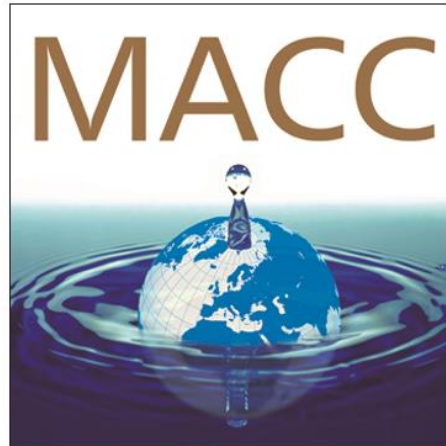


APPENDIX C

- ✚ MACC International Limited Preliminary UXO Report (Ref: 5609-05, Dated: 07.10.2020)
- ✚ Brimstone UXO Letter of Attendance



UXO PRELIMINARY RISK ASSESSMENT – KNELLER HALL

**Kneller Hall
Kneller Road, Twickenham
TW2 7DN**

Prepared for: Defence Infrastructure Organisation

Project Number: 5609-05

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Annexes:

- A. Site Mapping
- B. WWII Air Raids
- C. Risk Zoning

REFERENCES

COVID-19: At the time of writing this report, the COVID-19 pandemic induced restrictions in access to material held by The National Archives and Local Records Offices. Where specific records were not available or accessible, this has been identified within the below list (marked *).

The following sources were considered and where available consulted:

- Aerial Photographs – Twickenham aerial imagery dated 2019, 2013, 1945. Kneller Hall Aerial Photograph dated 1935.
- Bomb Census Mapping (TNA Ref: HO 193 series).
- Home Guard Records **not available*
- Internet Sources – including Newspaper Articles and Witness Accounts (BBC People’s War personal accounts).
- Local Authority Records – **not available*
- The National Archives – HO 192; HO 193; HO 198 series.
- Official Abandoned Bombs Register (Department of Communities and Local Government)
- Ordnance Survey Mapping: OS 1897, OS 1947 & OS 1960s mapping.
- DIO Estate Intelligence Report – *Kneller Hall UXO EI August 2019* – provided to MACC International Ltd by Wood plc on 15/07/2020.
- LQA Report – *Phase 1 Land Quality Assessment Kneller Hall DRAFT*, June 2020, Document Reference: 42394-WOOD-XX-XX-RP-OC-0001_S3_P01 – provided to MACC International Ltd by Wood plc on 16/07/2020.
- MACC International Ltd internal bespoke database.

The following publications were also considered in support of the compilation of this report:

- Unexploded Ordnance (UXO) – A guide for the Construction Industry. CIRIA C681
- German Air Raids on Britain 1914-18. Morris 1925
- The Blitz Then and Now Volumes 1 to 3. Ramsey 1987
- Advanced German Weapons WW2. Ford 2000
- Dealing with Munitions in Marine Aggregates. UMA 2008

- Military Engineering Volume XII. War Office 1956
- German Bomb Fuzes. USN 1945
- Fields of Deception & Anti-Aircraft Command. Dobinson 1988
- Battle Stations Volume 3 DJ Smith 1980.

Project Information: Site drawings and project information was provided by Wood plc.

TERMS AND DEFINITIONS

Abandoned Bomb

An Unexploded Bomb that was left/abandoned after attempted recovery was unsuccessful.

Anti-Aircraft Ammunition (AAA)

High Explosive shells ranging from 30mm to 155mm used by air defence batteries to attack or deter enemy air attack.

Air Dropped Munition

A bomb or container dropped from an aircraft which is designed to detonate at a pre-determined altitude, on impact or using a delay mechanism; after impact.

Air Dropped Sub-Munitions (Bomblet)

Small sub-munitions dispensed from a larger carrier which may be fixed to the aircraft or dropped as a single container munition which was designed to open above the target spreading its contents over a large area. Some designs are extremely dangerous and fitted with anti-handling devices.

Area Clearance

This is the term used for the systematic clearance of explosive ordnance from land, including military property, firing and bombing ranges, airfields and training areas. When the land is a former wartime battle ground, the term used is Battle Area Clearance (BAC)

Blast Zone

This term refers to the area around an explosive detonation where the explosive overpressure (Blast) can cause damage, injury or death.

Explosive Ordnance (EO)

All manufactured or improvised items designed to contain explosive, propellant, pyrotechnic and fissionable material or biological or chemical agents or pre-cursors which when coupled with an initiation or dispersal system are designed to cause damage, injury or death.

Explosive Ordnance Disposal (EOD)

A series of recognised procedures and protocols which are used by specialists in the detection, identification, evaluation, risk assessment, render safe, recovery and disposal of any item of explosive ordnance or improvised explosive device.

Fragmentation Zone

This is the term which refers to the danger area in which a piece of an item of explosive ordnance will travel on detonation. This zone is normally greater than the blast zone.

Geophysical Survey

The use of magnetometers, ground penetrating radar or other geophysical data gathering systems, which is then used for evaluation, risk assessment and to quantify further mitigation requirements.

High Explosive (HE)

High explosives react/detonate at a rate of around 9,000 metres per second, to all intents and purposes, instantaneously.

