB: no evidence of fire watches active in the vicinity (providing night time observation) was found.

At the time, the Site was developed and as several dwellings survived the war intact, they probably remained inhabited for part of the Blitz, if not throughout the entire bombing campaign. NB: properties could conceivably have been temporarily evacuated. The residential back yards / gardens on Site were very small and therefore probably accessed in full by their owners. For those houses that weren't bomb damaged, these yards were probably frequently accessed, reducing the chance of any UXB evidence going unreported. Furthermore, residents were probably encouraged, by ARP wardens, to search their grounds for UXB entry holes following each local air raid. The bombsite (on Site) will have been abandoned (probably cordoned off), likely for the remainder of the war. The rear gardens / yards associated with the destroyed housing will have been neglected. Evidence of a UXB strike here could have easily remained unseen for a significant period.

Bomb Damage
As the bombing campaign continued, damaged areas became vulnerable to unreported UXBs. Bombsite wreckage or soil disturbance at a bomb crater could obscure evidence of a subsequent UXB strike.
It is not clear exactly when the bomb damage on Site occurred, although it was likely a HE bomb. Alternatively, although less likely, the damage on Site could have resulted from a fire caused by IBs dropped during the first few weeks of the Blitz. Had it occurred early in the bombing campaign, the ruin would have been exposed to a subsequent UXB strike on multiple occasions. A subsequent HE UXB strike to the ruins in the south of the Site could have easily gone unnoticed, its entry hole obscured under the wreckage. NB: the diameter of the smallest German HE bomb (which was also the most commonly deployed over Britain) was 200mm, creating a small easily obscured entry hole. NB: Any such UXB striking within a certain impact angle window, could have come to rest under adjacent structures or yards / gardens within the Site boundary, due to the J-Curve (lateral offset) Effect. The blast damage to the north-east house on Site will have been insignificant (broken windows, chipped brickwork, dislodged roof tiles, etc).

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.
Any UXB strike to the undamaged houses on Site would have caused incontrovertible evidence of its incidence as it passed through structure and into the ground beneath. The same can be said for the road surface and pavements, where (assuming no cratering) a HE UXB entry hole would have been persistent and easily recognisable. The undamaged back yards / gardens are unlikely to have contained significant quantities of tall / dense vegetation, within which a UXB entry hole could be obscured from view. However, it is possible that the gardens belonging to the destroyed houses became subsequently overgrown. A UXB strike within such conditions could have gone undetected and unreported.

5.5 Bombing During WWI

During 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.

A collection of large-scale contemporary bomb plot maps recording each significant raid over the city, an original small-scale consolidated bomb plot map of central London and a collection of London air raids reports were reviewed.

In the early hours of the 20th May 1918, a Gotha bomber dropped three bombs on Kentish Town. One (a UXB) hit the railway line by Grafton Road (380m north of the Site), a 100kg bomb struck 5 Gospel Oak Grove (950m north-west), and the third hit Kentish Town Road (>250m east or north-east). This north-west / south-east orientated bomb-stick did not straddle the Site and therefore there is a low likelihood of any UXB release near the Site.

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	
	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
250	4.8	13.7	4.8	13.7	6.0	13.1	6.8	15.8
500	6.0	17.3	6.0	17.3	7.6	16.4	8.7	19.8
1,000	7.6	21.9	7.6	21.9	9.6	20.7	10.9	24.9

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 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 is 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:** None	**Bedrock Deposits:** London Clay Formation (Clay, Silt and Sand)
SI Data	No Site-specific SI data was provided by the Client. No BGS SI data for the Site was available. The closest BGS SI (through the same mapped geology as the Site) is approximately 50m west of the Site. The associated borehole log (dated July 1974) describes the encountered geology as: - 0.15m of concrete - 1.75m of Made Ground (clay with gravel and brick) - 4.3m of London Clay (firm to stiff fissured slightly silty sandy Clay) - 8.0m of London Clay (stiff to very stiff fissured silty Clay)	

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.

Some of the WWII-era back gardens are likely to have been grass covered and greenfield. Therefore, accurate bomb penetration depths can be calculated. To calculate an approximate maximum bomb penetration depth, BSI has taken the average of the two figures for the predominant Site-specific geologies (clay), in the table above. This gives a maximum bomb penetration depth of **14m** (rounded down) below WWII ground level for a 500kg HE bomb within the garden areas. NB: a large HE UXB penetrating a building in ruin and made ground beneath will have experienced more rapid loss of kinetic energy prior to striking the bedrock below. The maximum bomb penetration depth will therefore have been shallower within such conditions.

NB: theoretically penetration depths could be greater if the UXB was larger, however, War Office statistics confirm that between October 1940 and May 1941 the majority of HE UXBs (>90%) were either 50kg or 250kg, with the 500kg bombs making up most of the remaining 10%.

Based on the proportions of different models of general purpose HE bomb dropped on London (50kg to 1,800kg), the average penetration depth of the average HE UXB weight on Site is approximately **5.0m** below WWII ground level.

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. 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.

Numerous (>30) permanent HAA batteries were active within range of the Site during WWII. No evidence of permanent LAA gun batteries defending Vulnerable Points within range of the Site was found. Luftwaffe activity was frequent and intense over the wider area and therefore these guns would have expended a vast quantity of ammunition. Consequently, there is an elevated likelihood of unexploded AA shells striking the Site. Had such UXO struck soft ground on Site (residential gardens), it could have penetrated to shallow depths. Full below ground level penetration is unlikely to have been achieved within the built / ruined areas of the Site.

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 EOD 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 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.

BSI 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. No recent incidents on or near the Site were identified. NB: in November 2017, a confirmed 'World War Two bomb' was discovered at an unknown location on Bartholomew Road, approximately 380m east of the Site.

8.3 Ground Works

The WWII-era houses were cleared post-war. Foundations may have been broken up and removed, resulting in some below WWII ground level disturbance of made ground. The existing car park structure represents the only phase of post-war redevelopment. This development will likely have required shallow excavations only, however the possibility that deeper intrusions occurred cannot be ruled out. The car park appears to be just below street level and therefore a large volume of made ground / soil was probably excavated and removed from Site.

