UNEXPLODED ORDNANCE DESK STUDY
DEESIDE AIRFIELDS
(FORMER RAF SEALAND)

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REFERENCES

Publications

Sources of information used in the compilation of this study included:

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Unexploded Ordnance (UXO) – A guide for the Construction Industry. CIRIA C681

Dangerous Energy. Cocroft 2000

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

United Nations International Mine Action Standards (IMAS). UN 2010

Military Engineering Volume XII. War Office 1956

German Bomb Fuzes. USN 1945

Fields of Deception & Anti Aircraft Command. Dobinson 1988

Target Reconnaissance Photography. Luftwaffe 1939-44

Battle Stations Volume 3 DJ Smith 1980

Internet Information

Additional information was provided through the following credible internet sites, their assistance is credited where appropriate:

Army EOD Incidents

RAF EOD Incidents & Air Situation Reports 1939-45

Luftwaffe Strategy & Tactics

Luftwaffe Bomber Specifications

WO Defence Arrangements 1939-45

News Reports Witness Accounts 1939-45

Latest News Reports

Project Information

Site and project information was provided by JPG (Leeds) Limited

TERMS AND DEFINITIONS

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-cursers 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.

Incendiary Bomb (IB)
Incendiary bombs ranged from 1kg in size to 500kg the larger sizes were designated as Oil Bombs. Fills 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 safety.

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.

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.

1 INTRODUCTION

1.1 Instruction & Scope

MACC International Ltd was commissioned by JPG (Leeds) Limited to conduct an Unexploded Ordnance (UXO) Desk Top Study for the Deeside Airfields (Former RAF Sealand) in Flintshire. The scope of the study is to determine the likelihood and consequences of an encounter with UXO within the context of the execution of geotechnical investigations and subsequent development.

1.2 Methodology & Purpose

The methodology used in the study complies with the United Nations (IMAS) standards for UXO/Mine Level 1 Survey (Desk Top Study), the CIRIA C681 "Unexploded Ordnance (UXO) – A guide for the Construction Industry" and the recognised best practice advocated by the Health and Safety Executive (HSE). The quality and environmental aspects of the study comply with UKAS Accredited ISO 9001:2008 and ISO 14001:2004 standards. The purpose of the study is that of evaluation and to provide an aid in decision making by our client.

2 DETERMINING THE LIKELIHOOD OF ENCOUNTER

2.1 Aim, Research Restrictions & Indemnity

This study 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. The Secretary of State of the United Kingdom and MACC International Ltd does not accept responsibility for the accuracy or completeness of the information contained within the records. Some records regarding the UXO situation on some sites may not yet be within the public domain. Consequently such information was not available for evaluation by MACC International Ltd. Research of the site history, with regard to military usage, bombing raids and bomb impacts has been undertaken to establish the following:

2.1.1 Frequency and location of enemy bombing raids and damage sustained to the site.

2.1.2 The potential for UXO to remain on the site.

2.1.3 Records of UXO removal activities and encounters.

2.2 Relevant Publications & Credible Internet Information

Published sources of information used in the compilation of this study are listed within the reference section of this study including those provided by the client. Additional information was provided through credible internet sites, their assistance is credited where appropriate and details are listed within the reference section of this study.

3 THE SITE

The area under assessment is located on the site of the former WWII airfield "RAF Sealand". Its approximate grid reference is SJ323695 with the nearest postcode given as CH5 2JE. (See Annex 'A'). Much of the site has been extensively redeveloped since the end of the war.

4 FUTURE DEVELOPMENT

The intention is to conduct geotechnical investigations and subsequent development of the site.

5 HISTORICAL INFORMATION

5.1 British Archives

Prior to 1942 the United Kingdom did not operate a national recording system for EO/UXO incidents or military use of land. The records compiled during 1939-1942 were conducted under local arrangements and were only as detailed and accurate as the availability of time, personnel and the ease of access to information would allow. In April 1942 the Ministry of Home Security instigated a training programme for all personnel maintaining bomb census records, these standardised national records and greatly improved the accuracy of the information.