Imperial War Museum (IWM)

Wartime records source based in Lambeth Road London.

Incendiary Bomb (IB)

Incendiary bombs ranged from 1kg in size to 500kg. The larger sizes were designated as Oil Bombs. Fillings range from Thermite mixtures, Phosphorus, Kerosene or other pyrotechnic mixtures.

Intrusive Search

This term refers to the process of introducing a specialist magnetometer by pushing or drilling the sensor in to the ground to a pre-determined depth, thus allowing construction activities such as: piling, soil testing and deep intrusive ground works to be conducted safely.

Land Service Ammunition (LSA)

LSA is a term that refers to all items containing explosives, pyrotechnic or noxious compounds which are placed, thrown or projected during land battles.

Local Records Office (LRO)

Wartime records source which maintains the records for the Region, County, Borough or City.

The National Archives (TNA)

Wartime records source housed in Kew Gardens London.

Oil Bomb (OB)

Large airdropped bomb or modified ordnance container containing flammable material and accelerant, these weapons normally range in weight from 250 – 500kg.

Parachute Mine (PM)

Air-dropped mine designed to detonate at a pre set altitude above the ground. Essentially a large blast bomb with an explosive content of 1600 kg commonly fitted with anti-handling or anti-removal fuzes.

Unexploded Bomb (UXB)

Any air dropped bomb that has failed to function as designed.

Unexploded Ordnance (UXO)

Explosive ordnance that has been primed, fused, armed or otherwise prepared for use or used. It may have been fired, dropped, launched or projected yet remains unexploded either through malfunction or design or for any other cause.

War Office (WO)

This was the United Kingdom Government department responsible for defence of the realm, forerunner of the Ministry of Defence (MoD).

White Phosphorus (WP)

Munitions filled with WP are designed for signalling, screening and incendiary purposes. They achieve their effect by dispersing WP, which burns on contact with the air.

World War One or Two (WWI or WW2)

Period of multi-national conflict, specifically: WW1; 1914-1918 or WWII; 1939-1945.

1 INTRODUCTION

1.1 Instruction & Scope

MACC International Ltd was commissioned by Wood plc, on behalf of the Defence Infrastructure Organisation to conduct a Preliminary Unexploded Ordnance (UXO) Risk Assessment for Kneller Hall, Kneller Road, Twickenham, TW2 7DN (See Annex 'A') in accordance with the DIO 'UXO PRA Task Directive'. The scope of the assessment is to determine the likelihood of an encounter with UXO within the land footprint in the context of the land disposal. It is understood that whilst a residential development is proposed, no development works are confirmed at this stage.

1.2 Methodology & Purpose

The methodology used in the assessment complies with the CIRIA C681 "Unexploded Ordnance (UXO) – A guide for the Construction Industry", the recognised best practice advocated by the Health and Safety Executive (HSE) and the DIO Task Directive. The quality and environmental aspects of the assessment comply with UKAS Accredited ISO 9001:2015 and ISO 14001:2015 standards. The purpose of the assessment is that of evaluation and to provide an aid in decision making by our client.

2 THE SITE

2.1 Current Site Use

Kneller Hall (the 'site footprint') is located at Kneller Road, Twickenham and is centred at approximate grid reference 514773, 174245. The site has been home to the Royal Military School of Music since 1857.

The below aerial imagery (Image 1.) shows Kneller Hall at the south-west of the site footprint and various buildings including accommodation and offices at the north-west of the site. The majority of the eastern area of the site is undeveloped land in use as sports grounds and a bandstand is located near the centre of the site.

Adjacent land to the north, east, south and west of the site is in residential use at present.

Image 1. 2013 Aerial Imagery.



2.2 **Site History**

Kneller Hall was built within the site footprint in the 1700s; however, the estate has been partially developed since the 1600s. In 1857, Kneller Hall was requisitioned by the War Office for use as a school for military bands and would later become the Royal Military School of Music.

OS 1897 mapping for the area shows the site footprint to be occupied by the Royal Military School of Music at Kneller Hall. Kneller Hall is present at the south-west of the site footprint with wooded areas to the north. A large lake was located adjacent to the northern site boundary and largely undeveloped land was located at the east of the site footprint.

During WWII, the site was briefly used as the headquarters of the Commander-in-Chief, Home Forces from 1939 until July 1940. OS 1947 mapping indicates the addition of several buildings within the vicinity of Kneller Hall at the south-west and west of the site footprint. By the 1960s, further buildings had been developed at the north-west of the site within the vicinity of the lake which had been partially infilled by this time. A ditch formerly present at the south-east of the site has also been infilled by this time.

Various additions and demolitions of buildings took place until the 1970s by which time the site largely resembled the present day layout.

3 DETERMINING THE RISK OF ENCOUNTER

3.1 Aim, Research Restrictions & Indemnity

This risk assessment has drawn upon archive records which are within the public domain; however, these are acknowledged to be incomplete. Consequently, some incidents may have occurred where the records no longer exist or could not be located. MACC International Ltd does not accept responsibility for the accuracy or completeness of the information contained within the records. An Estate Intelligence UXO report for Kneller Hall (*Kneller Hall UXO EI August 2019*) was also provided to MACC International Ltd by Wood plc, on behalf of the DIO. However, it remains a possibility that further records regarding the UXO situation may exist. Any such information was not available for evaluation by MACC International Ltd.

