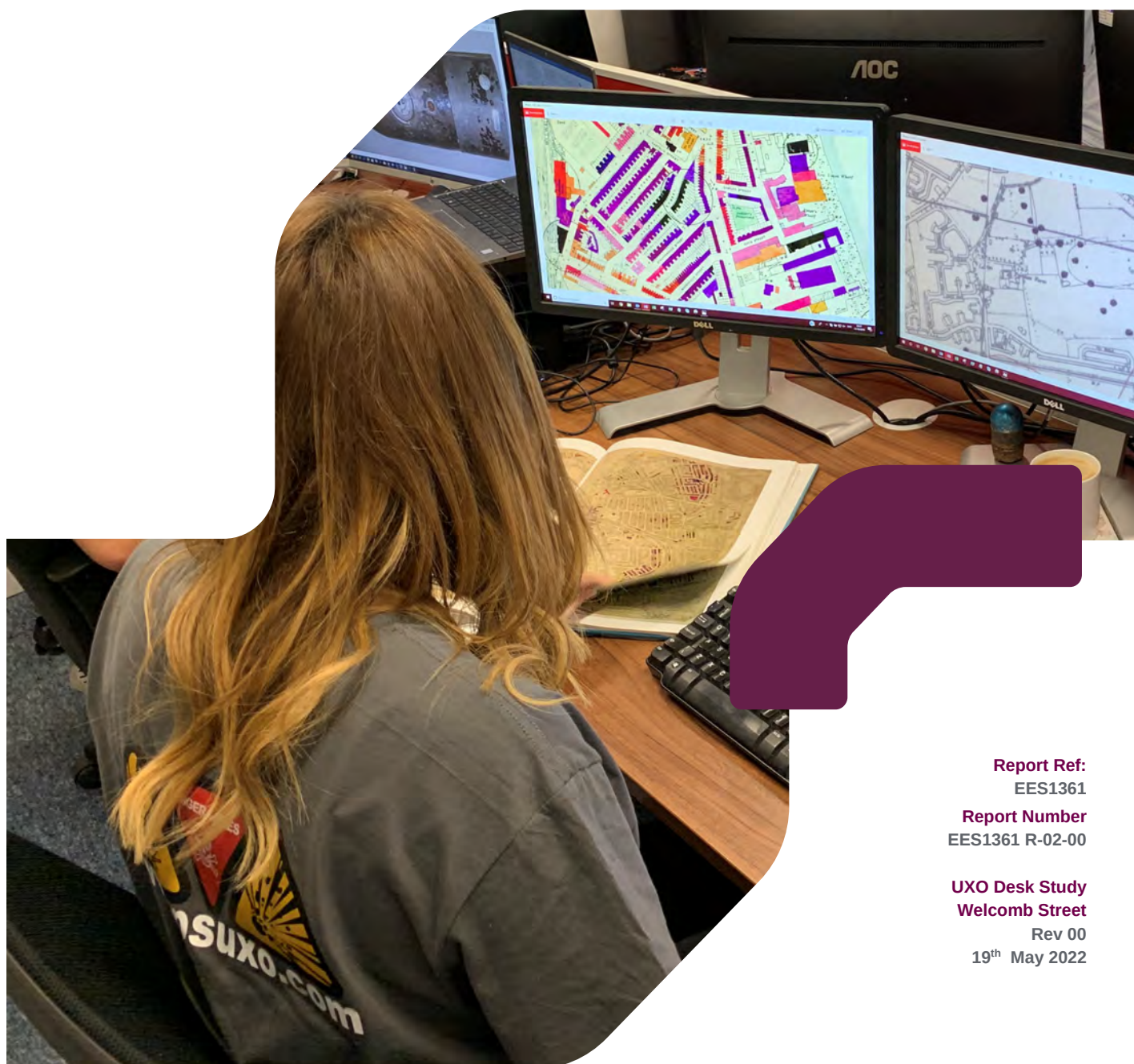


DETAILED DESK STUDY (STAGE 2) FOR POTENTIAL UXO CONTAMINATION, WELCOMB STREET, OPENSHAW

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EXECUTIVE SUMMARY

Summary of UXO DTS

RPS was commissioned to produce an unexploded ordnance (UXO) detailed desktop study for the Welcomb Street, Openshaw project site. This study was conducted in accordance with CIRIA, Unexploded Ordnance (UXO) A guide for the construction industry (C681) and CIRIA, Unexploded Ordnance (UXO) risk management guide for land-based projects (C785).

During its compilation the study collated information of various explosives-based contamination sources known to affect sites within the United Kingdom. This information was integrated to establish the level of risk it posed to the reporting area. Finally, a site-specific risk mitigation solution was developed to ensure that the final risk level was deemed As Low as Reasonably Practicable (ALARP).

The content of the UXO desktop study of the Welcomb Street Area of Interest (AOI) is summarised in the subsequent table.

Table 1. Summary of EES1361 Welcomb Street, UXO DTS

UXO Contamination Source	Relevant Section	Negligible Risk	Low Risk	Moderate Risk	High Risk	Mitigation Solution
Defensive Positions	3.3					n/a
Anti-Aircraft Artillery	3.4					Ap016
Military Training / Presence	3.5					Ap016
Explosives Storage Areas	3.6					n/a
Military Airfield	3.7					Ap016
Bombing Decoy Site	3.8					Ap016
Munitions Production	3.9					n/a
WWI Bombing	4.1					n/a
WWII Bombing	4.2					Ap016

Observations

There is evidence that German bombs were dropped 180m from the site and there were a large number of Heavy Anti-aircraft and Rocket projectile batteries within 5km. However, multiple phases of development and re-development have reduced the potential for the presence of UXO to a **Low** level.

Recommendations for Future Intrusive Works

Based on the assessed risk, the following mitigation is recommended to be implemented in support of works taking place for the project:

All Areas:

- **Explosives Safety & Awareness Briefings / Site Safety Guidelines,**

Full descriptions of each of the mitigation recommendations are presented at *Appendix 016*.

1 INTRODUCTION

1.1 Instruction

RPS Explosives Engineering Services (RPS EES), part of RPS Energy Ltd, has been commissioned by RPS Consulting UK and Ireland to conduct a Stage 2, Detailed Desktop Study for potential Unexploded Ordnance (UXO) contamination for the Welcomb Street, Openshaw Area of Interest (AOI), in line with CIRIA C681 Guidelines, within the boundaries of the project site.

1.2 Scope of Work

The purpose of this Desktop Study is to assess the likelihood of buried historic air-delivered ordnance and / or UXO-related items to be present within the footprint of the Area of Interest (AOI). Moreover, to then evaluate the implications of potential items on any future land use.

The site is considered to offer a potential explosives risk based on the successive sources:

- **Enemy Bombing:** Great Britain sustained widespread aerial attacks throughout historic German air-raids, and as such, there is the potential for aerial-delivered ordnance to have been dropped within the area local to the site.
- **Anti-Aircraft Artillery (AAA) Shells:** Throughout World War II (1939-1945), AAA batteries were utilised in the defence of key strategic positions. If projectiles were fired in the immediate environment of the AOI and failed to function as intended, then it is conceivable that the projectiles could have come to rest within the bounds of the site.

1.3 Definitions

The term 'site' and / or 'Area of Interest' (AOI) refers to the area that encompasses the extent of the works associated with the Welcomb Street AOI. This report will focus on the activities that occurred within the bounds of the site and its immediate environment. A location map is presented at *Appendix 001*, which details the extent of the site. Selected terminology referred to throughout this report is presented at *Appendix 002*.

1.4 Reporting Conditions

It must be emphasised that this detailed Desktop Study can only indicate the potential for UXO-related items to be present on-site, and, dependent on the information identified throughout the desk-based process, further UXO mitigation may be advised / recommended prior to and in support of any future redevelopment and / or works on-site. Any such recommendations are stipulated later in this document.

It should be recognised that any recommendations made may require alteration, or further mitigation may be advised, if information outside of that already documented within the Desk Study subsequently comes to light. This Desk Study did not involve a site visit, or any non-intrusive survey or intrusive site investigation works.

Our appraisal relies on the accuracy of the information contained within the documents consulted; therefore, RPS will in no circumstances be held responsible for the accuracy of such information or data supplied.

Records of air raids, bomb damage, casualties and the locations of Unexploded Bombs (UXB) were rarely released into public domain in the interest of national security and moral, this is particularly pertinent with military establishments. Furthermore, details pertinent to these records are often difficult to locate. The records compiled were only as detailed and accurate as the availability of time, personnel and the ease of

access to information would allow. Densely populated areas, such as those associated with major cities, tended to have a greater number of records than those produced for the more provincial, or rural areas. Official records were often supplemented by press reports and local information. This source of information was sometimes discredited as being inadvertently inaccurate, or purposely made inaccurate, in order to confuse enemy intelligence. Even the accuracy of classified official records is somewhat dubious. This stance has been established based on the quantities of unrecorded German UXO and part-exploded ordnance discovered since 1945.

1.4.1 Archive Limitations

This study consists solely of a desk-based collation and review of accessible official records, relating to the possibility of UXO being present within the project area. Certain information acquired for the purpose of this study may be either classified or restricted material; therefore, summaries of such information have been provided.