5.2 Manned Air Raids & Unmanned Rocket Attack Reports

Records were found to indicate that the immediate area was subjected to bombing raids during WWI.

During WWII the numbers of attacks were limited with most intended to strike military installations and aircraft manufacturers. The most significant incident occurred on 14th August 1941; two enemy aircraft bombed the station. The aircraft approached RAF Sealand from the west and dropped 8 HE bombs and 1 Incendiary bomb in a line across the airfield. Bombs cut the main electricity cable and damaged the Sergeants' Mess. Further damage was caused to the main guardroom and air-man's accommodations block. One officer was killed and twenty-five airmen injured in the raid which had continued with the bomber crews using machine guns once the bomb load had been used up. Records searched included:

HO 192/Series
10-19 Reports

HO 198/Forms BC2/4 V1s
64 Damage Reports
97 23/24 Dec 1944
58 Provincial Bomb Census Maps

HO 198/Series Country Blitzes
121 4 Nov 1940 to 20/21 Oct

HO 198/Series Special Reports
204 Regions 6-11

HO 198/Series Miscellaneous
110 Attacks on Aerodromes 19/20 Feb to 11/12 Oct 1941
111 Attacks on Aerodromes 12/13 Oct 1941 to 21/22 Jul 1942
112 Attacks on Aerodromes 21/22 Jul to 17/18 Dec 1942
113 Attacks on Airfields 11 Jan to 31 Aug/1 Sep 1943
114 Attacks on Airfields 6/7 Sep 1943 to 20/21 Oct 1943
115 Attacks on Airfields 18/19 Nov 1943 to 21/22 Mar 1944
116 Attacks on Airfields 18/19 Apr to 27/28 Jun 1944
117 Attacks on Airfields 3/4 Mar to 20/21 Mar 1945
118 Attacks on Army Stations 13/14 Mar 1941 to 28/29 May 1944
119 Attacks on Communications 26/27 Aug 1941 to 30 Dec 1942
120 Attacks on Communications 11 Jan 1943 to 9/10 Apr 1944
121 Attacks: Country Blitzes 4 Nov 1940 to 20/21 Oct 1941
122 Attacks on Decoys 1 Sep 1941 to 29/30 Dec 1941
123 Attacks on Decoys 10/11 Jan 1942 to 17/18 Dec 1942
124 Attacks on Decoys 3/4 Jan to 26/27 Jul 1943
125 Attacks on Decoys 12/13 Aug 1943 to 22/23 May 1944
126 Attacks on Decoy Aerodromes 17/18 Aug 1941 to 17 Sep 1942
127 Attacks on Decoy Aerodromes 2/23 Jan 1943 to 14/15 May 1944
128 Attacks on Factories 9 Jan 1941 to 27 Jul 1942
129 Attacks on Factories 3 Aug to 16 Dec 1942
130 Attacks on Factories 2 Jan to 22/23 Dec 1943
131 Attacks on Naval Stations 10/11 Jun 1941 to 28 Oct 1942
132 Attacks on Naval Stations 16/17 Feb 1943 to 21/22 Jan 1944
133 Attacks on RAF Stations 15/16 Oct 1941 to 17/18 Dec 1942
134 Attacks on RAF Stations 9 Feb 1943 to 20/21 Apr 1944
139 Starfish Decoy Sites 16/17 Jan 1941 to 31 Oct/1 Nov 1942
140 Starfish Decoy Sites 3/4 Mar 1943 to 15/16 May 1944

HO 198/Series Raid Summaries
184 April 1940 to November 1940
185 Dec1940 to Aug 1944

5.3 Airdropped Sub-Munitions' Reports

Records did not indicate that air dropped sub munitions (Cluster Bombs) fell within the site footprint.

5.4 Anti-Aircraft Ammunition (AAA) Reports

Local fixed and mobile Anti-aircraft batteries are known to have been positioned in the airfield to defend against air attack and it is a matter of record that successful combat engagements with enemy aircraft did take place during WWII.