Research of the site history regarding military use and activities, bombing raids and bomb impacts has been undertaken to establish the following:

- Frequency and location of enemy bombing raids and damage sustained to the site.
- Military use of the site throughout its history.
- The potential for UXO to remain on the site.
- Records of any UXO clearance activities and encounters.

3.2 Records, Reports & Archives

Multiple public open sources of information have been searched or consulted in compiling this assessment including National & Local Archives where available. Additional private closed sources are also consulted if provided by the client. These are listed within the References List within this report. Historic records (prior to 1942) pertaining to EO/UXO incidents or military use of land within the United Kingdom were not part of the national recording system. Rather, records compiled during 1939-1942 were conducted under local arrangements and were only as detailed and accurate as the availability of time, proficiency of personnel and information availability.

4 HISTORICAL INFORMATION

4.1 Historic Explosive Ordnance (HEO)

Prior to use of the site by the Royal Military School of Music (1957 onwards), the site footprint was occupied by Kneller Hall and its grounds which date back to the 1700s. No records were found to indicate significant military activity within the site footprint prior to 1957. Consequently, UXO contamination as a result of historic ammunition being buried prior to use of the site by the Royal Military School of Music is not considered to be credible.

4.2 Explosive Storage

No records were found to confirm present or former explosive storage areas within the site footprint. The DIO Estate Intelligence Report confirms that no areas are identified, although it is “possible that various munitions types may have been stored on site for training and security use” (Kneller Hall UXO EI August 2019). It is considered reasonable to assume that if such explosive storage areas did exist, these were suitably cleared and that such items will be suitably removed from any present storage locations before any alternative future site use. Consequently, these are not considered to be a credible source of additional UXO contamination.

4.3 Special Weapons [Chemical, Biological, Nuclear] (SW)

No records (including information provided within the DIO Estate Intelligence Report) were found to indicate that such weapons have been stored within the site footprint. Consequently, this source of UXO contamination is not considered to be credible.

4.4 Ranges

No records (including information provided within the DIO Estate Intelligence Report) were found to confirm the presence of current or former firing ranges within the site footprint. Consequently, this source of UXO contamination is not considered to be credible.

4.5 Airdropped Weapons

WWI: Although the general area did suffer enemy bombing during this period, no records were found to confirm a bomb strike within the site footprint or adjacent land. Consequently, this source of UXO contamination is considered to be highly unlikely.

WWII: The Twickenham area suffered a moderate level of enemy bombing during WWII. Bomb Census Mapping for the area (TNA Ref: HO 193 series) was found to indicate that at least one HE bomb struck the south-eastern area of the site footprint during WWII (see Annex A-2 WWII Air Raids).

Several additional HE bomb strikes were recorded in the immediate surrounding area including (distances are approximate):

- 70m west of the site at Kneller Road.
- 80m south-west of the site at Seaton Road.
- 130m south of the site at Godfrey Avenue.
- 200m south-east of the site near Chertsey Road.
- 200m north-west of the site at Murray Park.

Enemy cluster/incendiary bombs were also recorded within the immediate surrounding area of the site during WWII; most notably, approximately 100m to the north-west of the site and adjacent to the site to the south (See Annex A-2).

Given that at least one HE bomb strike within the south-east of the site footprint was confirmed within primary records, this source of UXO contamination is considered to be credible within a 30m 'buffer zone' from the recorded bomb strike. Additionally, a lake that has been infilled post-war was present at the north of the site footprint during WWII. Given the level of enemy bombing recorded in the immediate surrounding area, it is considered credible that any additional UXB may have fallen within this area unnoticed or unrecorded. Consequently, this risk is also considered to increase within this area, as well as an adjacent 'buffer zone' to account for the potential for a UXB to have fallen within the lake and 'J curved' to now rest within the immediately adjacent land (see Annex A-3 Risk Zoning).

No records were found to confirm a bomb strike within the remainder of the site footprint. Consequently, this source of UXO contamination is on balance considered to be unlikely within the remainder of the site footprint.

Bombing Decoys: Bombing decoys were designed to deflect enemy bombing away from potential targets of strategic importance to the enemy. The presence of a bombing decoy increases the risk of airdropped weapons being dropped in that area if the decoy has operated effectively. There were no bombing decoys located in the immediate area of the site with the nearest (designated SF8a) located approximately 5.5km to the south-east. Consequently, decoys are not considered to be a credible source of additional UXO contamination.

4.6 **Abandoned Bomb Reports**

The Official Abandoned Bombs Register (Department of Communities and Local Government) did not confirm an abandoned bomb within the site footprint. No alternative records were found to confirm or otherwise indicate that an unexploded bomb was abandoned within the site footprint.

4.7 **WWII Anti-Invasion Defences**

Pipemines: No records were found to indicate that the site footprint was fitted with command detonated pipe mines or demolition charges.

Minefields: No defensive minefields were recorded within the site footprint.