8.4 Deductions

The risk associated with any very shallow buried UXO (smalls German IBs) will have almost certainly been mitigated. It is likely that any shallow buried unexploded British HAA shell was encountered and removed during post-war excavations. Any deep buried German HE UXB contamination of the Site is unlikely to have been mitigated to any significant degree.

8.5 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.

- The bomb census maps appear to be missing a HE bomb strike on Site. The severity and pattern of damage here indicates that this was probably a medium weight HE bomb, as opposed to fire damage caused by IB strike(s).
- Several bomb strikes occurring during day time air raid(s) are plotted on a night time bomb plot map.
- The house at the south-eastern corner was still standing by 1948, however the bomb damage map shows this property to be seriously damaged, doubtful if repairable.
- The house at the south-western corner was demolished by 1946, however the bomb damage map shows this property to be seriously damaged, repairable at cost.

- The national and local government figures for the quantity of bombs dropped on the borough differ significantly.

These observations highlight the difficulties in accurate record keeping during frequent, intense bombing raids. It is quite possible that additional local bombing incidents are missing from the maps. NB: a second original record of local bombing incidents is unavailable and therefore the accuracy of the bomb census maps cannot be properly assessed and corroborated.

8.6 The Risk of UXO Contamination on Site

8.6.1 Key Findings - German UXO Risk

- London was the most frequently and heavily bombed British city during WWII, with most damage being sustained by the central and eastern boroughs (including Camden). The study area experienced a very high bombing density, the result of at least six (likely more) large-scale air raids.
- The original bombing incident records plot approximately 65 HE bombs within 400m of the Site boundary, the closest of which appears to have landed approximately 50m south-east of the Site. However, a HE bomb strike to the southern extent of the Site appears to be missing from the historic record. This bombing incident caused the destruction of four houses on Site. NB: 1kg / 2kg IBs are unlikely to have struck the Site.
- It has been possible to identify the flightpath orientations of a few aircraft that bombed the local area, but probably did not fly over the Site. These bombloads are insignificant, however multiple local bombloads could not be analysed. The precise date of the bomb damage on Site is not known, however there is a good chance that it occurred during the first month of the Blitz. If this were the case, then the study area will have been bombed several times following this damage, raising the possibility of a UXB (unobserved and unplotted) strike to ruins on Site.
- Most local air raids occurred at night. Consequently, there is a greater risk of UXBs falling to the ground unwitnessed.
- Following the destruction on Site, the ruins will have been abandoned, probably for the remainder of the war. This raises the possibility that any UXB entry hole could have persisted here unseen for a significant period of time. Even if this bombsite was accessed, evidence of a UXB strike could have easily been overlooked, obscured by rubble / debris (houses in ruin) or overgrown vegetation that likely occupied the neglected back gardens / yards.
- The majority of the Site area was occupied by residential properties that survived the war largely intact. Any UXB strike to these structures (or the road / pavement surfaces) would have caused incontrovertible evidence of its incidence. The residential back gardens / yards were probably accessed frequently during the Blitz and their very small size suggests a low likelihood of dense vegetation (risk elevating ground cover). A large UXB entry hole within one of these small plots will have been easily recognisable.

8.6.2 Key Findings - British UXO Risk

- Numerous (>30) permanent HAA batteries were active within range of the Site during WWII. Luftwaffe activity was frequent and intense over the wider area and therefore these guns would have expended a vast quantity of ammunition. Consequently, it is quite possible that an unexploded AA shell struck the Site. For the same reasons as above, any such UXO could conceivably have gone unreported within the abandoned back yards / gardens and could have penetrated to shallow depths within soft ground.
- No evidence of historic military activity within the Site boundary has been found and it is highly unlikely that any has occurred historically. Consequently, the risk from associated UXO is low.

8.7 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)	Likely deep burial (>3m)	HIGH RISK
WWII British Heavy Anti-Aircraft Shells	1.1kg - 1.7kg	Shallow burial (<1.5m)	MODERATE-HIGH RISK
WWII British Land Service Ammunition	<2kg	Shallow burial (<1.5m)	
WWII German 2kg Incendiary / HE Bombs	680g incendiary hazard + ~500g explosive hazard	Shallow burial (<1.5m)	
WWII German 1kg IBs	680g (incendiary, not explosive hazard)	Shallow burial (<1.5m)	MODERATE RISK
WWII British Light Anti-Aircraft Shells	4g - 70g	Very shallow burial (<1m)	LOW-MODERATE RISK

8.8 The Likelihood of UXO Encounter

8.8.1 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.

8.8.2 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.

8.8.3 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.

8.8.4 Deductions

At the time of writing, the layout of the proposed development was not known and therefore no specific comments relating to the likelihood of a UXO encounter during specific intrusive methodologies at specific locations, can be made.

As deep intrusions (piling) are planned, a risk pathway may exist between these works (in the south of the Site) and deep buried (large) German UXBs. NB: piling is the engineering activity most at risk of initiating a large German UXB, due to the forces involved and the 'blind' nature of the intrusion. It is also conceivable that an unexploded British HAA shell or 50kg German HE UXB could be encountered during shallow mechanical excavations below WWII ground level in this part of the Site.

9 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. The UXO risk to the proposed works varies. **Low** and **Moderate** risk zones have been identified. These are illustrated on a Risk Map displayed at **FIGURE 8**.