5.5 Abandoned Bomb & Post War UXO Find Reports

No records were found to indicate that an unexploded bomb (UXB) was abandoned on the site. However records indicate that in 2010 one UXB (Incendiary) was recovered from Chester.

5.6 Migration of UXO

For the most part it is considered that due to the extent of post war excavation within the site footprint there is a greater likelihood that a bomb was exported from the site within material which was to be deposited elsewhere. Nevertheless, wartime and immediately after war “Infill” material or “Made Ground” must be considered to have the potential to contain items of UXO imported from other bomb sites.

6 DETERMINING THE NATURE OF RISK

6.1 General

Records indicate that the area sustained light bombing during 1940-44. While HE bombs 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 (Picrate Acid) to explode. However, in the case of incendiary bombs containing White Phosphorus (WP) exposure of the WP to the air will result in its violent ignition and combustion.

6.2 German Bombing Tactics

The tactics employed by the German Air Force during WWII show that they had a wide variety of bombs at their disposal. The most common ranged in weight from 50 kg through to 500 kg. Some models in this range of bombs were designed to be “carrier” bombs. These containers could hold potentially hundreds of smaller sub-munitions (anti personnel or incendiary bomblets). Although dropped in lesser quantities, the German arsenal also included larger bombs and parachute mines up to 1,400 kg in weight. Unmanned attacks were also mounted by the Germans using V1 Rockets and V2 Missiles, each with a warhead around 1,000 kg in weight.

6.3 Bomb Trajectory & Ground Penetration

During WWII the Ministry of Home Security undertook a major study on bomb penetration depths using 1,328 actual bomb impact events to provide statistical analysis of penetration potential. As a result they determined the expected behaviour of a range of bomb weights through different geological strata around the Capital. Their findings remain the only empirical gained figures to have been gathered to date for England. A summary of their findings can be found in Table 1 of this study. A number of factors will influence the behaviour of a bomb on impact with the target and its trajectory through the ground. Relevant factors include: Height and speed of release of the bomb, aerodynamic qualities of the bomb, the angle of flight and impact and the nature of impact surface and sub soil.

6.3.1 In determining the potential bomb penetration depths into the ground, using the historic geotechnical information, and the reported circumstances of the RAF Sealand raid. Factors considered were: Release height 300m metres, Bomb 50 kg in weight and an impact Angle Range of 90° (tail vertical) to 0° (tail horizontal)

6.3.2 Table 1. Extract of Ministry of Home Security Bomb Penetration Study

	Bomb Weights			
Sub Soil Type	50kg	250kg	500kg	1000kg
Soft Rock or Made Ground	2.442	5.016	6.006	7.062
Gravel	2.442	5.016	6.006	7.062
Dry Clay	3.7	7.6	9.1	10.7
Average Offset (m)	0.8-1.6	1.6-3.7	3-4.5	3.4-5.3

6.3.3 Bombs on penetration of the surface do not tend to follow a straight line trajectory, due to a number of factors, shape, angle of entry, weight and speed; they tend to arc or curve; known as a "J" curve. With the horizontal distance from the entry point to the resting point known as the offset. The typical offset is generally taken to be 1/3rd of the penetration depth. However this distance can vary greatly if the bomb strikes an obstacle just below the surface. With this mechanism of offset, it is therefore a possibility that a bomb could enter the ground outside a building and come to rest within its footprint.

6.3.4 Having reviewed all of the bomb penetration information and having provided a reasonable safety factor it is considered that:

6.3.4.1 Based on the anticipated geology gravels over clay: The maximum bomb penetration depth is estimated at 3.0 metres from the 1941 ground levels.