1.5 Objectives

The primary objective of this document is to ensure the safety of site personnel and members of the public within the vicinity of the AOI with regards to possible impacts from potential UXO contamination and to identify the potential risk of unearthing either buried UXO or explosive devices. Research into the history of the AOI and its immediate environment has been undertaken to establish the following:

- Frequency and intensity of WWII bombing raids,
- Bomb impacts and associated damage,
- Review of military activities in the area,
- Records of Explosive Ordnance Clearance (EOC) tasks or bomb disposal activities throughout and post-WWII,
- The potential for UXO-related devices to remain on-site,
- Site-specific assessment of the penetration depths of UXO to determine the risk horizon on-site.

The main sources of information consulted are presented at *Appendix 003*.

1.6 Legislation

Whilst undertaking this desk study, the requirements of a number of legislations have been borne in mind, as presented at *Appendix 004*.

2 SITE DETAILS AND DESCRIPTION

2.1 Site Location and Description

The site and its associated Area of Interest (AOI) is located off Welcomb Street within the Openshaw area of Manchester and occupies an irregularly shaped boundary measuring approximately 1.57ha, centred on British NGR SJ 87903 97212. The AOI and surrounding area is characterised by light industrial units of modern construction on three sides, with a large stockyard for the bulk storage of aggregates located immediately to the south. Topographically, the site is flat and consists entirely of made ground; no original natural ground appears to survive within the AOI.

The AOI can be observed in relation to the immediate environment, below in *Figure 001* and at *Appendix 001*.



Figure 001: The AOI (plum outline) in relation to its surrounding environment.

2.2 Proposed Scheme of Work

RPS understand this Detailed (Stage 2) UXO Desktop Study (UXO DTS) is being written to support the development of the AOI through provision of new light industrial units. However, at the time of publication RPS is unaware that the specific processes to be used in the development. RPS understands that breaking ground processes, such as Ground Investigation works, excavation works, trenching, piling works, and installation of roads and buried services are also proposed to take place. It is envisaged that demolition of existing structures will be required.

2.3 Geology

One of the principal factors in the assessment of the maximum ordnance penetration depth is to establish the geological stratigraphy of the site. Ground conditions present will have a significant influence on the

path of ordnance; therefore, the consistency and thickness of pre-WWII made ground should be considered as this would have the potential to restrict the penetration depth. The ordnance penetration calculation will be stipulated later in the document.

At the time of issue, the Client has not provided any geological data for the AOI, Therefore, RPS has reviewed open-source British Geological Survey (BGS) Geology viewer.

The records indicate that the project site consists of superficial Devensian till deposits overlaying Openshaw series sandstone.

No recorded borehole scans for the AOI are held by the BGS data base. The closest detailed borehole (BGS id 937539) was excavated approximately 160m north east of the AOI in 1970. The record indicates that a small amount of made ground was present, overlaying various deposits of clay and sandy clay. The makeup of ground is likely to be similar within the AOI:

Table 2.Open-Source Geological Data

Strata	Depth below ground level
Road setts	9" (0.22m)
Sand, ashes, -Fill	2' (0.6m)
Firm grey/brown mottled sandy and silty clay with stone inclusions	3'6" (0.92m)
Stiff brown sandy clay with stone inclusions	8' (2.43m)
Stiff to very still brown sandy clay with stone inclusions	20' (6m)
Very stiff to hard brown sandy and silty clay with stone inclusions	36' (10.97m)

The data shown above has been used to calculate the maximum bomb penetration for the site (see below).

2.4 Historical Site Conditions

The Client has not disclosed a historical map suite pertinent to the land located within the AOI. Therefore, RPS has studied a number of historical map suites and aerial photographs that were available within the public domain: Google Earth, Heritage England, the National Library of Scotland and National Collection of Aerial Photography (NCAP) websites. The process was undertaken to develop a greater knowledge of the historical alterations experienced within the site boundaries.

The AOI is not well served by historic aerial photography, which is more extensive further south.

A selection of Historic mapping and Aerial images reviewed are presented at *Appendix 005*.

Table 3. Details of open-source historical map suites and aerial photographs.

Date	Map / Photograph	Description of the Area of Interest
1845	Map Lancashire Sheet CIV	The AOI is visible in open ground located between the Manchester to Sheffield Railway, to the south, and the Old Ashton Road to the north. The Manchester and Stockport canal is visible to the east of the AOI. Two ponds are visible within the AOI and others are shown around the surrounding area, suggesting a relatively high water table.
1898-90	Map Lancashire Sheet CIV.SE	Massive industrialisation and urbanisation has taken place and the AOI is now part of the Armstrong-Whitworth engineering works, and elements of two buildings and a network of rails are shown as being within the AOI. Further afield, large amounts of workers housing and heavy industry such as locomotive factories such as Gorton Yard immediately east of the AOI, are shown.
1915-1916 published 1923	Map Lancashire Sheet CIV.SE	Major expansion of the Armstrong-Whitworth works has taken place and the AOI is shown as being almost completely contained within works buildings. The Crossley Gas and Oil motor company is shown west of the AOI, and a Carriage, Wagon and Locomotive Works to the east. The rail network has increased substantially, with a large marshalling yard shown immediately south of the AOI; this later became known as the Ashbury's Sidings and survived the demolition of the Armstrong-Whitworth works in the 1930s. Expansion north and south was restricted by large workers housing estates and the boundary imposed by the Old Ashton Road and railways.
1938	Map Lancashire Sheet CIV.SE	The Armstrong-Whitworth works have been completely demolished and the AOI is devoid of any features. A photograph of 1936 suggests that some upstanding remains from the works may still have been present into the late 1930s but the site was essentially empty brown field. Whilst heavy industry is still present in the surrounding area, several smaller works have been demolished and replaced with housing.
Undated but early 1940s	Luftwaffe Manchester target map pack sheet BB 12 m	Luftwaffe targeting map based on the 1932/1933 revision of the OS map published in 1938. The Armstrong-Whitworth works are still shown, although are labelled as 'Disused'. There is otherwise little significant difference from the 1915-1916 edition. Ironically, the Germans still considered the works to be present for targeting purposes, despite it having been thoroughly demolished well before the outbreak of war.
1948-1955 published 1956	Map SJ89NE	The AOI now forms part of the Crossley New Forge, specifically the south-central portion adjacent to Ashbury's Sidings. The works were built during the war as an extension

Date	Map / Photograph	Description of the Area of Interest
		to the existing Crossley site. Most of the AOI was open ground and the current boundary for the AOI appears to follow the original Crossley New Forge boundary. This is confirmed by examination of the RAF aerial image of the site taken in 1946 (see below)
07 May 1946	Aerial photograph RAF/3G/TUD/UK/185	Aerial image showing the Crossley New Forge and surrounding area. The image confirms the plan of the area depicted on OS mapping. Camouflage paint is visible on the Crossley New Works roof, indicating it was present during WWII. The AOI contains two rectangular buildings which are still present within the AOI today.
04 Jul 1969	Aerial photograph RAF/543/4782	No appreciable change has occurred within the AOI since 1946. The Rail network has atrophied and the Gorton rail depot to the east of the AOI has been completely demolished.
2000-present	Google Earth	The AOI remains part of the Crossley complex until at least 2000. Between 2000 and 2003, a number of small industrial units/workshops are constructed along the southern boundary of the AOI, at least one of which is then demolished between 2009 and 2013. The two rectangular buildings noted above are renovated during this period but remain essentially unchanged.

2.4.1 Post-World War II (1939-1945) Alterations

Through the examination of historical map suites and aerial photographic sources, RPS has established that the AOI was initially part of the Armstrong-Whitworth engineering works. This works was demolished in the mid-1930s, to be replaced during WWII by the Crossley New Forge. The AOI remained as part of the same complex until the early 2000s when it began to be broken up and redeveloped, with a number of light industrial units appearing and disappearing between 2000 and the present day. Much of the AOI appears, therefore, to have undergone several phases of redevelopment which may be regarded as mitigation against the discovery of UXO.

3 BRITISH MILITARY IMPACTS / SOURCES

3.1 General

The successive sections present information identified relevant to the various categories of military positions historically present across the UK (as observed throughout periods of warfare). Additional information relevant to categories of military positions identified can be observed at *Appendix 006*.

3.2 World War I (WWI)

There are no records that indicate that military defensive positions were located within the vicinity of the AOI during WWI. As a producer of ordnance, the Armstrong-Whitworth engineering works may have been patrolled or guarded by troops but RPS consider the potential for the presence of ordnance arising from this source to be **Negligible**.

3.3 World War II (WWII) Defensive Positions

No evidence has come to light to suggest that any World War II (1939 – 1945) defensive positions were present within the AOI, or within 1km of the AOI. The closest recorded defensive positions are recorded as a single pillbox 2.3km south east of the AOI, by the side of the Gorton Upper Reservoir.

Many industrial firms organised their own local defence during WWII by enrolling workers into the Home Guard and facilitating defences. No evidence has been found, however, that any such activity was carried out within the AOI, although occasional patrols of the rail sidings and industrial premises is likely.

Given the distance of this feature from the AOI, RPS understand that the potential to encounter a UXO-related device associated with this source is **Negligible**.

3.4 WII Anti-Aircraft Artillery (AAA) Positions

No evidence has come to light to suggest that an AAA position was active within the AOI or within 2.4km of the AOI. A number of Heavy Anti-Aircraft (HAA) batteries and Rocket Projector batteries (so called Z Batteries) were located within 5km of the AOI and are summarised in the table below.