Risk Table: Low Risk

UXO TYPE (ASSOCIATED HAZARD)	LIKELIHOOD OF UXO CONTAMINATION	LIKELIHOOD OF UXO REMAINING	LIKELIHOOD OF ENCOUNTER	OVERALL RISK RATING
WWII German 'Iron' Bombs	Low	n/a		**Low**
WWII British Heavy Anti-Aircraft Shells	Low	n/a		
WWII British Land Service Ammunition	Low	n/a		
WWII German 2kg Incendiary / HE Bombs	Low	n/a		
WWII German 1kg Incendiary Bombs	Low	n/a		
WWII British Light Anti-Aircraft Shells	Low	n/a		

Risk Table: Moderate Risk

UXO TYPE (ASSOCIATED HAZARD)	LIKELIHOOD OF UXO CONTAMINATION	LIKELIHOOD OF UXO REMAINING	LIKELIHOOD OF ENCOUNTER	OVERALL RISK RATING
WWII German 'Iron' Bombs	Moderate	Moderate	Moderate	**Moderate**
WWII British Heavy Anti-Aircraft Shells	Moderate	Low	n/a	**Low**
WWII British Land Service Ammunition	Low	n/a		

WWII German 2kg Incendiary / HE Bombs	Low-Moderate	Low	n/a	
WWII German 1kg Incendiary Bombs	Low-Moderate	Low	n/a	
WWII British Light Anti-Aircraft Shells	Low	n/a		

10 RISK MITIGATION RECOMMENDATIONS

BSI has identified an elevated UXO risk to some of 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 within both risk zones.
EOD Engineer - On Site Supervision: Watching brief for open excavations below WWII ground level. Portable magnetometer instruments for clearing ground ahead of borehole positions and shallow excavations (where / when appropriate). Positive identification of suspicious (non UXO) objects. Liaison during confirmed UXO incidents. Provision of additional UXO Safety Awareness Briefings.	Watching brief of all 'open' mechanical excavations and magnetometer survey of any borehole locations within the **Moderate Risk Zone** only.
Intrusive Magnetometer Probe Survey: A range of intrusive magnetometer methodologies can be deployed to survey the ground (down to the maximum bomb penetration depth) prior to deep intrusive works; pile foundations. The appropriate technique is governed by a number of factors, the most important being the site-specific ground conditions.	Of all pile positions within the **Moderate Risk Zone** only.

Figures: 1 - 8

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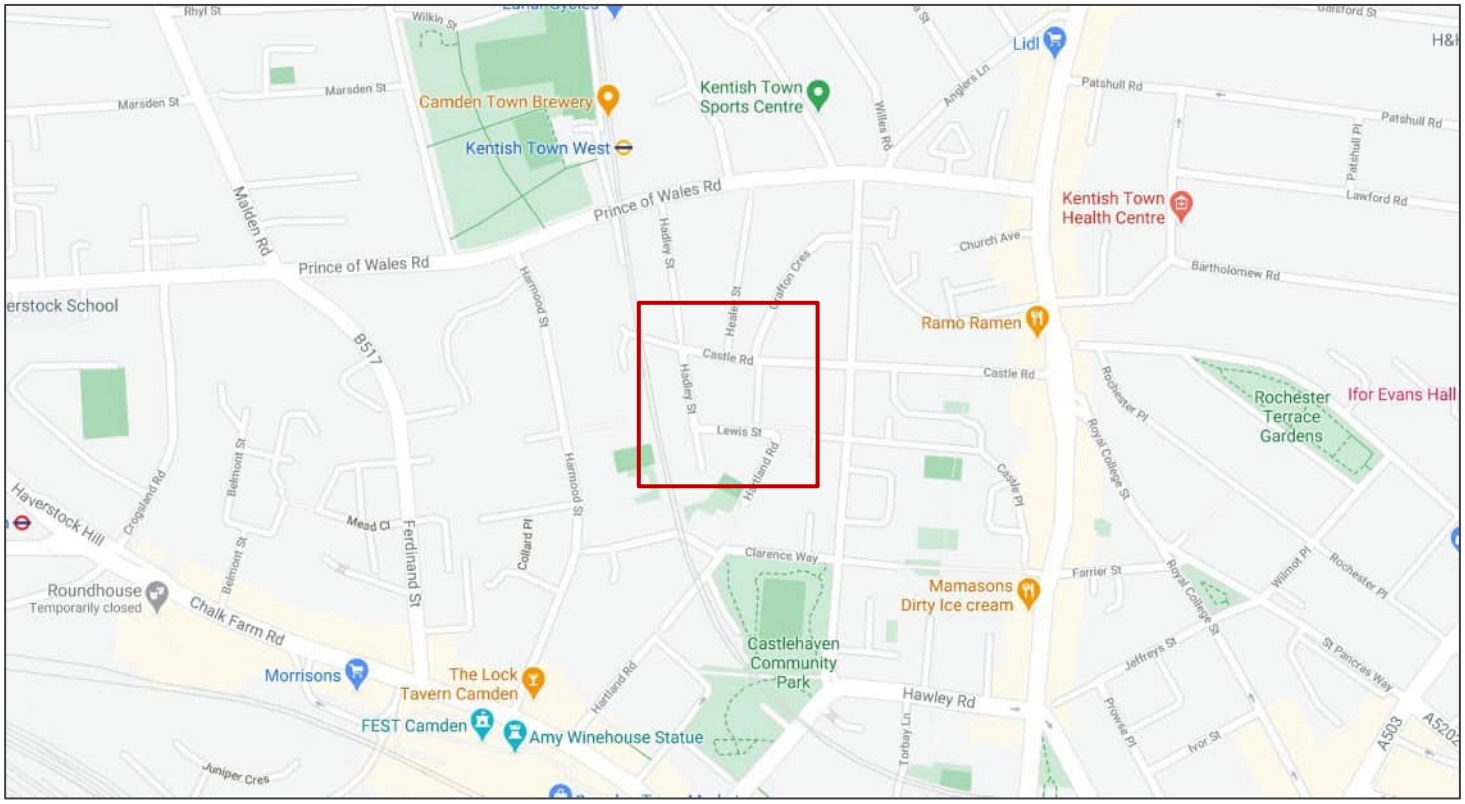
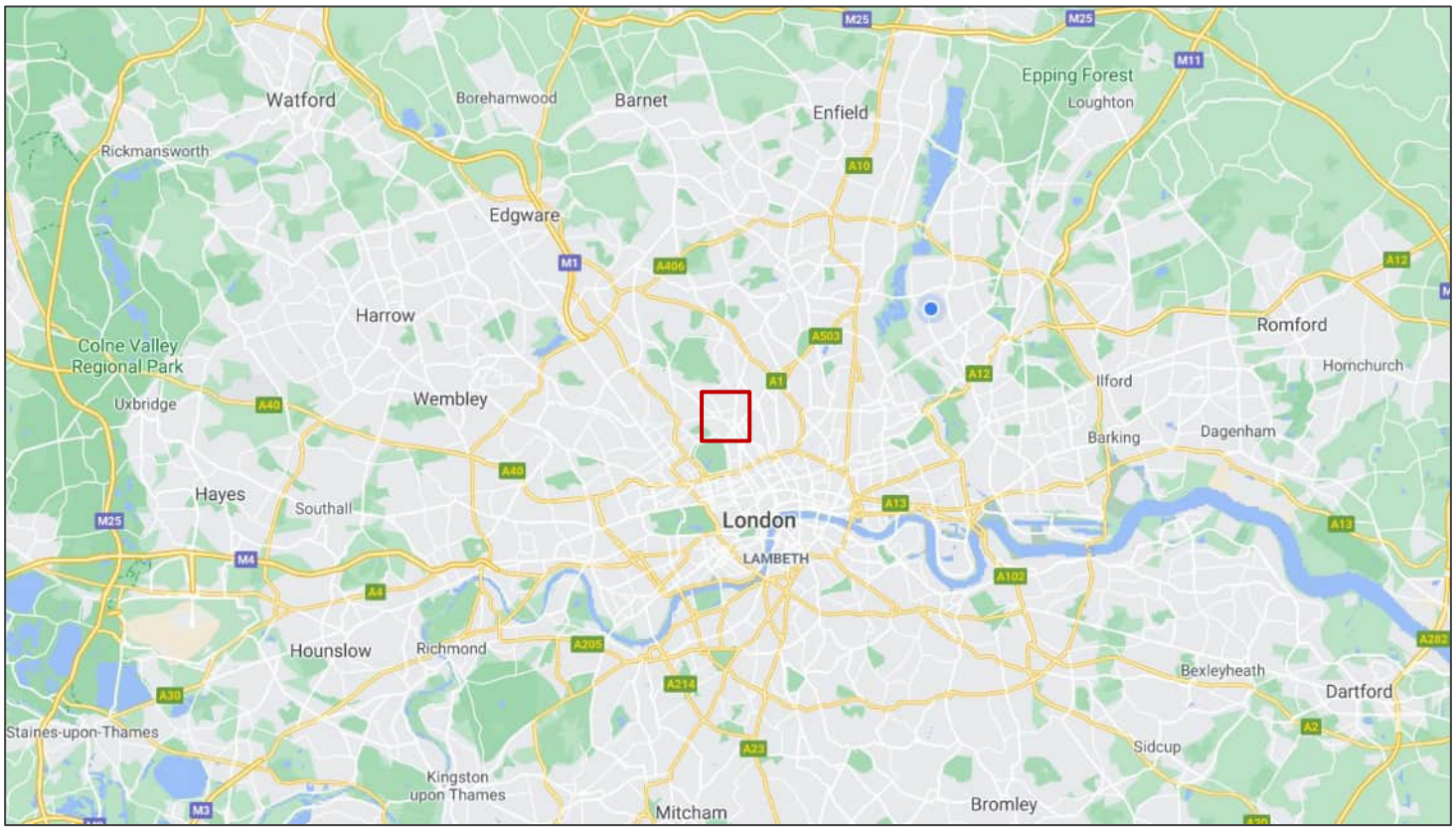
Title:	Site Location Maps	FIGURE: 1