6.3.4.2 The maximum sub munition or AAA Shell penetration depth is estimated at 1.0 metres below the 1941 ground level.

7 ENVIRONMENTAL IMPACT FROM UXO

7.1 Ground Contamination & Health Risk vectors

While it is acknowledged that there is a potential risk of ground contamination arising from explosive fillings which may leach from a damaged bomb casing into the surrounding soil. The amount of explosive material within the most common bombs is not considered sufficient to pose a significant environmental risk. Nevertheless it should be noted that the following components are commonly used in the manufacture of a high explosive bomb and may pose a localised contamination risk to health:

7.1.1 Metals: Lead, Zinc, Brass, Copper, Steel, Mercury, Silver Fulminate and Aluminium.

7.1.2 Chemical Compounds: Trinitrophenol, Trinitrotolulene, Trimethylene Trinitramine, Ammonium, Sodium Nitrate and Nitro-glycerine

Other contaminants, specifically White Phosphorus (WP) may pose a significant risk of self combusting when exposed to oxygen in open air. WP will generate large quantities of toxic white smoke when ignited. It is recommended that specialist medical advice be sought to identify specific risks to health posed by these chemical compounds.

8 RISK ASSESSMENT

8.1 Risk Source

National Archive material and public records contain sufficient information to confirm that the footprint was struck by airdropped bombs of 50kg in weigh. Records are acknowledged to be incomplete and may include omissions. Site specific clearance operations are yet to be confirmed by the MoD consequently the possibility that a bomb struck, failed to explode and was never reported or that UXO was discarded by deliberate burial (a common practice in 1940-50s) cannot be entirely discounted. Therefore it is considered that there is a credible risk that UXO may be present on site.

8.2 Risk Pathway

The risk pathway is considered to be ground intruding investigations and other intrusive earth works.

8.3 Consequence

The consequences of a UXB detonation on site during construction works 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.

8.4 Risk Rating

H = A figure derived from assessing the history of the site weighing up factors such as recorded bomb damage, military use and the scope of any post conflict development.

W = A figure derived from assessing the type of the process to be undertaken without putting in place any UXO mitigation measures. A low figure is assigned where the process is relatively non aggressive (minimal ground or point shock). A high figure is used where the work is considered aggressive (significant ground or point shock).

L = A figure derived by multiplying figures H and W to provide an overall likelihood of an encounter with UXO.

S = A figure derived by assessing the scope or extent of the works; a low figure is assigned where the volume of risk material is limited. A high figure is used where for example the volume of risk material is considerable such as “bulk digs” or shafting.

P = A Figure derived from assessing the result of an explosion, including primary and secondary risk pathways and receptors. A high figure is attributed for example in a gas works while a low figure is applied to a remote, rural open space.

C = A figure derived by multiplying figures S and P to provide an overall consequence of an encounter with UXO.

8.5 Table 2 Risk Level – From Airdropped Bombs and Burial Pits within post war worked ground.

UXO RISK RATING **Within post war worked ground**			
Activity	Likelihood (H x W = L)	Consequence (S x P = C)	Risk Rating (L x C = R)
Drilling, Sampling, Piling or Excavations	2 x 3 = 6	2 x 5 = 10	6 x 10 = 60
Bulk Excavations or Extensive Trenching	2 x 3 = 6	3 x 5 = 15	6 x 15 = 90
1= Minimal 5=significant	**LOW** 0-100	**MEDIUM** 100-200	**HIGH** 200+

8.6 Table 3 Risk Level – From Airdropped Bombs and Burial Pits within un- worked post war ground.

UXO RISK RATING **Within un- worked post war ground**			
Activity	Likelihood (H x W = L)	Consequence (S x P = C)	Risk Rating (L x C = R)
Drilling, Sampling, Piling or Excavations	4 x 3 = 12	2 x 5 = 10	12 x 10 = 120
Bulk Excavations or Extensive Trenching	4 x 3 = 12	3 x 5 = 15	12 x 15 = 180
1= Minimal 5=significant	**LOW** 0-100	**MEDIUM** 100-200	**HIGH** 200+

9 STUDY FINDINGS

9.1 Risk Levels

The desk study has identified a credible UXO threat to intrusive investigations being undertaken on site, the risk is considered significantly (Medium) throughout the post war un-worked areas of the footprint. When viewed from likelihood versus consequence standpoint, the risk levels for the most part are considered to be low to moderate. Consequently it is considered appropriate to recommend a suitable degree of UXO mitigation to permit the work to proceed in the safest "acceptable" manner.