Ref	Feature	Location	Distance & Direction from the AOI	Possible Impact on AOI?
3.4.1	HAA battery E/-	Levenshulme	2.25km SSE	Possible
3.4.2	HAA battery P/H23	Ashton under Lyne	3.35km E	Possible
3.4.3	HAA battery C/H25	Guide Bridge	4.27km E	No
3.4.4	HAA battery	Brookdale Park	3.3km NE	Possible
3.4.5	HAA battery D / H24 21/11/17	Little Moss	4.62km NE	No
3.4.6	HAA battery	Brookdale	4.31km NNE	No
3.4.7	HAA battery	Moston	5km N	No
3.4.8	HAA battery C/H16	Queens Park	4.3km NW	No
3.4.9	HAA battery R/-	Fallowfield	3.13km SW	Possible
3.4.10	HAA battery R/H-18	Unsworth Park	3.43km SW	Possible
3.4.11	Rocket battery ZH6	Birchfields Park	2.8km SW	Possible
3.4.12	Rocket battery ZH5	Cheetham	4.35km NW	No

RPS attribute a 10% failure rate to munitions that have been fired from AAA batteries throughout WWII; therefore, the potential to unearth projectiles attributed to the identified batteries cannot be discounted.

RPS understand that the potential to encounter a UXO-related device associated with this source, at the AOI, is **Low**.

3.5 Military Presence / Training

There is no indication that the AOI itself was the subject to a Military presence.

A Prisoner of War camp, Mellands Camp, was located approximately 2.4km south of the AOI during WWII but would not represent a UXO risk to the AOI.

There is no evidence to indicate the conducting of Military training took place nearby, although it is possible that regular army or Home Guard units did patrol the area, as a general security measure during the war, although there is no evidence to substantiate this.

3.6 Explosives Storage Areas

Whilst the Armstrong-Whitworth Engineering works and the later Crossley works did engage in military production, no evidence has come to light to indicate that an explosive storage area is located within the AOI.

RPS understand that the potential to encounter a UXO-related device associated with this source, at the AOI, is **Negligible**.

3.7 Military / Royal Air Force (RAF) Airfields

No Royal Air Force airfields were present any closer than 15km to the AOI during WWII and the risk of UXO from this source, within the AOI, is considered **Negligible**.

3.8 Decoy Sites

At the outbreak of WWII, a sophisticated system of decoy sites was deployed across Great Britain with the intention of diverting aerial attacks from major cities, military sites and essential infrastructure. In the event of an imminent air-raid, beacons were ignited at the decoy sites. These were occasionally successful in misleading the Luftwaffe bombers into thinking it was their intended target, with ordnance jettisoned upon open, unoccupied landscapes.

One bombing decoy (Starfish Decoy SF9(h), parent Manchester) was located approximately 4.6km south east of the AOI. The decoy was located on farmland south of Dane Bank but it is unknown if it was particularly successful.

RPS have determined that the potential to encounter a UXO-related device associated with this source, at the AOI, is **Negligible**.

3.9 Munitions Production Facilities

A WWI era explosives factory was located approximately 790m south west of the AOI. H M Factory, M N Morris and Co Ltd, Gorton Brook, West Gorton, was a chemical works which made synthetic phenol, a component of the explosive TNT. A further explosives factory was located 1.7km north of the AOI during WWI (the Clayton Aniline Company). This factory made picric acid, an explosive projectile filling. There is no risk to the AOI from the presence of either of these former facilities.

The AOI forms part of what was once the great weapons manufacturing complex operated by the Armstrong Whitworth Company until the late 1920's, early 1930s. It was there that some of Britain's largest battleship guns were manufactured, including 18-inch guns. Additional products included locomotives, armour and aircraft. Although ordnance formed a significant part of their output, munitions themselves were not manufactured on the site although it is probable inert projectiles were kept on site for gauging purposes. Frustratingly little information is available concerning the operation of the works. Attempts were made to re-purpose the plant away from munitions and aircraft manufacture in 1930 but these were apparently unsuccessful, and the works were thoroughly demolished by 1936¹.

Crossley Brothers, a manufacturer of oil and gas powered engines, opened their works to the west of the AOI in 1882. They remained focussed on the manufacture of engines but branched into motor vehicles in the early 20th century. During WWI, Crossley became a major supplier of military trucks and armoured cars, a business it continued in the post-WWI period. The firm resumed mass manufacture of military vehicles during WWII, and it is believed the Crossley New Forge, built on the site of the former Armstrong-Whitworth works, was built during WWII to facilitate this increased production. It should be noted that limited production of civilian vehicles, such as buses, continued alongside production of military vehicles.

As for the Armstrong-Whitworth works, there are no indications that munitions themselves were manufactured on site. The potential for such devices from this source to be within the AOI, is considered to be **Negligible**.

¹ <https://blog.mechanicallandscapes.com/2019/07/02/518-english-steel-and-manchester/>

4 GERMAN AERIAL BOMBING

Successive sections present the relevant information that has been identified with regard to German Aerial Bombardment of the UK (throughout historic periods of warfare). Additional information pertinent to these periods and the sources of information consulted are presented in the relevant appendices. Basic overviews of the German WWI and WWII bombing campaigns against the UK are presented at *Appendix 007*.

4.1 WWI German Bombing

In the latter phases of World War I (1914-1918), the Luftstreitkräfte utilised zeppelin aircraft and later Gotha G.V. and Zeppelin-Staaken R.VI bombers, to drop payloads of High Explosive (H.E.) and Incendiary Bombs (I.B.) in aerial assaults upon the UK. The majority of air-raid activities were experienced within the counties located on the South and East Coasts and within London; although, a number of isolated incidents have been registered in alternate counties.

There is no evidence to show that Openshaw or the surrounding area were subject to air raids during WWI. Given the lack of evidence of bombing RPS has determined that the potential to encounter a UXO-related device associated with this source, at the AOI, is **Negligible**.

4.2 WWII German Bombing

4.2.1 German Bombing Targets

RPS hold a collection of Luftwaffe aerial photographs and target maps of the UK, including Target maps for the Manchester area. The Openshaw area is visible on one of these target maps, with the former Armstrong-Whitworth works being outlined as a target (see *Appendix 005*). German intelligence had clearly not been updated considering the works had been demolished by 1936. Nevertheless, a large number of engineering and locomotive works were located around the AOI during the war and represent an obvious strategic target for Luftwaffe bombing.

4.2.2 Details of Air-Raids

Classified records, Local Government reports, Air Raid Precaution (ARP) reports and RPS EES archival documents pertinent to local air-raids have been examined. It should be recognised that air-raid records in no way constitute an exhaustive account of the potential air-raids that could have occurred throughout WWII. It should be noted that the ARP records for Warrington do not appear to have survived and the following information has been gathered from centralised data held by the Home Office.

The City of Manchester, its suburbs were subjected to three main phases of aerial attacks. July 1940 until June 1941 saw a year of persistent, occasionally heavy raids, then until August 1942 the area saw a period of much lighter and more intermittent attacks, after which a long period of inactivity was broken by a single attack using aircraft delivered V1 rockets on Christmas Eve 1944.

The first air raid on the Manchester area occurred on the night of the 20th of June 1940, The target being Accrington. In total the Manchester Area was subject to 314 air raids between 1940 and 1945. The worst being the 'Manchester Blitz' over the period 22nd – 24th December 1940 when 149 aircraft of Luftflotte 3 and 121 aircraft of Luftflotte 2 dropped 272 tons of high-explosive bombs and 37,152 incendiaries across the city and its suburbs.

Manchester Archives holds copies of maps annotated during WWII to show where bombs impacted. The map of Openshaw and Gorton for 1940 to 1941 indicates that two incendiary bombs fell within the perimeter

UXO DETAILED DESKTOP STUDY – WELCOMB STREET, OPENSHAW

of the former Armstrong-Whitworth works between 22 and 24 December 1940 i.e. as part of the Manchester Blitz; neither fell within the AOI but did fall 180m to the east of the AOI.