4.8 **Anti-Aircraft Ammunition (AAA)**

Local fixed and mobile Anti-Aircraft batteries were positioned in the area to defend against air attack, the nearest of which was an Anti-Aircraft Searchlight battery located approximately 1.4km to the east. Combat engagements with enemy aircraft did take place in the area during WWII. Consequently, this source of UXO contamination is considered to be credible, albeit unlikely.

4.9 **Migration of UXO**

Pre-WWII mapping of the area indicates the presence of a large lake located adjacent to the northern site boundary. Records indicate that this lake was present on site during WWII, but was infilled in stages between 1945 and the 1960s. A ditch was also located at the south-east of the site appearing to act as a boundary to the adjacent land. This area has also been infilled post-war.

Where land ground levels have been increased or in-filled using Marine Dredges Aggregates there is a high potential for the aggregate to contain items of UXO. Consequently, these known infilled areas are considered to pose a credible source of potential UXO contamination (see Annex A-3 Risk Zoning).

5 DETERMINING THE NATURE OF RISK

5.1 General

While munitions are very unlikely to detonate if left undisturbed they remain inherently dangerous and may function if subjected to suitable stimuli. The most common of these stimuli is shock, friction or heat which may cause the fuze to function or unstable explosive materials such as Picric Acid (2-4-6 Trinitrophenol (TNP)) to explode. However, in the case of incendiary bombs containing White Phosphorus (WP) exposure of the WP to the oxygen in the air will result in its violent ignition and combustion which may cause any HE content within the munition to detonate.

5.2 Potential Depth of UXO Contamination

The depth of potential UXO contamination will vary depending on the nature of the item. The below table identifies various delivery scenarios with the resulting potential contamination depths shown.

Table 1. UXO Contamination Depths

| Delivery Method | Estimated Maximum Depth |
|---------------------------------------|-------------------------|
| Air-dropped Steel Bombs | 8.5m bgl |
| Air-dropped Sub-Munitions (Bomblets) | 0.3m bgl |
| Anti-Aircraft Projectiles (Fall Back) | 1.5m bgl |
| Training / Firing / Loss | 0.5m bgl |
| Disposal / Dumping / Burial | 8.0m bgl |

5.3 Potential Impact of Land Development on UXO Contamination

The level of ground disturbance to which ground has been subjected since deposition of an item of UXO will have bearing on the likelihood of encountering UXO. The greater the ground disturbance, the greater the opportunity for such work to have encountered an item and afforded an opportunity for its removal / disposal. Consequently, there is a lesser likelihood of an encounter with UXO on developed/redeveloped parcels of land than on those that have remained undisturbed.

6 RISK ASSESSMENT

6.1 Potential Contaminants

The credibility of the following potential contaminants within the site footprint has been assessed throughout Section 4 of this report. Potential contaminants considered to pose a 'Medium Risk' of encounter are considered to be credible within specific 'medium risk zones' only – see Annex C Risk Zoning.

Table 2. Potential Contaminants

| Contaminants | High Risk | Medium Risk | Low Risk |
|--|-----------|-------------|----------|
| Historic Explosive Ordnance [Prior to 1850] (HEO) | | | ✓ |
| Explosive Storage | | | ✓ |
| Special Weapons [Chemical, Biological, Nuclear] (SW) | | | ✓ |
| Ranges | | | ✓ |
| Airdropped Weapons | | ✓ | |
| Abandoned Bombs | | | ✓ |
| Anti-Invasion Defences | | | ✓ |
| Anti-Aircraft Ammunition (AAA) | | | ✓ |
| Infilled Land | | ✓ | |

6.2 Contamination Sources

The following land uses and events have been assessed to determine their credibility as potential Contamination Sources in relation to the identified medium risk contaminants.

Table 3. Potential Contamination Sources

| Contamination Sources | High Risk | Medium Risk | Low Risk |
|---|-----------|-------------|----------|
| Live Firing | | | ✓ |
| Military Training | | | ✓ |
| Manufacture & Development | | | ✓ |
| Explosive Accident / Explosion | | | ✓ |
| Enemy Action & Collateral Friendly Fire | | ✓ | |
| Importation | | ✓ | |
| Disposal by burial | | | ✓ |
| Disposal by burning | | | ✓ |
| Inadvertent loss | | | ✓ |

6.3 Risk Levels

The risk assessment has determined the risk of encounter to vary from Low-Medium within the site footprint. A Medium risk level has been identified within the following specific areas (Risk Zoned site mapping is included within Annex C):

Table 4. Medium Risk Zones

| Medium Risk Area | Potential Contamination Source |
|---|---|
| Infilled lake at North | Migration of UXO (infilled land) Unrecorded airdropped munitions |
| Infilled ditch at South-East | Migration of UXO (infilled land) |
| 30m radius of recorded HE bomb strike at South-East | Additional airdropped munitions |

6.4 Consequence

The consequences of an UXO detonation on site are considered to be a factor of the size of the blast and the proximity of assets and individuals to the point of detonation. These will include potential to kill or seriously injure personnel destroy or damage high value site assets, nearby public and private property and infrastructure.

6.5 Risk of Harm to Current Site Users

The risk of harm to current site users in relation to the UXO hazards identified is considered to be negligible unless ground intruding works are being undertaken.