N

Project	Site 4 Heybridge, Camden
Client:	Campbell Reith
Report Ref:	DRA-21-1242
General Site Location	Info Source: Google (open-source)

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Title:	Recent Aerial Photograph	FIGURE: 2

N

Project	Site 4 Heybridge, Camden
Client:	Campbell Reith
Report Ref:	DRA-21-1242
Approx. Site Boundary	Info Source: Google (open-source)

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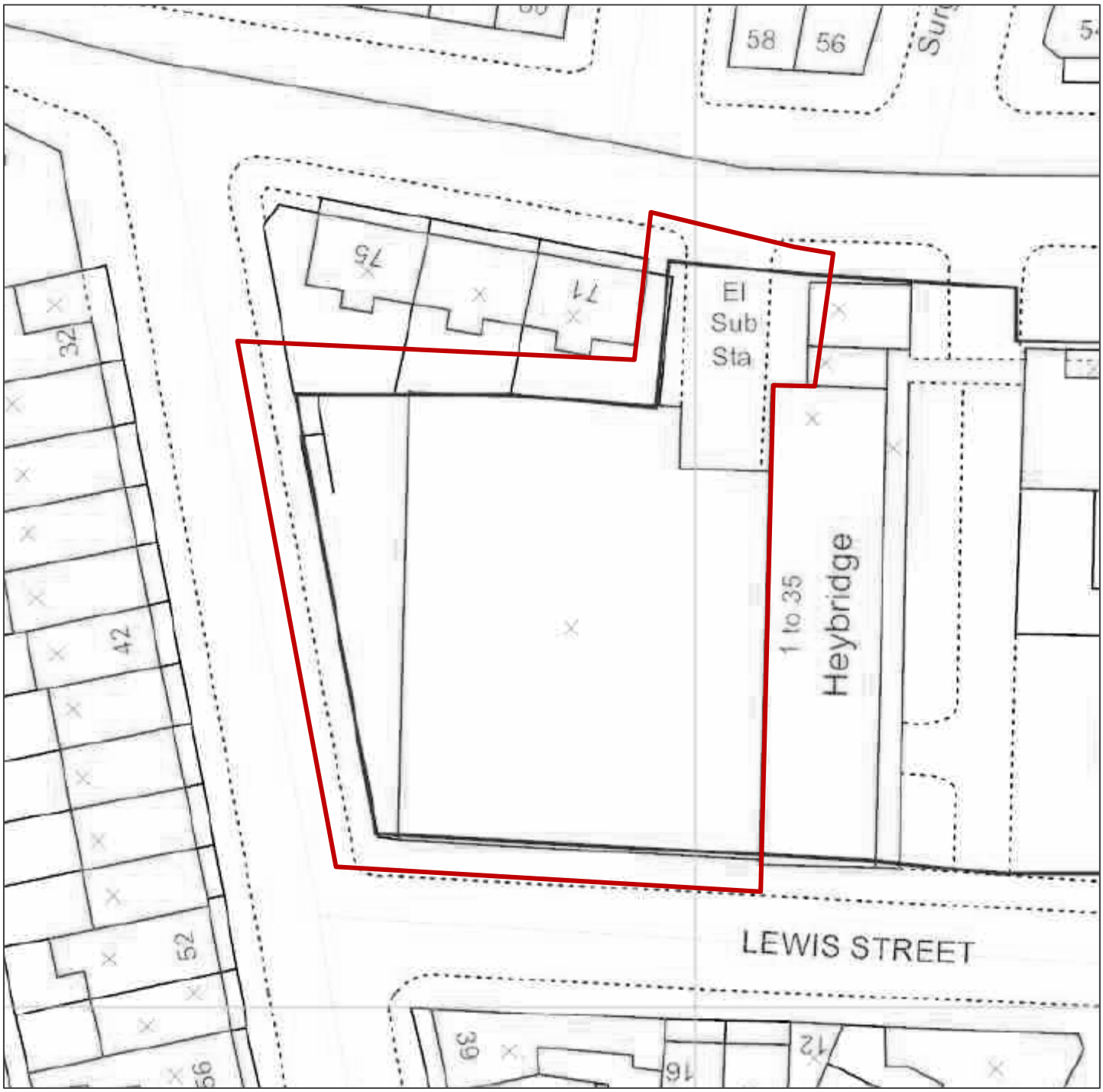
Title:	Current Site Plan	FIGURE: 3