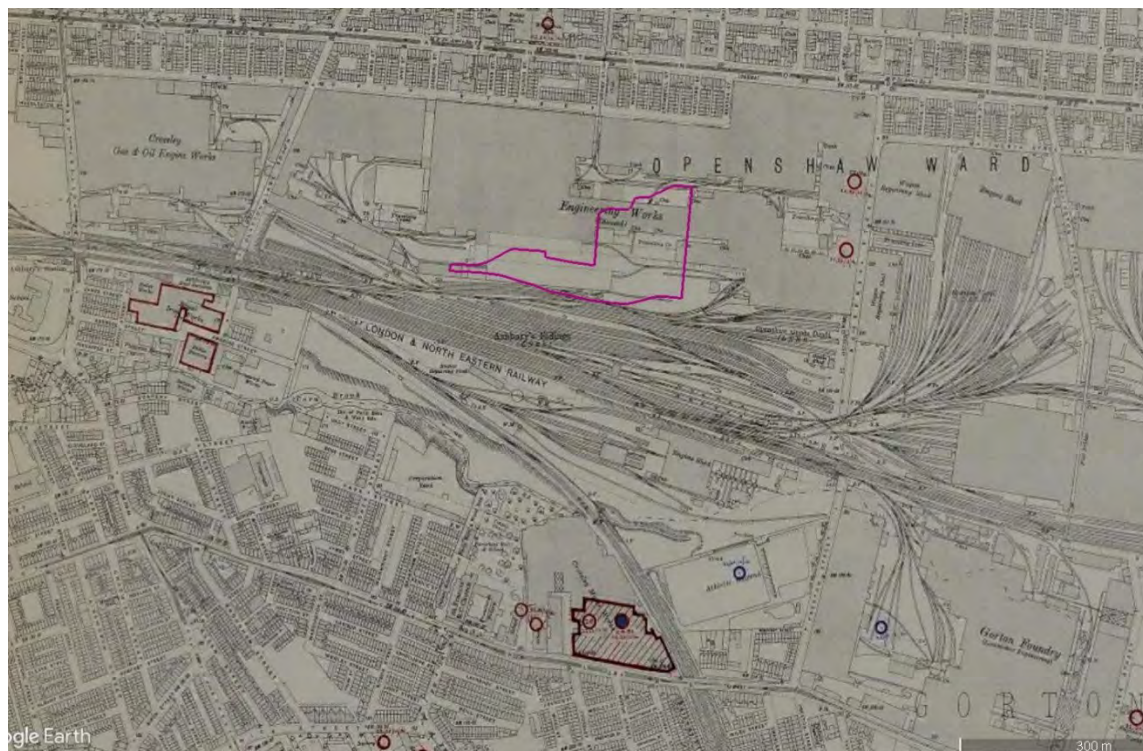


Figure 2. Overlay of bomb impacts in Openshaw and Gorton 1940-1941 (Manchester Archives). Red circles are incendiary bombs, blue are High Explosive. Red outlined buildings were damaged/destroyed.

Openshaw was within the central Manchester Air Raid Precaution (ARP) reporting area and experienced a bomb density of 27.1 bombs per 1000 acres, a relatively low density when considering the density of heavy industry targets located in the city. This is much lower than that of Liverpool, with a density of 91.5 bombs per acre. This relatively low number is borne out from the bomb census data held by the Manchester Archive, which shows remarkably few impacts in and around the AOI. The bombing statistics are presented in *Table 5* below. Select raids of interest identified and relevant bomb census maps have been documented in *Appendix 008*.

Table 4 Manchester bombing statistics

ARP Region	Administrative Area	Land Area		Totals of Ordnance Recorded									Ordnance Density	
		Acres	Hectares	HE Bombs	Parachute Mine	Oil Bombs	Phosphorous Bombs	Incendiaries	Fire Pots	V1 Rockets	V2	Total	Per 1,000 Acres	Per 100 ha
10	Liverpool	27321	11065	2332	117	50						2499	91.5	22.6
10	Manchester	27255	11038	712	18	7				1		738	27.1	6.7
10	Oldham	4735	1918	25	1					1		27	5.7	1.4

Other bombs fell in the surrounding area but are not particularly concentrated. Only three of the bombs within the immediate area were High Explosive (targeting the Crossley works in Gorton, south of the rail line); the remainder were all incendiary bombs. Interestingly, although the local authority records indicate the presence of incendiaries, this is not reflected in the Home Office statistics, highlighting the inaccuracies or inconsistencies for such wartime data.

Although the AOI during this period was considered a target by the Luftwaffe target maps, there is no evidence to suggest the AOI was deliberately bombed; rather the impacts which occurred appear to be rather random and are certainly not indicative of targeted attacks on the works. Given the low density of bombing, RPS has determined that the potential to encounter a UXO-related device associated with this source, within the AOI, is **Low**.

4.3 Reports of UXO

RPS have examined media sources and our records for UXO-related incidents within the Welcomb Street area. No records relating to the discovery of UXO have been found.

5 POTENTIAL ORDNANCE DETAILS

Based on the information gleaned at this juncture, RPS consider that the subsequent categories of ordnance have the potential to have been utilised on-site, or within its immediate environment.

- **German High Explosive Aerial Delivered Bombs:** Description and examples are presented at *Appendix 009*,
- **German Aerial Delivered Bomblets:** Description and examples are presented at *Appendix 010*,
- **British Anti-Aircraft Artillery Shells / Projectiles:** Description and examples are presented at *Appendix 011*.

6 RISK HORIZON

6.1 General

The risk horizon at a site will depend on the expected categories of ordnance to be encountered and the manner in which they may have been deposited at the site. The subsequent diagram provides a basic simplified overview of the 'zones' within the ground where alternate classifications of ordnance may typically be encountered at onshore sites within the UK:

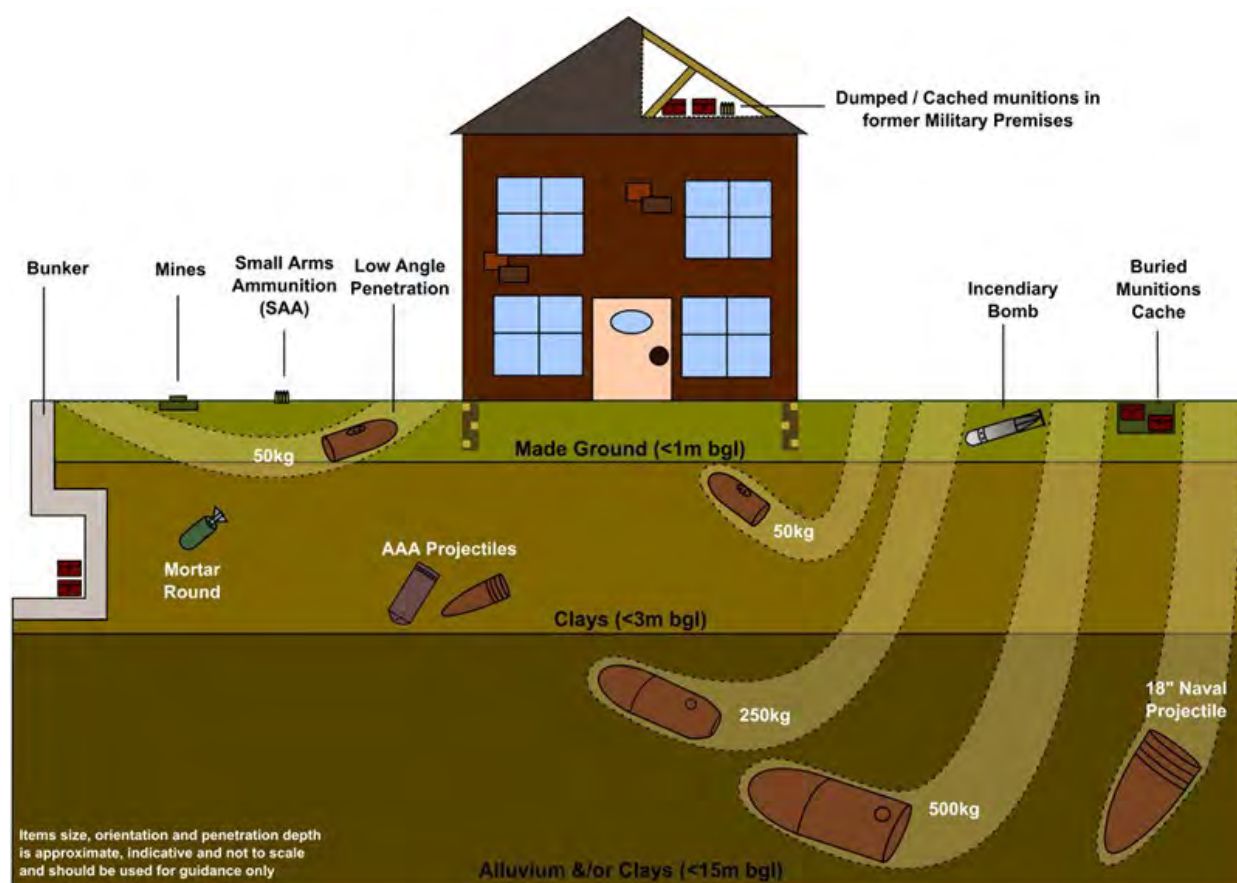


Figure 003: Penetration depth of select ordnance

6.2 Site Specific Ordnance Penetration Assessment

RPS typically assesses the bomb penetration for a site based on the typical penetration depths for a 500kg German Sprengbombe Cylindrisch (SC) bomb. When assessing the potential for ordnance ground penetration, it is essential not to rely solely on either an empirical, statistical or arithmetical formula. Experience has shown that a realistic depth is determined through the consideration of the above approaches, supplemented by accounts of Bomb Disposal Tasks.

It should be acknowledged that the bomb penetration at the site would have been significantly deeper for bombs larger than this; however, comparatively, only a limited number of devices in excess of 500 kg were utilised throughout WWII Luftwaffe bombing campaigns.

Background information on Bomb Penetration Depths can be observed at *Appendix 012*.

6.2.1 General Purpose/High Explosive (H.E) Bombs

As alluded to in *Section 2.3*, one of the most important factors in the assessment of the maximum ordnance penetration depth is to establish the geological stratigraphy present within the bounds of the AOI.

RPS has reviewed open-source geotechnical information with regards to depths of strata in close proximity to the AOI; as such, RPS has determined a maximum site-specific bomb penetration for a 500kg HE bomb of 10m below ground level depending upon thickness of each of the previously detailed strata.

Penetration depths detailed relate to the depths below ground level at the time of WWII and do not account for basement levels, which can retard penetration. If levels have experienced significant variation post-WWII, this could have an effect on the possible depths at which UXO-related items could be present, relative to current ground levels in the area of the site.