6.6 **Risk of UXO Encounter During Construction Works**

Table 2 identified potential contaminants considered to pose a higher than acceptable risk within certain areas of the site footprint (See Annex C Risk Zoning). The following risk table demonstrates the risk of encountering UXO during potential construction works in relation to the undertaking of specific activities (as listed within the DIO Task Directive).

Table 5. Risk of Encounter

| RISK OF UXO ENCOUNTER | | | | | | | | |
|---|---------------|---------------------|--------------------------|---------------------|---------------|---------------------|--------------------------|---------------------|
| Low Risk Zones | | | | | | | | |
| Activity | Low Risk | Medium Risk | High Risk | | | | | |
| Archaeology works (hand dug) | ✓ | | | | | | | |
| Trial pitting | ✓ | | | | | | | |
| Boreholes | ✓ | | | | | | | |
| Bulk movement, screening or transportation off site | ✓ | | | | | | | |
| Deep excavations or other major groundworks | ✓ | | | | | | | |
| Piling | ✓ | | | | | | | |
| Medium Risk Zones | | | | | | | | |
| Activity | Low Risk | Medium Risk | High Risk | | | | | |
| Archaeology works (hand dug) | | ✓ | | | | | | |
| Trial pitting | | ✓ | | | | | | |
| Boreholes | | ✓ | | | | | | |
| Bulk movement, screening or transportation off site | | ✓ | | | | | | |
| Deep excavations or other major groundworks | | ✓ | | | | | | |
| Piling | | ✓ | | | | | | |
| <table border="1" style="width: 100%; text-align: center;"> <tr> <td>1= Minimal</td> <td>5=significant</td> <td>LOW 0-100</td> <td>MEDIUM 100-200</td> <td>HIGH 200+</td> </tr> </table> | | | | 1= Minimal | 5=significant | LOW 0-100 | MEDIUM 100-200 | HIGH 200+ |
| 1= Minimal | 5=significant | LOW 0-100 | MEDIUM 100-200 | HIGH 200+ | | | | |

6.7 **Risk of Harm to Construction Workers**

The Risk of Harm to construction workers when undertaking intrusive ground works can be assessed by multiplying the Consequence (C) by the Likelihood of Occurrence (LO). The Risk of Harm is assessed in terms of a future scenario where no UXO mitigation measures have been put in place. The Risk of Harm has been assessed in relation to potential activities as listed within the DIO Task Directive. An assessment to refine these risk levels further should be carried out once a specific scope of works has been confirmed.

Table 6. Consequence.

| Consequence (C) | | |
|-----------------|---------------|--|
| 5 | Major | Fatality |
| 4 | Serious | Major Injury (Life changing) |
| 3 | Moderate | Serious Injury (Short term disability) |
| 2 | Minor | Minor Injury (cuts, bruises) |
| 1 | Insignificant | No Injury |

Table 7. Likelihood of Occurrence.

| Likelihood of Occurrence (LO) | | |
|-------------------------------|----------------|---------------------|
| 5 | Almost Certain | Commonly occurs |
| 4 | Likely | Often occurs |
| 3 | Possible | Occasionally occurs |
| 2 | Unlikely | Uncommonly occurs |
| 1 | Remote | Rarely occurs |

Table 8. Risk of Harm.

| Risk of Harm | | |
|--------------|--------|--------------------------|
| 16-25 | High | Warrants risk mitigation |
| 10-15 | Medium | Warrants risk mitigation |
| 1-9 | Low | Acceptable Risk Level |

Table 9. Risk of Harm to Construction Workers – Low Risk Zones

| Activity | Consequence (C) | Likelihood of Occurrence (LO) | Risk of Harm (C x LO) |
|---|-----------------|-------------------------------|-----------------------|
| Archaeology Works (hand dug) | 4 | 2 | 8 |
| Trial pitting | 4 | 2 | 8 |
| Boreholes | 4 | 2 | 8 |
| Bulk movement, screening or transportation off site | 4 | 2 | 8 |
| Deep excavations and other major groundworks | 4 | 2 | 8 |
| Piling | 4 | 2 | 8 |

Table 10. Risk of Harm to Construction Workers – Medium Risk Zones

| Activity | Consequence (C) | Likelihood of Occurrence (LO) | Risk of Harm (C x LO) |
|---|-----------------|-------------------------------|-----------------------|
| Archaeology Works (hand dug) | 4 | 2 | 8 |
| Trial pitting | 4 | 3 | 12 |
| Boreholes | 4 | 3 | 12 |
| Bulk movement, screening or transportation off site | 4 | 3 | 12 |
| Deep excavations and other major groundworks | 4 | 3 | 12 |
| Piling | 4 | 3 | 12 |

6.8 **Risk of Harm to Future Site Users**

The Risk of Harm to site users under various potential future site uses has also been assessed using the same methodology (Consequence x Likelihood of Occurrence = Risk of Harm). These potential future site uses include:

- Agricultural/Allotment Use
- Commercial Use
- Residential Use
- Public Open Space

Table 11. Risk of Harm – Future Site Use: Agricultural/Allotment

| Risk Zone | Consequence (C) | Likelihood of Occurrence (LO) | Risk of Harm (C x LO) |
|-------------------|-----------------|-------------------------------|-----------------------|
| Low Risk Zones | 4 | 1 | 4 |
| Medium Risk Zones | 4 | 2 | 8 |