N

Project	Site 4 Heybridge, Camden
Client:	Campbell Reith
Report Ref:	DRA-21-1242
Approx. Site Boundary	Info Source: Campbell Reith

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Title:	Historical OS Mapping - 1916	FIGURE: 4.1

N	Project	Site 4 Heybridge, Camden
	Client:	Campbell Reith
	Report Ref:	DRA-21-1242
	Approx. Site Boundary	Info Source: Groundsure

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Title:	Historical OS Mapping - 1952	FIGURE: 4.2

Cleared buildings

N	Project	Site 4 Heybridge, Camden	
	Client:	Campbell Reith	
	Report Ref:	DRA-21-1242	
	Approx. Site Boundary	Info Source:	Groundsure

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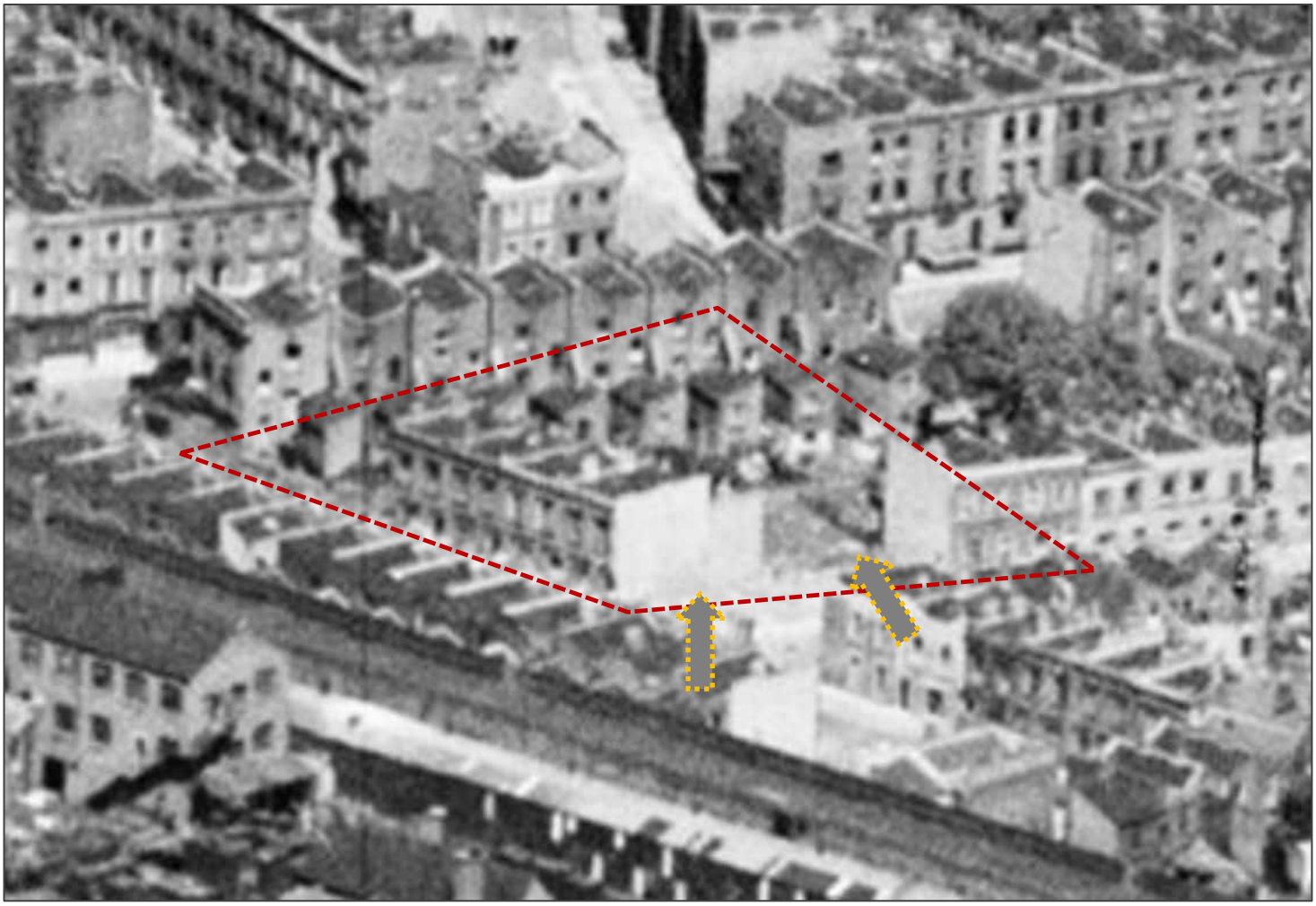
Title:	Historical Aerial Photography - May 1946	FIGURE: 5.1



Clearance

Project	Site 4 Heybridge, Camden	
Client:	Campbell Reith	
Report Ref:	DRA-21-1242	
General Site Location	Info Source:	Historic England

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Title:	Historical Aerial Photography - September 1948	FIGURE: 5.2

Missing bomb strike (confirmed)

N

Project	Site 4 Heybridge, Camden
Client:	Campbell Reith
Report Ref:	DRA-21-1242
Approx. Site Boundary	Info Source: Historic England

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Title:	Consolidated Bomb Census Map - Night Bombing - 07/09/1940 till 07/10/1940	FIGURE: 6.1

Note:
As there are no weekly plot maps available for this period and the bombing density is high, bomb-sticks (individual aircraft bombloads) cannot be confirmed.