7 REGULATORY AUTHORITY DATA

7.1 MoD Explosive Ordnance Disposal (EOD) Archives

Historically, RPS has received a response that states the archives are unable to respond to requests until further notice.

RPS has been advised that an official Freedom of Information (FOI) request should be made in order to attain the information at this juncture through the overarching MoD Information Rights Team.

At the time of issue, RPS has outstanding FOI requests issued to the MoD through the overarching MoD Information Rights Team. RPS has a limited database of historic Explosive Ordnance Clearance (EOC) tasks conducted within the UK by the MoD. A review of this database indicates that there are no recorded EOC tasking within the AOI or its wider area.

At the time of this reports publication no Freedom of Information (FOI) has been made to the MoD in order to understand any EOD activities undertaken within the site boundaries.

7.2 Abandoned Bomb Register

RPS has been provided with a database held by the Home Office, which details the abandoned bombs that are located throughout the UK. The list has been collated from various sources and details items that have been abandoned, but importantly, also those that have since been removed.

Having consulted the database, it is evident that no records exist within the site boundaries, however, there are a number recorded in the wider area. Although these abandoned bombs do not pose a direct hazard to the AOI they do show the presence of air dropped weapons or unexploded Anti-aircraft projectiles used in proximity to the AOI and are detailed below for completeness.

8 UXO CONTAMINATION RISK ASSESSMENT

8.1 General

Risk assessment is a formalised process to access the level of risk associated with a particular situation or action. It involves the identification of the hazards present and the potential receptor that could be affected by this hazard. The degree of risk is associated with the potential for a pathway to be present that links the hazard to the receptor. This relationship is usually summarised as the Source – Pathway – Receptor.

8.1.1 Unexploded Ordnance Detonation Characteristics

Since the conclusion of WWII, there have been a limited number of recorded incidents in the UK where items of ordnance have detonated during engineering works; however, significant quantities of ordnance have been unearthed. Information and discussion pertinent to the UXO detonation characteristics can be observed at *Appendix 013*.

8.2 Sources / Hazards

Previous sections of this report have specified a number of activities that are known to have occurred on/around the site. The subsequent sections will assess if they have the potential to cause significant explosive ordnance contamination.

Table 5. Source of contamination

Source of Contamination	Contaminate
German Bombing	High Explosive (H.E) Bombs
	Incendiary Bomblets
British Anti-Aircraft Artillery	Primarily 40mm, 3", 3.7", 4.5" and 6" Projectiles

8.3 Pathway

The pathway is described as the route as to which the hazard reaches the site personnel. Given the nature of the site and the proposed developments, the only pathways would be through:

- Enabling Works,
- Intrusive Site Works (site investigations, trenching etc.),
- Excavations.

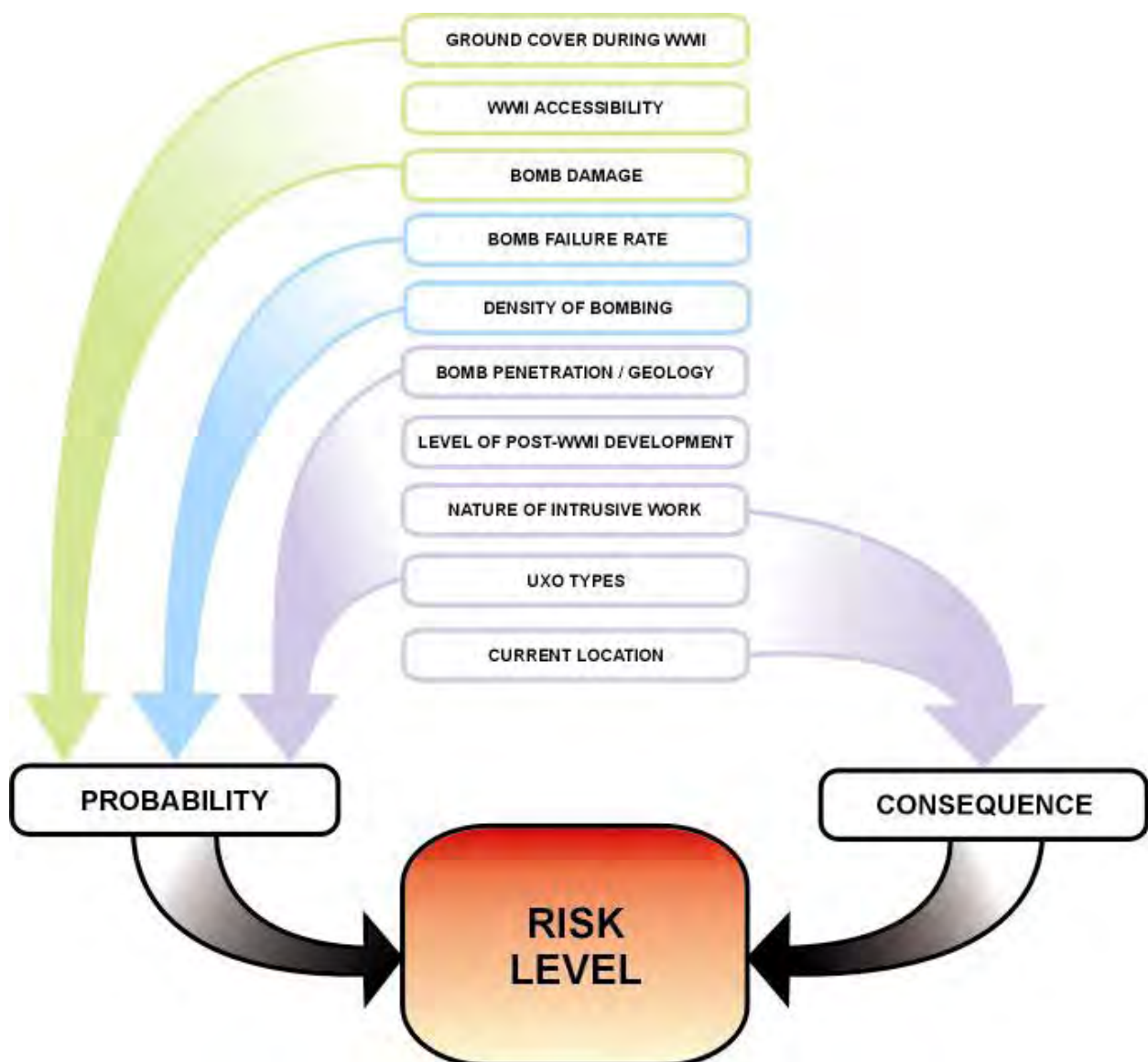
8.5 Receptors

Sensitive receptors applicable to this site would be:

- People (Site Personnel, Construction Works, and General Public),
- Plant and Equipment,
- Structures (Including existing buildings and nearby properties),
- Environment.

8.6 Risk Assessment

The successive sections contain the risk assessment for the site, prior to the implementation of any risk mitigation measures. For the risk to be properly defined, several factors have to be taken into consideration including the consequences of initiation and the probability of encountering UXO at the site. The technique used to assess the level of risk is detailed in the diagram below:



8.6.1 Risk Assessment Matrix

In order to identify an appropriate risk mitigation strategy for the proposed works, it is now necessary to complete a semi-quantitative assessment of the identified risks.

Once the factors detailed above have been assessed for the site, the consequence level is obtained from the table presented in *Appendix 014*, which provides a consequence rating from 1 to 5, depending upon the severity. The probability is also deduced and given a rating between 'Improbable' and 'Almost Certain'. These two ratings are then combined to determine the final risk levels to the proposed site works from the various threat items, using the risk matrix in *Appendix 014*, taking into consideration the potential UXO threat items as detailed earlier.

Within *Table 6* is the risk assessment for the site, prior to the implementation of any risk mitigation measures:

Table 6. Risk assessment matrix (*see Appendix 014 for assessment scheme)

Contaminate	Hazard	Potential Pathway	Potential Sensitive Receptors	Probability of Encounter*	Consequence of Initiation*	Final Risk Level		
German	Incendiary Bombs (excluding 2kg with Explosive Nose)	Heat	Surface Activities	Enabling Works	Site Personnel, General Public, Engineering Equipment, Existing Buildings & Infrastructure, Environment.	1	3	L
			Intrusive Activities	Excavations		2	3	L
				Piling/ Boreholes		2	3	L
	HE Bombs	Blast, Fragmentation	Surface Activities	Enabling Works	Site Personnel, General Public, Engineering Equipment, Existing Buildings & Infrastructure, Environment.	1	5	L
			Intrusive Activities	Excavations		2	4	M
				Piling/ Boreholes		2	4	M
British	AAA Rounds	Blast, Fragmentation	Surface Activities	Enabling Works	Site Personnel, General Public, Engineering Equipment, Existing Buildings & Infrastructure, Environment.	1	3	L
			Intrusive Activities	Excavations		2	3	L
				Piling/ Boreholes		2	3	L

KEY:

N: Negligible

L: Low

M: Moderate

H: High

8.7 Risk Assessment Analysis

WWI Bombing: Although the UK experienced a number of air-raids between the 31st of May (1915) and the 20th of May (1918). RPS has seen no evidence to indicate the AOI experienced any bomb strikes associated with an air-raid in WWI. Therefore, RPS have determined that the potential to encounter a UXO-related device associated with this source, is **Negligible**.