Table 12. Risk of Harm – Future Site Use: Commercial

| Risk Zone | Consequence (C) | Likelihood of Occurrence (LO) | Risk of Harm (C x LO) |
|-------------------|-----------------|-------------------------------|-----------------------|
| Low Risk Zones | 4 | 1 | 4 |
| Medium Risk Zones | 4 | 2 | 8 |

Table 13. Risk of Harm – Future Site Use: Residential

| Risk Zone | Consequence (C) | Likelihood of Occurrence (LO) | Risk of Harm (C x LO) |
|-------------------|-----------------|-------------------------------|-----------------------|
| Low Risk Zones | 4 | 1 | 4 |
| Medium Risk Zones | 4 | 2 | 8 |

Table 14. Risk of Harm – Future Site Use: Public Open Space

| Risk Zone | Consequence (C) | Likelihood of Occurrence (LO) | Risk of Harm (C x LO) |
|-------------------|-----------------|-------------------------------|-----------------------|
| Low Risk Zones | 4 | 1 | 4 |
| Medium Risk Zones | 4 | 2 | 8 |

6.9 **Determining Acceptable Level of Risk**

When viewed from likelihood versus consequence standpoint; it is considered prudent to recommend a suitable degree of UXO mitigation to permit any future works within the identified 'medium risk' zones to proceed in the safest "acceptable" manner in compliance with current legislation and best practices.

The meaning of the term "acceptable" in the context of this risk assessment is considered to be in keeping with the Health & Safety Executive directive which determines the acceptable level as that which is; "As Low as is Reasonably Practicable" (ALARP) to achieve within the resources available.

7 RECOMMENDATIONS FOR RISK MITIGATION

Execution of the following Risk Mitigation Strategy is recommended:

All Risk Levels:

- **Safety Training:** In keeping with CDM Regulations concerning all sub-surface hazards, UXO Safety Induction Training should be provided to anyone involved in commercial or similar ground intrusive earthworks. The training should be commensurate with the individual's responsibilities and duties on site. The training should be provided by a competent individual (preferably a trained EOD Engineer) and delivered as a separate module of the Site Safety Induction Course or as a Toolbox Talk.
- In the event that land is passed to 3rd parties, a Decommissioning Search of any known present or former ammunition or explosive storage areas should be undertaken. This should include a visual/physical search carried out by specialist EOD search assets.

Within the 'Medium Risk Zones' (see Annex C), the following measures should be considered to permit any subsequent development works to be completed with minimum risk from UXO:

- **Risk Communication & Planning:** A UXO Land Clearance Plan should be drawn up to permit the medium risk areas to be cleared of potential UXO contamination in the safest, most efficient manner to reduce the risk to an acceptable level.

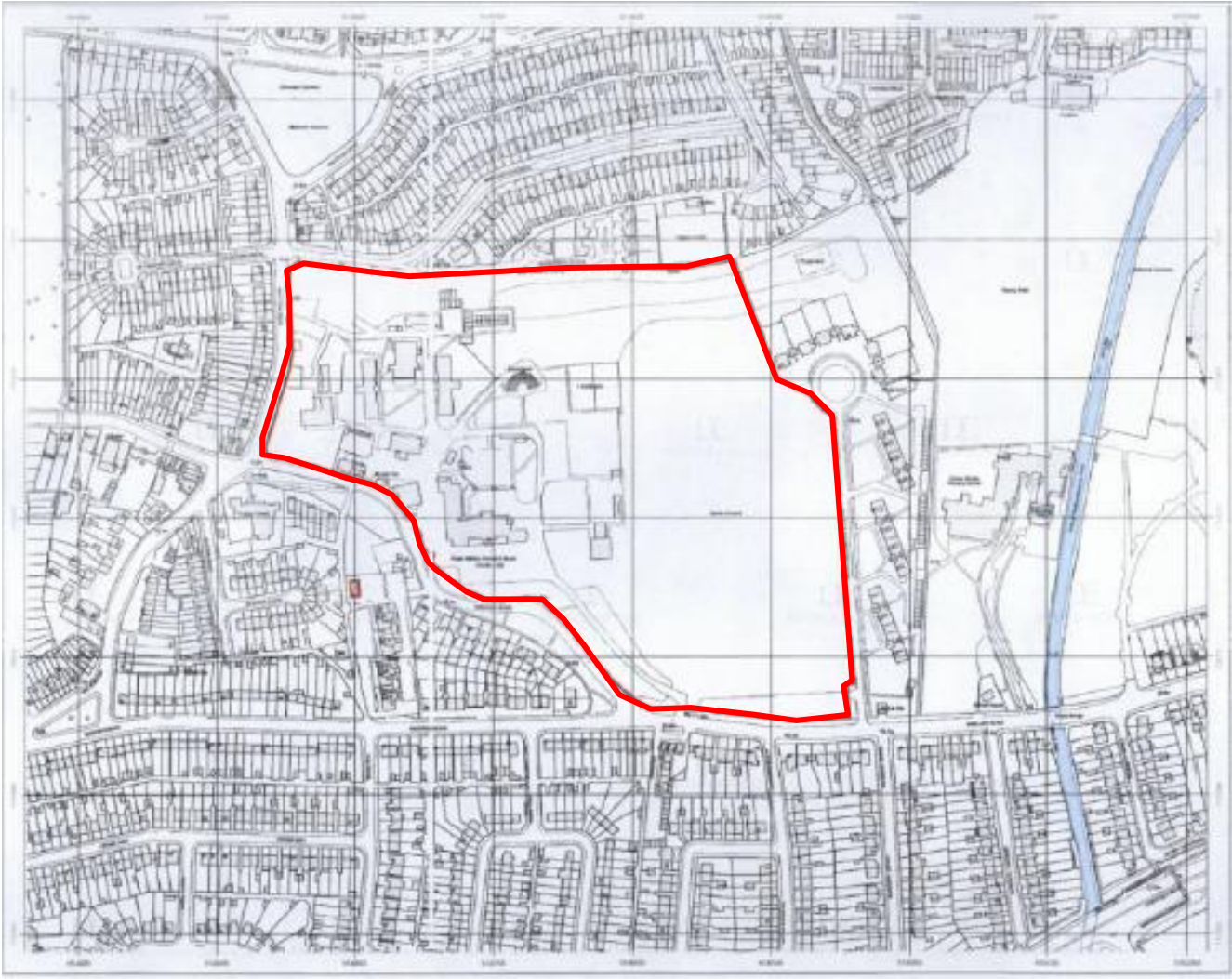
The clearance operation should be conducted by a suitably qualified and experienced UXO clearance organisation and should make use of the following recognised clearance methodologies:

- Non-Intrusive visual and instrument search and clearance (Magnetometer, Ground Penetrating Radar (GPR) or Electrical Resistivity Tomography (ERT) Survey of suitable ground.
- Intrusive instrument search and clearance.
- All search and clearance operations should be fully and accurately recorded and findings/results reported in detail.

SITE MAPPING




Annex A - Site Plan

 Site Boundary






Provided by Wood plc.

Annex B – WWII Air Raids

-  Site Boundary
-  Approximate HE Bomb Strike
-  Approximate Incendiary Strike Footprint



Annex C Risk Zoning

-  Site Boundary
-  Low Risk Zone
-  Medium Risk Zones





BRIMSTONE

LETTER OF ATTENDANCE

Client: Soil Consultants
Project Location: Twickenham, London
Project Ref: SCOL18
Letter Ref: 20220617-CL-SCOL18
Revision: 1
Status: Final
Date: 17th June 2022

| | | | |
|---------------------|----------------|---------------------|------------------------------|
| Written By: | Shaib Ahmed | Technical Executive | shaib.ahmed@brimstoneuxo.com |
| Reviewed By: | Andrew Lane | Operations Manager | andrew.lane@brimstoneuxo.com |
| Signed By: | Aaron Florence | Managing Director | |

QUALITY MANAGEMENT

Brimstone Site Investigation is committed to the provision of UXO risk mitigation services, including the safe removal and disposal, in the UK and overseas. Since our inception in 2016 it has been our goal to provide unsurpassed UXO risk mitigation services. Brimstone is a client-driven organisation, we aim to provide the client the services they need, to the agreed requirement, in accordance with national and international standards.

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, and
- Knowledge in new skills and information, to ensure we remain at the forefront of innovation and strategy.

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

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



Aaron Florence
Founder and Managing Director
Brimstone Site Investigation Ltd.

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The contents of this report are confidential. This report has been prepared for the use of the client and shall not be distributed or made available to any other company or person without the knowledge and written consent of either the client or Brimstone Site Investigation.



1 WHAT IS UXO?

UXO is an abbreviation for unexploded ordnance. It is a term that refers to explosive ordnance which has been primed, armed, fused, or otherwise prepared for use, and has been dropped, fired, launched, projected, thrown, or placed and remains unexploded either by malfunction or by design.

UXO is a catch-all term used in the UK to refer to explosive hazard contamination. Although, not all explosive hazards are correctly described as UXO. Abandoned explosive ordnance, or AXO, is ordnance, which is in a safe state, has not been prepared for use or has not been fire, projected, thrown, or otherwise used. Instead, AXO has been buried or hidden, either as a means of disposal or as a cache in anticipation of invasion.

An example of UXO would be an anti-aircraft projectile having been fired at an aircraft, failing to function and the falling back to land, unexploded. An example of AXO would be a 'bomb dump' of expired ordnance, whereby an excavation is filled with unwanted ordnance and backfilled. This was frequently used by the MoD up until the 1980s as a recognised means of disposal.

2 WHY IS LAND CONTAMINATED BY UXO?

There are four sources of UXO contamination in the UK. These are: enemy action, allied action, military activity or munitions manufacturing and storage locations. Enemy action refers primarily to artillery bombardment and strategic bombing campaign of the Second World War. Allied action refers to defensive activities, again primarily in relation to the Second World War, which includes land and sea mining, anti-aircraft batteries and rocket batteries.

Military training is a significant source of UXO contamination. In former and current military training areas, the risk of encountering UXO is significant, ranging from projectiles, mortars, and grenades. The MoD is the second-largest landowner in the UK, and as such large parts of the UK have historically been used or requisitioned by the military for training our armed forces and allied armed forces.