9.2 Determining Acceptable Level of Risk

The meaning of the term "acceptable" in the context of this study is considered to be in keeping with the Health & Safety Executive directive which identifies the acceptable level as that which is; "As Low as Reasonably Practical" (ALARP) to achieve.

10 RECOMMENDATIONS FOR RISK MITIGATION

10.1 Overview

The following Risk Mitigation Strategy has been designed to reduce the level of UXO risk to an acceptable level (ALARP) in the most efficient and cost effective manner. The Risk Mitigation Strategy will be required to be considered at all levels within the project planning to ensure it has minimum impact to the project's critical path.

10.2 General Mitigation:

It is recommended that the following mitigation measures are carried out.

10.2.1 Risk Communication & Safety Planning: Stakeholders should be made aware that the risk of encounter is considered to be low and the possible impact it may have on the project. Additionally a UXO site safety and emergency procedures plan should be produced.

10.2.3 Safety Training: UXO Safety Induction Training should be provided to everyone working or visiting the site. The training should be commensurate with the individual's responsibilities and duties on site. The training should be provided by a competent individual and delivered as separate module of the Site Safety Induction Course.

10.3 Intrusive Investigations or Excavations Mitigation:

10.3.1 UXO Safety supervision and monitoring; this should be conducted by a qualified EOD Engineer using a specialist magnetometer to clear the ground ahead of the excavator bucket or drilling bit.

10.4 Piling Mitigation:

10.4.1 Pre-testing and clearance certification of the pile positions to below the identified risk depth using a Magcone or other specialist "safe look ahead" magnetometer system.

11 POST MITIGATION RISK

11.1 Overview

Prudent execution of the recommended risk mitigation strategy will reduce the risk, however it is emphasised that zero risk is not achievable given the possible variables.

The study has confirmed a Medium UXO risk level based on the nature of the work to be undertaken and has recommended suitable mitigation. An effective risk mitigation strategy will require detailed scoping to achieve its desired results in providing an acceptable level of risk. For further information concerning any part of this study please contact MACC International Ltd.