WWII Bombing: Documentary evidence indicates that two incendiary bombs fell within 180m of the AOI during the Manchester Blitz of 22-24 December 1940. The bombing density for Manchester is relatively low and mapping indicates there was actually no viable target within the AOI at the start of the war. Furthermore, the construction of the Crossley New Forge on the site is likely to have proceeded only after a check for the presence of UXO and subsequent post-WWII redevelopment is likely to represent further significant mitigation against the presence of UXO. Nevertheless, much of the site was brownfield during the early part of the war and would have been subject to less stringent checks for UXO following air raids. There is, therefore, a limited possibility that air dropped ordnance might be found within the AOI and RPS have determined that the likelihood to encounter a UXO-related device associated with this source, is **Low**.

Anti-Aircraft Artillery (AAA): No AAA batteries have been identified within the AOI but 12 HAA and rocket projectile batteries are recorded within 5km of the AOI. As for air dropped bombs, the potential for encountering UXO Anti-aircraft projectiles is considered to be limited but cannot be completely eliminated. As a result, However, the presence of an abandoned Anti-aircraft projectile within 2.2km of the AOI means that as for bombs, the possibility of the presence of an unexploded projectile cannot be completely eliminated, and RPS has assessed the likelihood of encountering UXO from this source as **Low**.

8.7.1 Final Risk Level(s)

RPS was commissioned to produce an unexploded ordnance (UXO) detailed desktop study for the Welcomb Street project site. This study was conducted in accordance with CIRIA, Unexploded ordnance (UXO) A guide for the construction industry (C681) and CIRIA, Unexploded Ordnance (UXO) risk management guide for land-based projects (C785).

During its compilation the study collated information of various explosives-based contamination sources known to affect sites within the United Kingdom. This information was integrated to establish the level of risk it posed to the reporting area. Finally, a site-specific risk mitigation solution was developed to ensure that the final risk level was deemed As Low as Reasonably Practicable (ALARP).

The content of the UXO desktop study of the AOI is summarised in the subsequent table.

Table 7. Summary of EES1361 Welcomb Street UXO DTS

UXO Contamination Source	Relevant Section	Negligible Risk	Low Risk	Moderate Risk	High Risk	Mitigation Solution
Defensive Positions	3.3					n/a
Anti-Aircraft Artillery	3.4					Ap016
Military Training / Presence	3.5					Ap016
Explosives Storage Areas	3.6					n/a
Military Airfield	3.7					Ap016
Bombing Decoy Site	3.8					Ap016
Munitions Production	3.9					n/a

UXO DETAILED DESKTOP STUDY – WELCOMB STREET, OPENSHAW

WWI Bombing	4.1					<i>n/a</i>
WWII Bombing	4.2					<i>Ap016</i>

8.7.1.1 Observations

There is evidence that German bombs were dropped 180m from the site and there were a large number of Heavy Anti-aircraft and Rocket projectile batteries within 5km. However, multiple phases of development and re-development have reduced the potential for the presence of UXO to a **Low** level.

9 RECOMMENDATIONS

9.1 The 'ALARP' Principle

Based on the aforementioned risk assessment, RPS has found there to be a **Low** UXO risk from British anti-aircraft projectiles and German airdropped weapons generally across the AOI.

On sites where a UXO-related risk has been identified, an aim must be to mitigate the UXO risk to As Low as Is Reasonably Practicable (ALARP) considering safety and cost vs. benefit. Further detail and diagrammatic representations of the ALARP principles are presented at *Appendix 015*.

Based on the assessed risk, the following mitigation is recommended to be implemented in support of works taking place across the entire site:

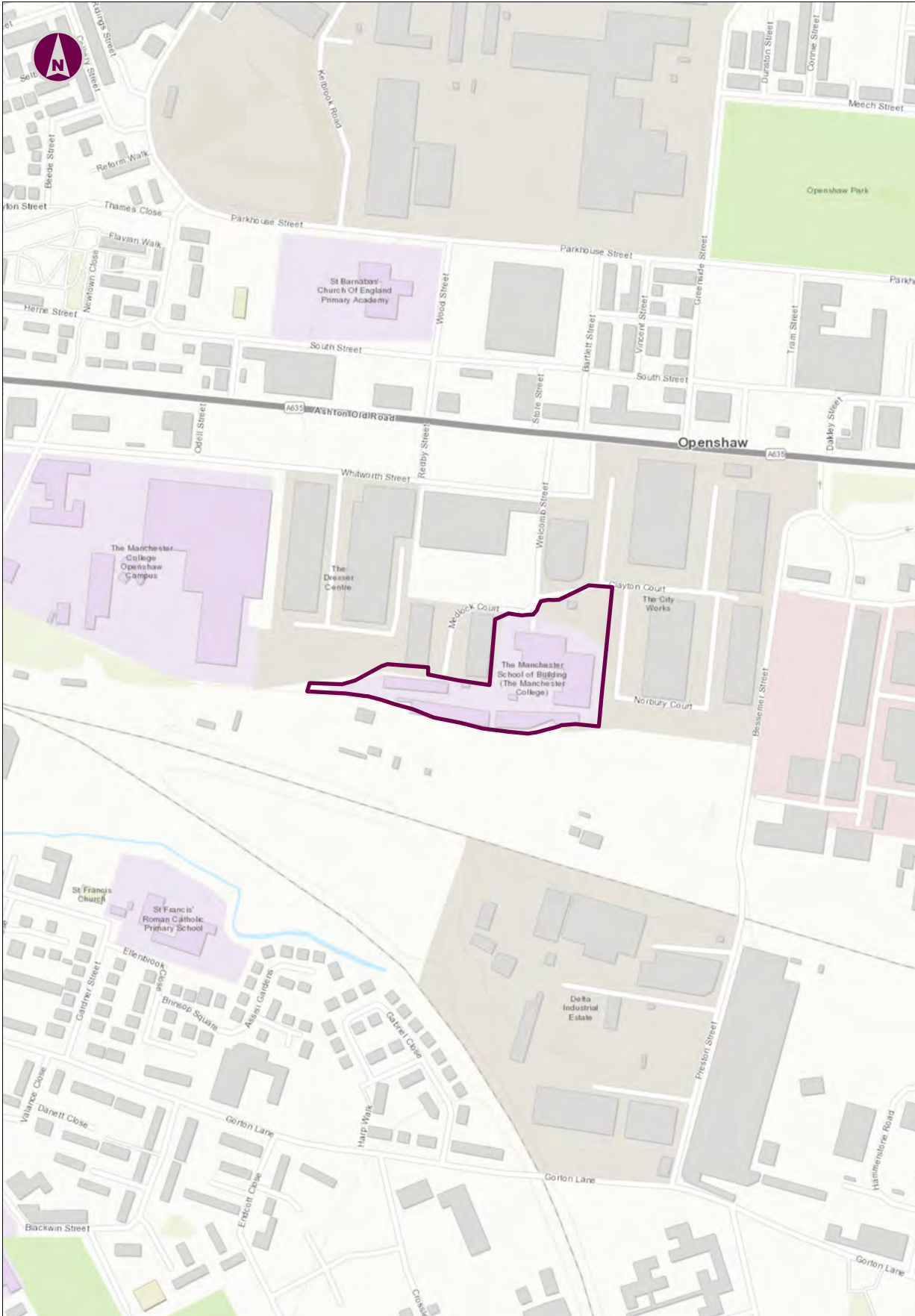
- **Explosives Safety & Awareness Briefings / Site Safety Guidelines,**

Full descriptions of each of the mitigation recommendations are presented at *Appendix 016*.

APPENDICES

Appendix 001

Site Location Map



02550100150200250300Meters

01002004006008001,000Feet

00	INITIAL ISSUE	NG	JC	18/05/22
Ver	Description	By	Check	Date

Figure Number

Rev

Page

EES1361-F-001

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1 of 1

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Geodetic Information:

CRS: British National Grid, Datum: OSGB 1936

EPSG Code: 27700

Client

Network Space

Project

Welcomb Street and Winwick Road Desk Studies

Title

Welcomb Street Site Location

Project Number

EES1361

Scale @ A3

1:5,000

Drawn By

NG

Checked By

JC

Status

INITIAL ISSUE

Date Created

18/05/22

Service Layer Credits: World Imagery: Maxar, Microsoft

World Topographic Map: Esri UK, Esri, HERE, Garmin, GeoTechnologies, Inc., USGS

World Topographic Map: Esri UK, Esri, HERE, Garmin, GeoTechnologies, Inc., USGS, METI/NASA, NGA

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4. Not to be used for Navigation.
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Appendix 002

Terminology

Terminology

Explosive Ordnance Disposal (EOD) - The detection, identification, evaluation, rendering safe, recovery and disposal of UXO.

Fuze- A designed and manufactured mechanism to activate munitions. It can be designed for use by electrical, chemical or mechanical systems, by push, pull, pressure, release and time activation, singly or in combination. Usually consists of an igniter and detonator.

High Explosive (HE) - An explosive that normally detonates rather than burns; that is, the rate of detonation exceeds the velocity of sound.

Initiation - A physical process that sets in motion a cascade of chemical reactions of ever increasing energy (the explosive chain) that will eventually generate sufficient energy (the velocity of detonation) to allow the main charge to detonate in a violent, explosive chemical reaction, releasing energy in the form of heat and blast.

Unexploded Bomb (UXB) -The term UXB refers to any WWII aerial-delivered unexploded bomb, torpedo, projectile or mine consisting of a complete ferrous casing (without tailfins) weighing 50kg or greater.