● 'Iron' bomb

N	Project	Site 4 Heybridge, Camden
	Client:	Campbell Reith
	Report Ref:	DRA-21-1242
	Approx. Site Boundary	Info Source: National Archives, London

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Title:	Consolidated Bomb Census Map - Day Bombing - 08/10/1940 till 31/12/1940	FIGURE: 6.2

Note:
As there are no weekly plot maps available for this period, bomb-sticks cannot be confirmed. However, some probable bomb-sticks are visible.

● 'Iron' bomb

N	Project	Site 4 Heybridge, Camden	BRIMSTONE SITE INVESTIGATION
	Client:	Campbell Reith	1-3 Manor Road, Chatham, Kent, ME4 6AE
	Report Ref:	DRA-21-1242	+44 (0) 207 117 2492
	Approx. Site Boundary	Info Source: National Archives, London	www.brimstoneuxo.com
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Title:	Consolidated Bomb Census Map - Night Bombing - 07/10/1940 till 30/05/1944	FIGURE: 6.3

Notes:
Blue circles and lines identify confirmed or probable bomb-sticks.
Unconnected blue circles highlight solitary bomb strikes (not part of closely spaced bomb-stick).
Dotted line circles represent confirmed UXBs.
Unhighlighted bomb strikes were not plotted on any weekly plot maps. NB: one weekly plot map (14/10/40 - 21/10/40) is missing from the collection.

● 'Iron' bomb

N	Project	Site 4 Heybridge, Camden
	Client:	Campbell Reith
	Report Ref:	DRA-21-1242
	Approx. Site Boundary	Info Source: National Archives, London

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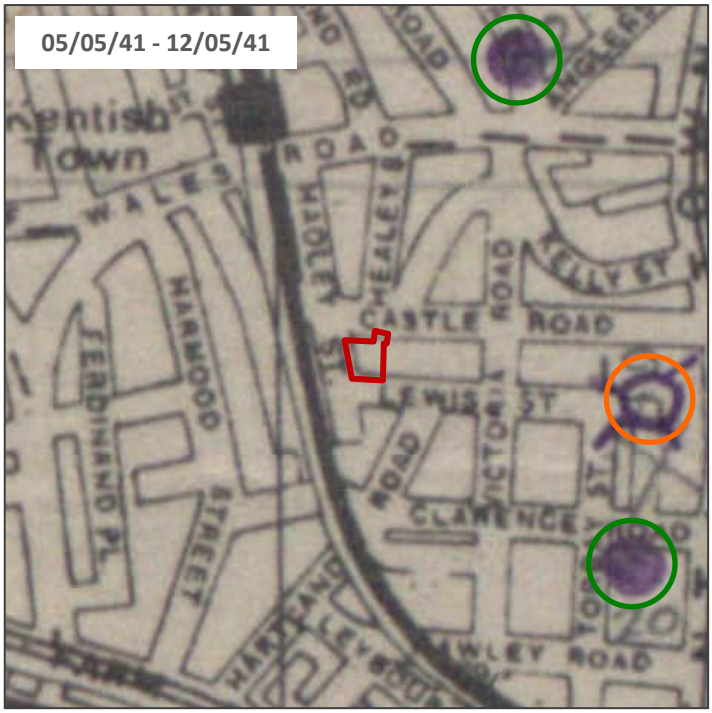
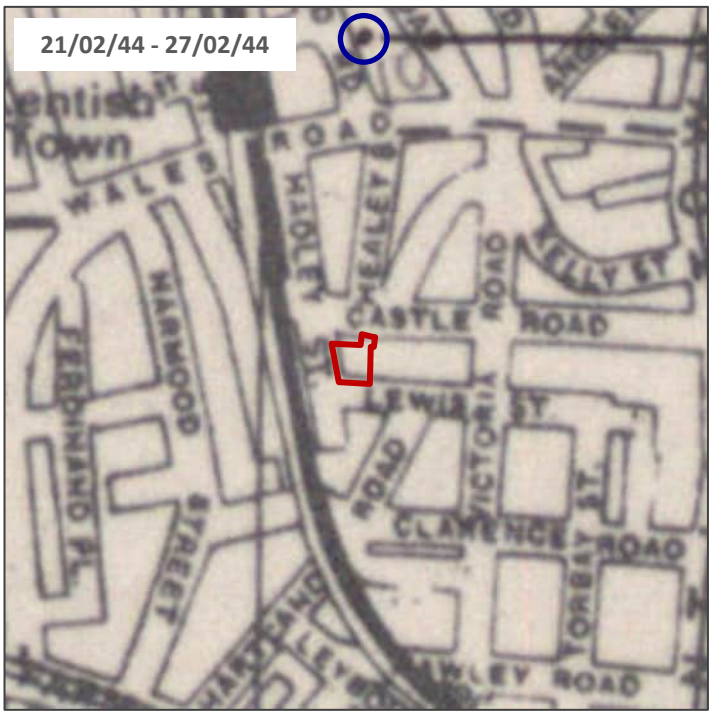
Title:	Select Weekly Bomb Census Maps - 07/10/1940 till 30/05/1944	FIGURE: 6.4





Note:
One weekly plot map (14/10/40 - 21/10/40) is missing from the collection.

~300 x 1kg / 2kg IBs
HE bomb
HE UXB

N

Project	Site 4 Heybridge, Camden
Client:	Campbell Reith
Report Ref:	DRA-21-1242
Approx. Site Boundary	Info Source: National Archives, London

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Title:	London County Council Bomb Damage Map	FIGURE: 7

- Pre-war clearance
- Minor blast damage
- General blast damage; not structural
- Serious damage; repairable at cost
- Serious damage; doubtful if repairable
- Damage beyond repair
- Total destruction

N

Project	Site 4 Heybridge, Camden
Client:	Campbell Reith
Report Ref:	DRA-21-1242
Approx. Site Boundary	Info Source: London Metropolitan Archive

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Title:	Risk Map	FIGURE: 8

LOW UXO RISK: Low likelihood of German and British UXO remaining here.