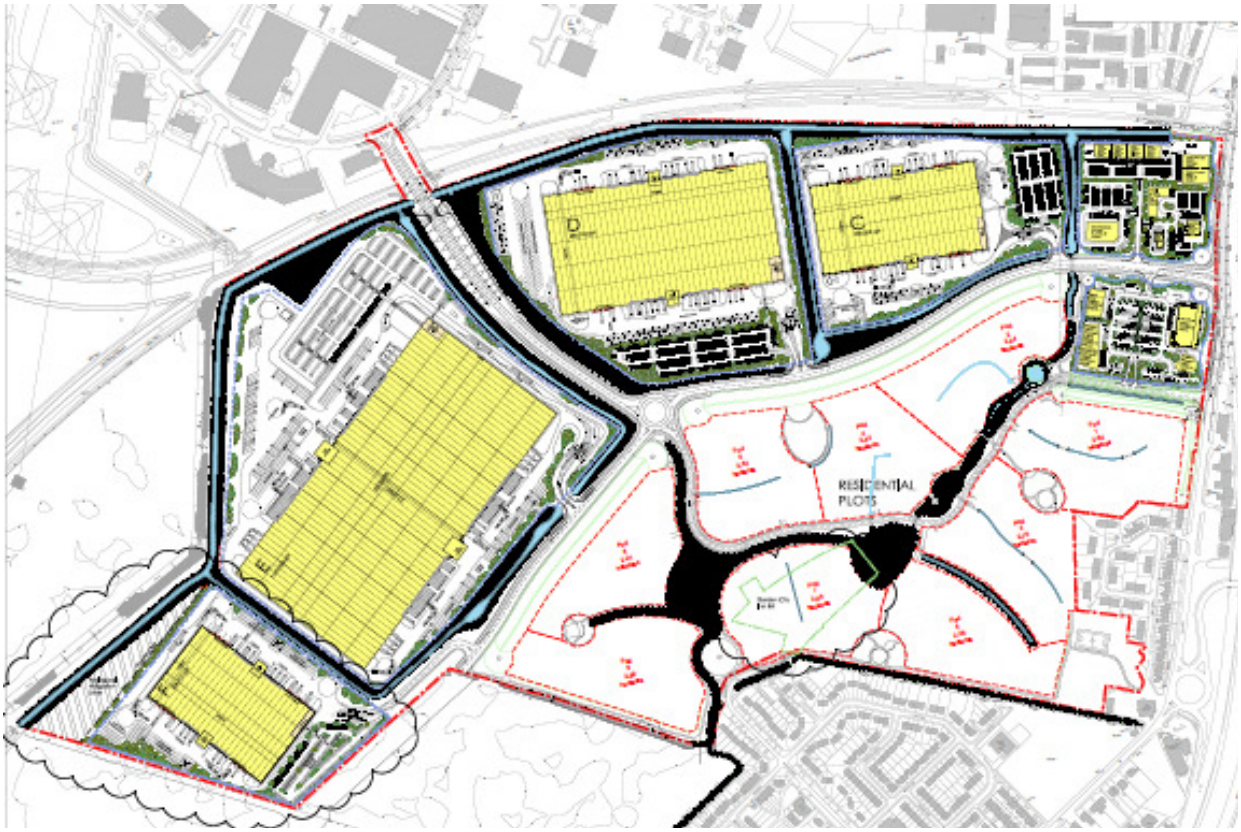
11.2 Intent & Use

This document has been produced in the United Kingdom by MACC International Limited and meets the requirements of CIRIA C681 “Unexploded Ordnance (UXO) – A guide for the Construction Industry” It has been provided solely for the purpose of assessment and evaluation. It is not intended to be used by any person for any purpose other than that specified. Any liability arising out of use by a third party of this document for purposes not wholly connected with the above shall be the responsibility of that party, who shall indemnify MACC International Limited against all claims, costs, damages and losses arising out of such use.

Annex A

SITE MAPPING

Site Map (Site footprint shown in red.)



Annex B

EXPLOSIVE ORDNANCE SAFETY INFORMATION

1 UNEXPLODED ORDNANCE

Since WWII the number of incidents in the UK where EO has detonated has been minimal, though a significant number of bombs have been discovered and safely disposed of without serious consequences. More commonly on mainland Europe (France, Germany and Belgium) incidents have occurred where ground workers have been killed or injured as a result of striking buried UXO or mishandling items of UXO found during excavation and piling work.

The threat to any proposed investigation or development on the site may arise from the effects of a partial or full detonation of a bomb or item of ordnance. The major effects are typically; ground shock, blast, heat and fragmentation. For example the detonation of a 50kg buried bomb could damage brick/concrete structures up to 16m away and unprotected personnel on the surface up to 70m away from the blast. Larger ordnance is obviously more destructive. Table B-1 shows the MOD's recommended safe distance for UXO. However it should be noted that the danger posed by primary and secondary fragmentation may be significantly greater. Almost 60% of civilian casualties sustained in London during the blitz were the result of flying glass.