Unexploded Ordnance (UXO) - Explosive Ordnance that has been primed, fuzed, armed or otherwise prepared for action, and which has been fired, dropped, launched, projected or placed in such a manner as to constitute a threat to the safety and/or security of people, animals, property or material and remains unexploded either by malfunction or design or for any other reason.

UXO Contamination - UXO that is present, within any given physical context that is considered to be an impediment to the safe on-going or intended use of a facility, including geological features. Safety in this instance is measured against an acceptable level of exposure to the potential risks that UXO present.

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Appendix 002: Terminology



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Glossary

AAA	Anti-Aircraft Artillery
Allied Forces	The Allies of World War II were the countries officially opposed to the Axis powers during the Second World War
ARP	Air-raid Precautions
BD	Bomb Disposal (historic term for EOD)
BDO	Bomb Disposal Officer
bgl	Below Ground Level
EOC	Explosive Ordnance Clearance
EOD	Explosive Ordnance Disposal
FP	Fire Pot (Incendiary bomb)
HE	High Explosive
IB	Incendiary Bomb
Kg	Kilogram
LSA	Land Service Ammunition
Luftwaffe	German Air Force
mbgl	Metres Below Ground Level
MoD	Ministry of Defence
OB	Oil Bomb
PM	Parachute Mine
RAF	Royal Air Force
RPS	RPS Group Plc
SC	Sprengbombe-Cylindrisch, thin cased General Purpose Bomb
SD	Sprengbombe-Dickwandig, Semi-Armour-Piercing Fragmentation Bomb
SI	Site Investigation
Sqm	Square Metres
USAAF	United States Army Air Forces
UXB	Unexploded Bomb
UXO	Unexploded Ordnance
WWI	First World War (1914 -1918)
WWII	Second World War (1939 – 1945)

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Appendix 002: Terminology



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Appendix 003

Sources of Information

Sources of Information

- RPS related site records.
- RPS Company records.
- Central and Local Government records.
- National Archives.
- Historic maps, photographs and records.
- Internet Research.

Supplemental Sources of Historical Information Consulted

The following additional sources were consulted for general background information:

- **Fleischer, W (2003)** German Air Dropped Weapons to 1945. Midland Publishing and Stephen Thompson Associates
- **Morris J (1993)** German Air Raids on Britain 1914-1918. Naval & Military Press
- **Fegan T (2002)** The 'Baby Killers. Pen and Sword military publishing
- **Dobson, C (2001)** AA Command, Britain's Anti-Aircraft Defences of the Second World War. Methuen.
- **Dobson C (2000)** Fields of Deception, Britain's Bombing Decoys of World War 2. Methuen.
- **Ramsey, W.G. (1988)** The Blitz Then and Now, Volumes 1, 2 & 3. Battle of Britain Prints International Limited

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Appendix 003: Sources of Information



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Specific Internet Sources

- British Geological Survey Map viewers - British Geological Survey (bgs.ac.uk)
- National library of Scotland
- Britain from Above
- National Collection of Aerial Photographs
- Manchester Archive

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Appendix 003: Sources of Information



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Appendix 004

Legislation

Whilst undertaking this desk study the requirements of a number of legislations has been borne in mind, as presented following:

- Explosive Regulations 2014
- Manufacture and Storage of Explosives Act 2005.
- Health & Safety at Work etc Act 1974.
- Construction (Design & Management) Regulations 2015.
- Control of Substances Hazardous to Health (COSHH) Regulations 2002.
- Personal Protective Equipment at Work Regulations 1992.

The Manufacture and Storage of Explosives Act 2005 does not specifically relate to UXO, but rather to the safety procedures and requirements associated with the storage and manufacturing of items containing explosive compounds. Even though this legislation is not directly applicable to site works where UXO may be encountered, there are several pertinent points which may be borne in mind when undertaking works on sites which pose a risk from encountering UXO, for example:

Disposal of explosives and decontamination of explosive-contaminated items

- Any person who disposes of explosives shall ensure, so far as is reasonably practicable, that they are disposed of safely.
- Any person who decontaminates explosive-contaminated items shall ensure, so far as is reasonably practicable, that they are decontaminated safely.
- No person shall store explosives unless he holds a licence for their storage and complies with the conditions of that licence.

These points just reinforce that when a significant risk from UXO is identified on a site, it is essential for proper procedures to be put in place and in higher risk scenarios for trained Explosives Safety Personnel to be present on site to mitigate the risks, and be on hand to handle the situation in the event of a suspicious item / UXO discovery.

The Reporting of Injuries, Diseases and Dangerous Occurrences Regulations 1995 (RIDDOR), place a legal duty on:

- employers;
- self-employed people;
- people in control of premises;

To report work-related deaths, major injuries or over-three-day injuries, work related diseases, and dangerous occurrences (near miss accidents).

These regulations do not directly apply to UXO, but under the RIDDOR legislation it is stated that as an employer, a person who is self-employed, or someone in control of work premises you must report "*dangerous occurrences - where something happens that does not result in an injury, but could have done*". As such, where a site has been shown to present a risk from UXO this legislation should be borne in mind if an eventuality occurs where an item of UXO is uncovered.

Although the Health & Safety at Work etc Act 1974 and the Construction (Design & Management) Regulations 2015 do not specifically require a search for unexploded ordnance, there is an obligation on those responsible for intrusive works to ensure that comprehensive assessment and risk mitigation measures are taken with regard to all underground hazards on site.

The Health & Safety at Work etc Act 1974 - Section 3, states:

1. *It shall be the duty of every employer to conduct his undertaking in such a way as to ensure, so far as is reasonably practicable, that persons not in his employment who may be affected thereby are not thereby exposed to risks to their health or safety.*
2. *It shall be the duty of every self-employed person to conduct his undertaking in such a way as to ensure, so far as is reasonably practicable, that he and other persons (not being his employees) who may be affected thereby are not thereby exposed to risks to their health or safety.*
3. *In such cases as may be prescribed, it shall be the duty of every employer and every self-employed person, in the prescribed circumstances and in the prescribed manner, to give to persons (not being his employees) who may be affected by the way in which he conducts his undertaking the prescribed information about such aspects of the way in which he conducts his undertaking as might affect their health or safety.*

Construction (Design & Management) Regulations 2015 - Regulation 10 states:

- (2) *The pre-construction information shall consist of all the information in the client's possession (or which is reasonably obtainable), including –*
- (a) Any information about or affecting the site or the construction works.

In addition to the above, the importance of adhering to safe systems of work should also be borne in mind, and explosives and their residues may have an implication concerning PPE requirements and COSHH.

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Appendix 004: Legislation



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Appendix 005

Historical Aerial Photographs



Location of AOI, (plum outline)

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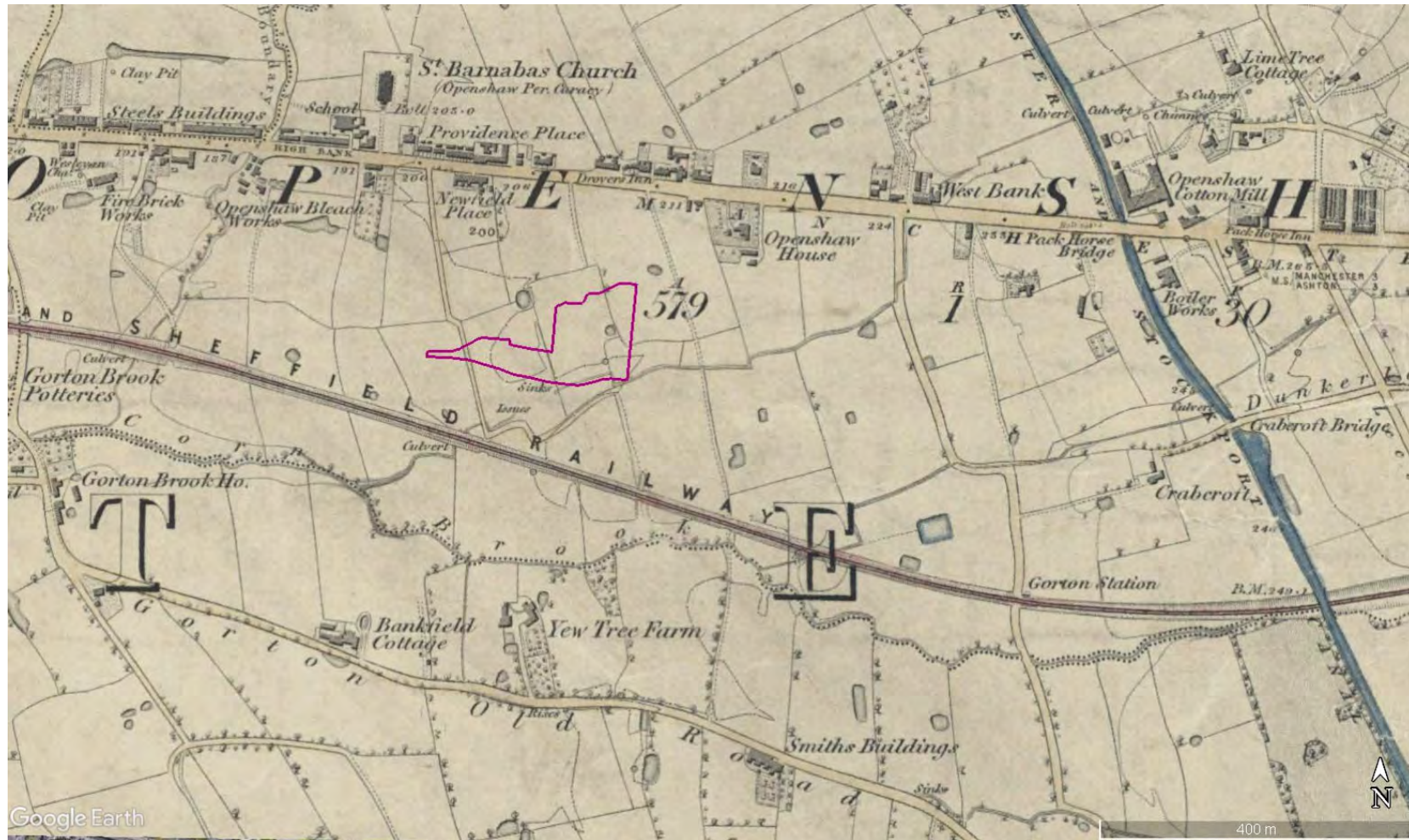
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Appendix 005: Historic Map Suite / Aerial Imagery