MODERATE UXO RISK: Elevated likelihood of German HE UXBs remaining here (includes a ~5.0m J-Curve Effect buffer area).

N

Project	**Site 4 Heybridge, Camden**
Client:	**Campbell Reith**
Report Ref:	**DRA-21-1242**
Approx. Site Boundary	Info Source: n/a

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Appendices: 1 - 5

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Recent German UXB Finds in the UK + Historical Analysis

- ***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.*
- ***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.*
- ***19th January 2017*** - An SD50 (semi-armour piercing 50kg HE bomb) was dredged from the Thames during barge dredging works near Westminster Bridge, London.
- ***12th May 2016*** - A 500kg HE bomb was found buried just 1m below the playground of the former Royal High Junior School in Bath. *Historical Analysis: The UXB landed in a plot of neglected, unmaintained vegetation in between the school gym and main school building.*
- ***23rd September 2015*** - A 1,000kg HE bomb was encountered by a mechanical excavator on a building site in Paradise Street, Coventry. *Historical Analysis: the UXB landed in a large residential back garden occupied by dense vegetation. A two storey building was built on top of the UXB post-WWII.*
- ***10th August 2015*** - A 250kg HE bomb was found immediately beneath a basement floor during refurbishment works in Temple Street, Bethnal Green (London). *Historical Analysis: The UXB struck a house that had been damaged beyond repair during a previous air raid. The existing house was then built on top of UXB post-WWII.*
- ***21st May 2015*** - An SC50 (general purpose 50kg HE bomb) was found during deep excavations at a construction site in Wembley, London. *Historical Analysis: UXB landed in a large residential back garden.*
- ***23rd March 2015*** - A 250kg HE bomb was found during deep excavations at a building site in Grange Walk, Bermondsey (London). *Historical Analysis: inconclusive - reported UXB position is likely inaccurate.*

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).

Initiation of WWII Allied Bombs

- ***6th January 2014*** - Mechanical excavator stuck a WWII bomb in Euskirchen (Germany) causing it to explode, killing the operator and injuring 13 more, two critically. The explosion was so large it damaged buildings 400m away.
- ***1st March 2013*** - During piling at a construction site in Ludwigshafen (Germany) a small buried WWII bomb exploded, injuring one worker.
- ***2nd June 2010*** - A British 500kg bomb detonated whilst being defused, killing three EOD engineers in Goettingen, Germany. The bomb was found as builders dug the foundations for a new sports hall. Several houses had their fronts blown off by the blast.
- ***19th September 2008*** - Seventeen people were injured and buildings were damaged when an excavator apparently drove over and set off a 250kg American bomb at a construction site in Hattingen, Germany.
- ***23rd October 2006*** - A construction worker breaking up tarmac at the side of a highway near the south-western German town of Aschaffenburg was killed when his machine struck and detonated a WWII bomb. In addition, the blast injured several motorists who were driving past.
- ***2006*** - A piling rig and dump truck were destroyed when a piling rig struck an Allied bomb on a construction site in Austria.
- ***2003*** - In the Austrian city of Salzburg, two people were killed while attempting to defuse a 250kg Allied bomb.
- ***1994*** - At a central Berlin construction site a piling rig struck a large WWII Allied bomb. 3 were killed and 14 more were injured. Dozens of cars in a 250m radius were wrecked, the top 10 floors of neighbouring office building collapsed and human remains were found 100m away.
- ***1990*** - In Wetzlar (Germany) two EOD engineers were blown up as they removed the detonator of an allied WWII UXB.

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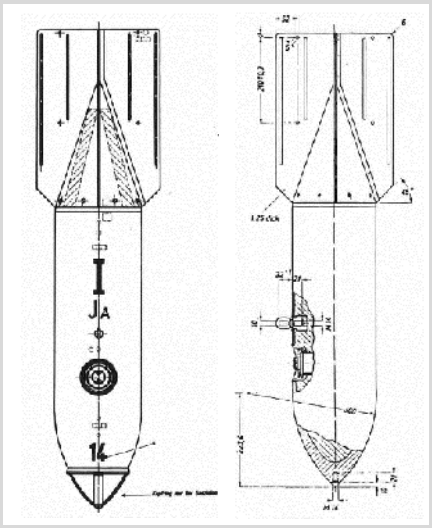
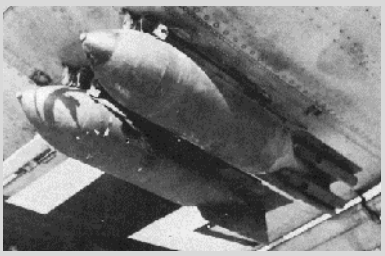
SC 50

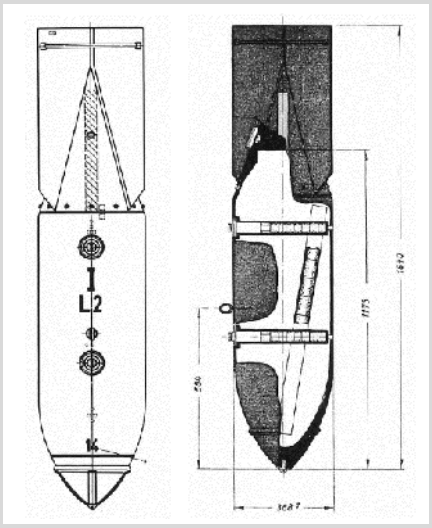
Bomb Weight:	40-54kg (110-119lb)
Explosive Weight:	25kg (55lb)
Filling:	TNT, Amatol or Trialen
Charge/Weight Ratio:	46%
Fuse Type:	Electrical impact fuse or mechanical delayed action fuse
Body Dimensions:	1,100mm length x 200mm diameter
Appearance:	Bomb body and tail painted grey/green with a yellow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