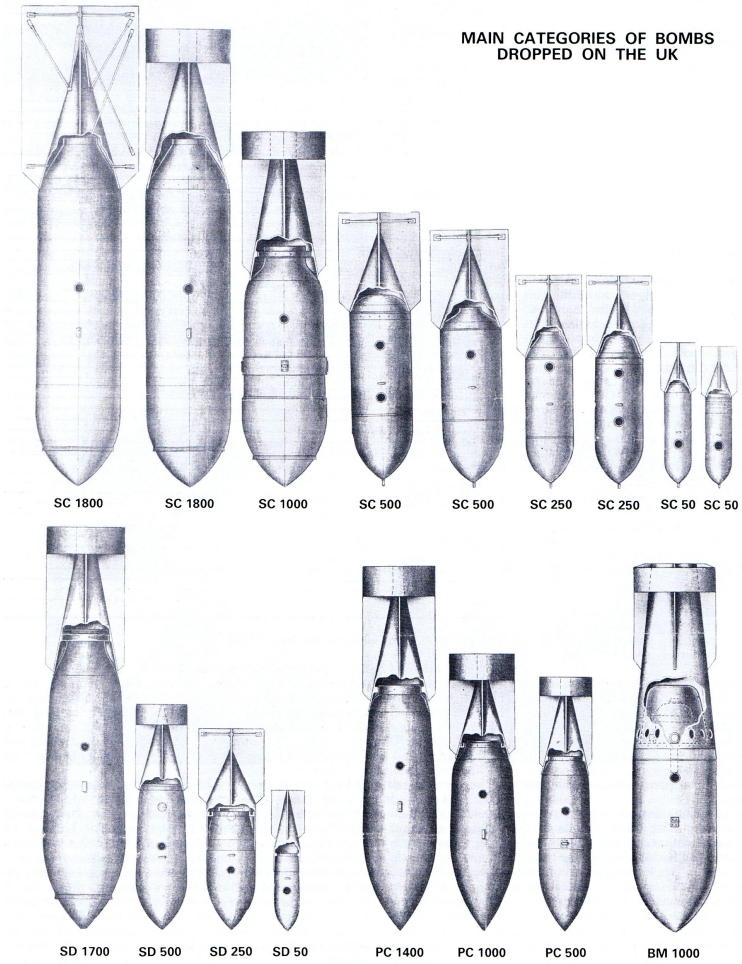
TABLE B-1 SAFETY DISTANCES FOR PERSONNEL

	Safety Distances (m)			
	Surface UXO		Buried UXO	
UXO (Kg)	Protected	Unprotected	Protected	Unprotected
2	20	200	10	20
10	50	400	20	50
50	70	900	40	70
250	185	1100	120	185
500	200	1250	140	200
1000	275	1375	185	275
3000	450	1750	300	450
5000	575	1850	400	575

Explosives rarely become inert or lose effectiveness with age. Over time some explosive materials can become more sensitive and therefore more prone to detonation. This applies equally to items that have been submersed in water or embedded in silt, clay, peat or similar materials.

2 TYPES OF GERMAN AIRDROPPED BOMBS & MINES

2.1 HE Bombs



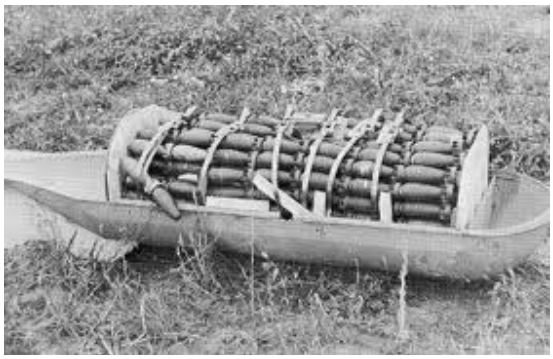
German bombs as found today.

2.2 Incendiary, Anti-Personnel Bombs & Parachute Landmines

1kg incendiary Bomblet (Top as found today)

Flam c500, c250 & c50 Oil Bombs

SD1 Anti-Personnel Bomblets



SD1 Container Bomb

Parachute Mines

3 Methods of Bomb Release

All German bombers could release their bomb load singly, in salvoes or in sticks. The spread of a stick of bombs would vary in length and shape according to the altitude and speed type of the aircraft. A straight stick at regular intervals could only be achieved by straight and level flying during the bombing run.