Finally, munitions manufacturing, and storage sites also present a UXO risk, although the risk is generally localised and in small specific parts of the UK.

3 THE REGULATORY ENVIRONMENT

There are no specific regulations that manage how UXO is dealt with on UK construction sites, and similar operations. However, there are pieces of legislation that must be considered when companies choose how to approach UXO risk, these include those listed below. The CIRIA guidelines are a set of guiding principles that offer a framework to the UK UXO risk mitigation sector, these are explained in the subsequent section.

- Construction (Design Management) Regulation (2015)
- Health and Safety at Work Act (1974)
- Management of Health and Safety at Work (1999)

3.1 Construction (Design Management) Regulations (2015)

CDM 2015 replaces CDM 2007. These regulations define the responsibilities of roles within construction projects. The Principal Designer is responsible for managing health and safety, in that role they must exercise identification, elimination and control of foreseeable risks. UXO is a significant potential hazard and must be considered at the design phase.

3.2 Health and Safety at Work Act (1974)

Employers must ensure as far as is reasonably practicable the health and safety of their employees. They must also ensure the health and safety of others affected by their work activity. When working on a site which is thought to have a UXO

contamination risk, employers have a responsibility to provide a safe system of work that addresses the assessed UXO risk.

3.3 Management of Health and Safety at Work (1999)

This adds on to the Health and Safety at Work Act (1974). The act sets out the general duties which employers have towards employees and members of the public, and those which employees have to themselves and each other. In relation to UXO, the act applied that duty holders are to ensure that proper assessments of foreseeable risks are completed and that necessary measures are taken to control risks to an acceptable level.

4 CIRIA C681 GUIDELINES

CIRIA is the Construction Industry Research and Information Association. Two sets of guidelines provide a framework to the UXO risk mitigation sector in the UK. They are not legally binding, and are optional to follow, but they form the accepted best-practice standards to which the industry operates.

CIRIA C681: Unexploded Ordnance: A Guide for the Construction Industry (2009)

This is the overarching document which provides the four stage UXO risk mitigation framework. Stages are:

1. Preliminary UXO risk assessment – a qualitative screening exercise to assess the likelihood of finding UXO on a site. This can be completed by a non-UXO specialist or a UXO specialist.
2. Detailed UXO risk assessment – A wider and deeper assessment of the site, using bomb damage maps, penetration assessments and other historical information.
3. Recommendations – A proposal of risk mitigation strategies determined in coordination with the client.
4. Implementations – the on-site UXO risk mitigation measures being put in place.

CIRIA C785: Unexploded Ordnance Risk Management Guide for Land-Based Projects (2019)

This guidance document adds on to C681. It provides additional details and structure to the risk assessment process. Both documents are available to purchase on the CIRIA website.

5 ALARP

The ALARP (as low as reasonably practicable) principle is about 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.

6 MAXIMUM BOMB PENETRATION DEPTHS

Using data gathered during WWII by the Ministry of Home Security, estimates 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 in 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:

- a) **Impact velocity.** German bombing raids were carried out at altitudes more than 5,000m. The velocity of impact is roughly 313ms⁻¹ (not accounting for resistance). It is the same velocity regardless of mass.
- b) **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.
- c) **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.

7 LAND SERVICE AMMUNITION

Land service ammunition (LSA) includes mortars, grenades, rockets, and projectiles. These types of ordnance can contaminate land in the UK due to prior and current training of the UK’s armed forces, as well as the activities of other allied nations on British soil. Training areas, airfields, barracks and camps are areas which may have a heightened risk of encountering LSA. During WWII anti-aircraft weaponry was deployed across much of the UK, and as a result contamination from anti-aircraft projectiles can occur in cities as well as in the open countryside.

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This document certifies that no items of UXO contamination were found in the subject area. The following limitations apply:

- a) Detection of UXO is dependent contrast between UXO and its host materials. There is an extremely remote likelihood that ferrous items can be missed by the equipment if its magnetic field is in the same orientation as local magnetic declination.
- b) The survey task specifically targets the anticipated risk of ordnance (mortars, grenades, bombs, and alike) within the limits of the equipment capability.
- c) As with all UXO survey tasks, 100% clearance certificates cannot be issued. This document certifies that work has been undertaken to mitigate against the risk of UXO, using the ALARP principle. However unlikely, encountering UXO cannot wholly be discounted.

Summary of Attendance

The scope of the project was to mitigate the threat of unplanned encounters with UXO. We provide services to reduce the risk to people and property to ALARP – as low as reasonably practicable. We achieve this by reducing the risk to a point where any further reduction in risk is grossly disproportionate in terms of cost, effort and time.

- This project was to provide a watching brief to mitigate the risk of encountering UXO.
- Our engineer attended the site on the 9th and 10th of May 2022 to supervise works.
- No items of ordnance were found under the supervision of our engineer.

If any questions or concerns arise from this subject area in relation to this survey, or any question arise in relation to the scope and context of this clearance then please contact Brimstone HQ using the address or details above.

Yours faithfully,



Aaron Florence

Founder and Managing Director

Brimstone Site Investigation Ltd.