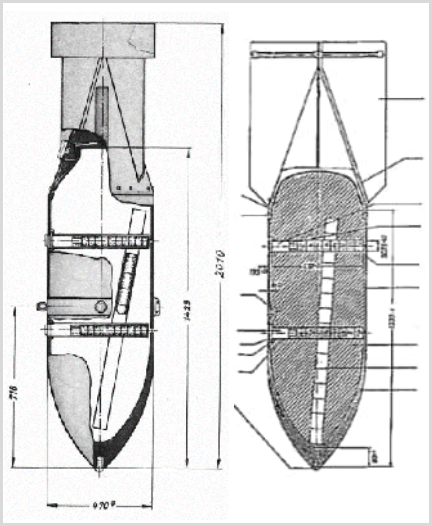
SC 250

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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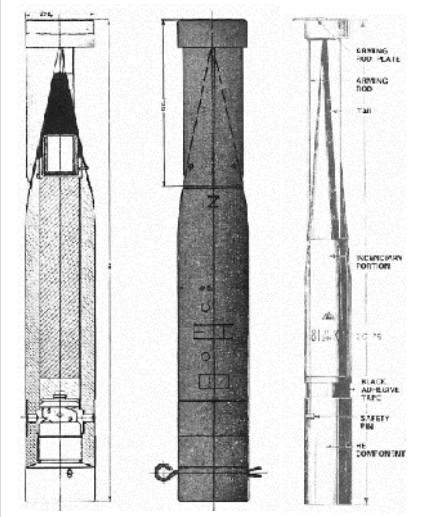
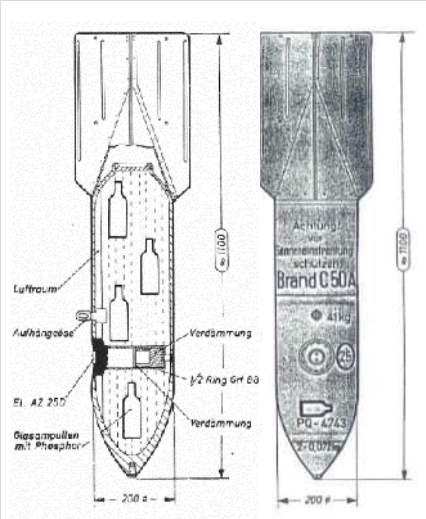
B-1E Sub-Munition

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.



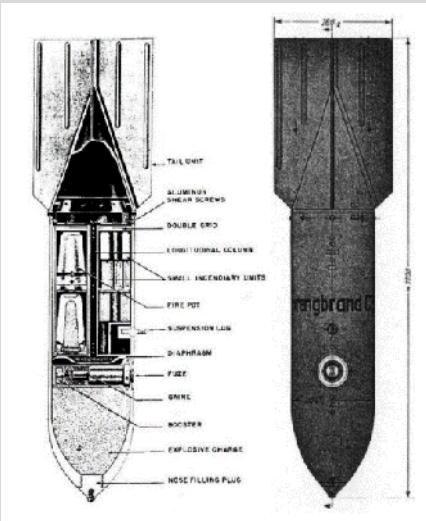
Brand C50

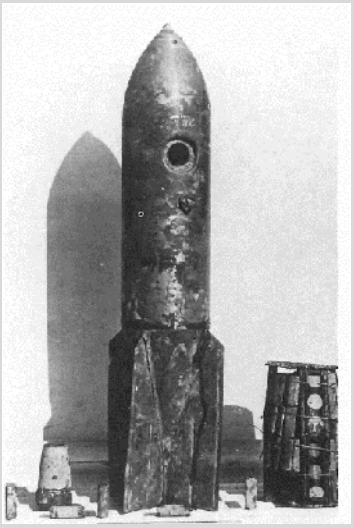
Bomb Weight:	41kg (90.4lb)
Incendiary Weight:	13kg (30lb)
Filling:	Main fill (86% Benzine, 10% Rubber) plus 4% Phosphorus in glass bottles
Fuse Type:	1 x electrical impact fuse
Bomb Dimensions:	762mm length x 203mm diameter
Appearance:	bomb body and tail painted grey or green with the rear of the bomb 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	Site 4 Heybridge, Camden	
Client:	Campbell Reith	
Report Ref:	DRA-21-1242	
	Info Source:	*W, Ramsey.1988 / various news sources*

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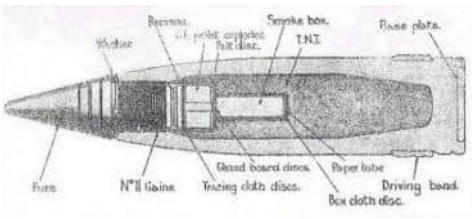
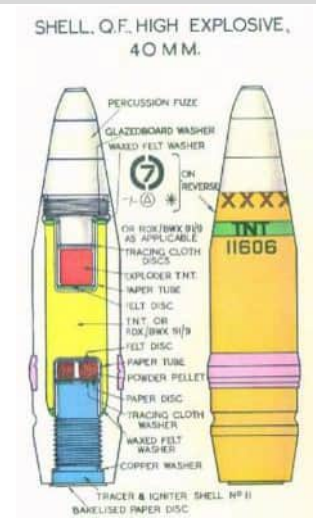
HAA Battery - 3.7" QF Shell

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.



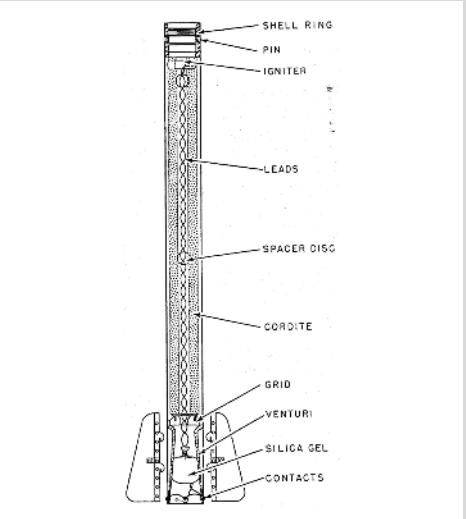
LAA Battery - 40mm Bofors Shell

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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