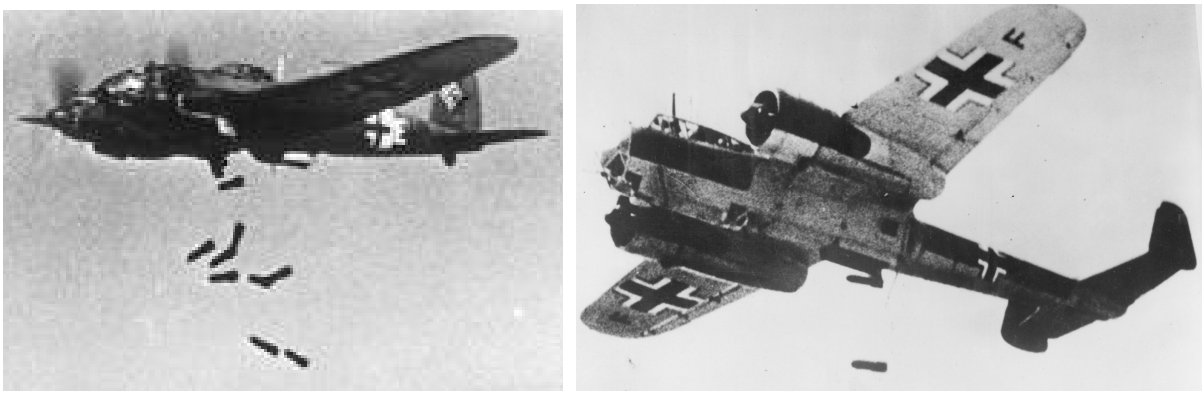
3.1 German Bombers

The following example from the German attack plan for London was issued by the General Officer Commanding 1 Air Corps. It demonstrates the makeup of a typical air raid. The principle German aircraft used to drop bombs on the UK can be seen below

"Flying altitudes for the bomber formations are to be: KG30; 5,000 - 5,500m, KG1; 6,000 - 6.500m and KG76; 5,000 - 5,500m. To stagger heights as above will provide maximum concentration of attacking force. On return flight some loss of altitude is permissible, in order to cross the English coast at approximately 4,000m.

The intention is to complete the operation in a single attack. In the event of units failing to arrive directly over target, other suitable objectives listed in target log may be bombed from altitude of approach.

Bomb loads for the He111 and Ju88 are to be 50kg bombs, 20% incendiaries, 30% delayed-action 2-4 hour and 10-14 hour (the latter without concussion fuses). The Do17 are to carry 25% disintegrating containers of B1, EL and SD 50. Load only to be limited by security of aircraft against enemy flak."

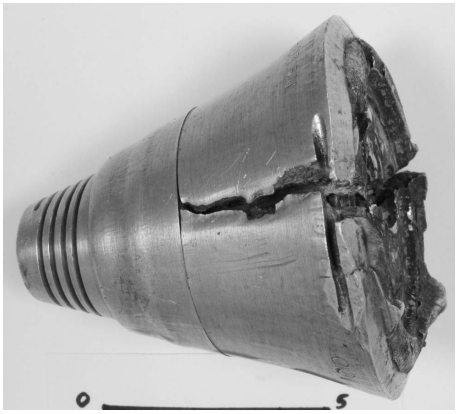


Heinkel He111 (left) capable of carrying 1,500kg of bombs and the Dornier Do17 (right) capable of carrying 1,000kg of bombs

4 British Anti-Aircraft Guns & Rockets

Examples of British Anti-Aircraft Guns and rockets used to defend the UK against German bombing raids can be seen below.

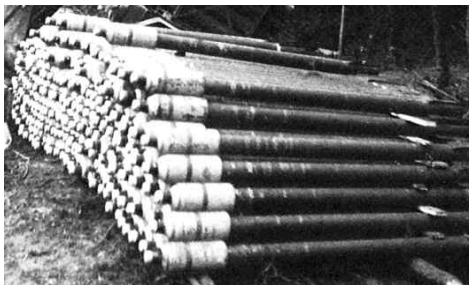




British H993 Gun in Hyde Park 1941. The 3.7" anti-aircraft gun could propel High Explosive and Incendiary shells up to 59,000 feet, higher than the German bomber aircraft could fly.


The 40mm Bofors Gun anti-aircraft gun could propel High Explosive and Incendiary shells up to 41,000 feet.





3.6” anti-aircraft rocket ‘Z’ Battery London 1942