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Overlay of the 1845s OS map showing the AOI (plumb outline) as open ground located between the Manchester and Sheffield rail line and the Ashton Old Road. The Manchester and Stockport canal is clearly visible to the east

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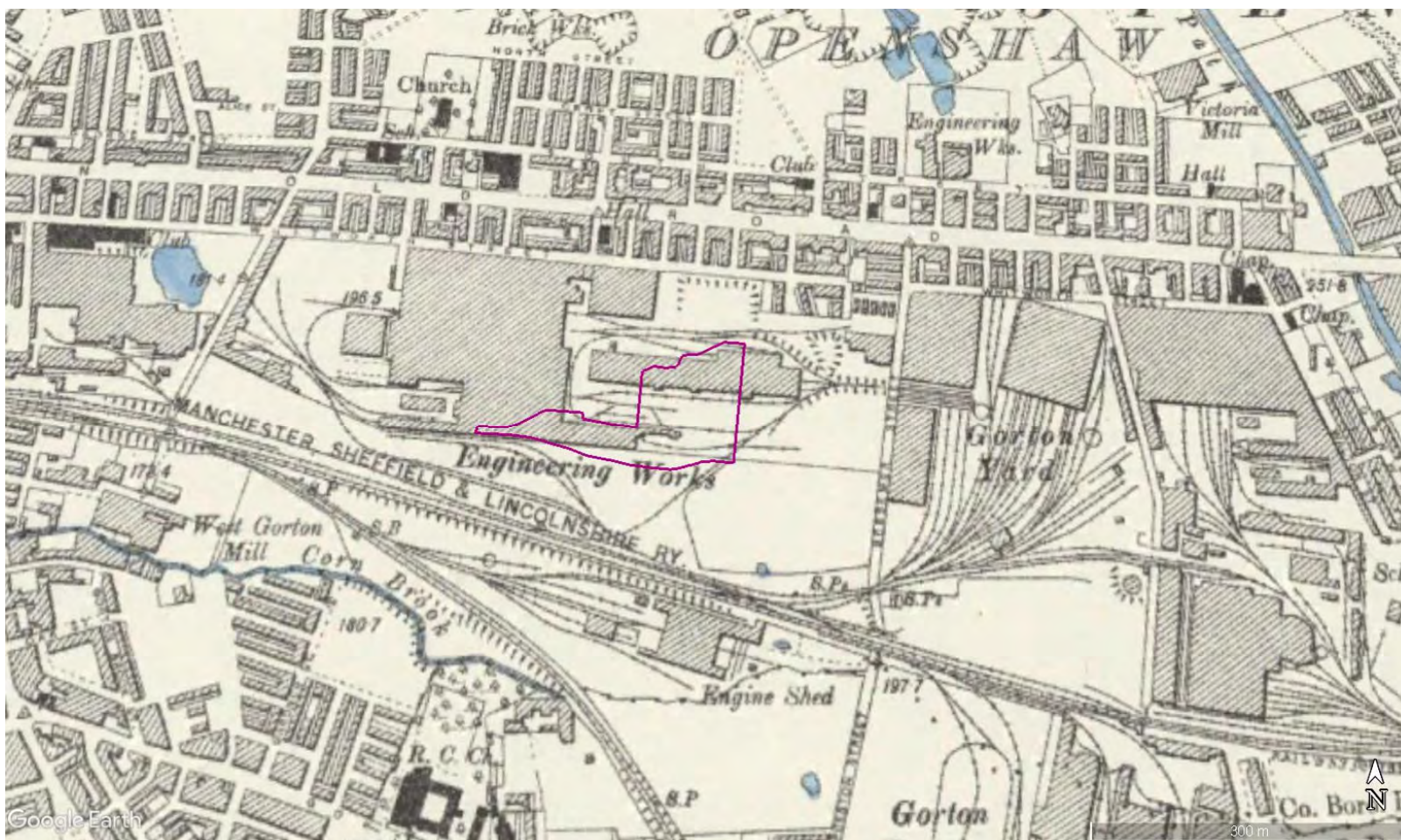
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1888-1890 OS map showing the AOI (plumb) as part of the Armstrong-Whitworth Engineering works

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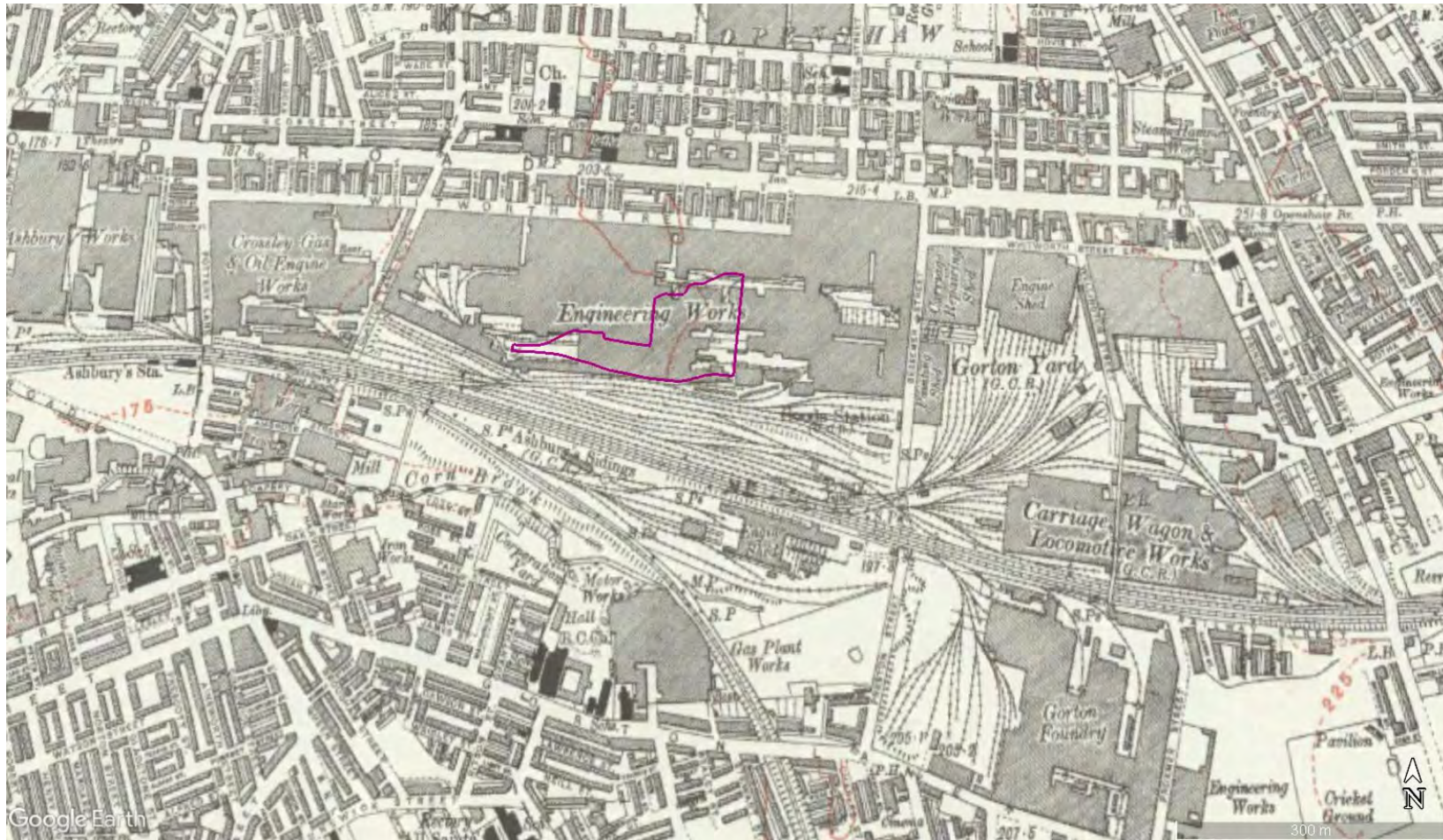
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1915-1916 OS map showing the AOI and surrounding area as massively developed as heavy industry. This was the last phase of expansion of the Armstrong-Whitworth works prior to its demise in the late 1920s.

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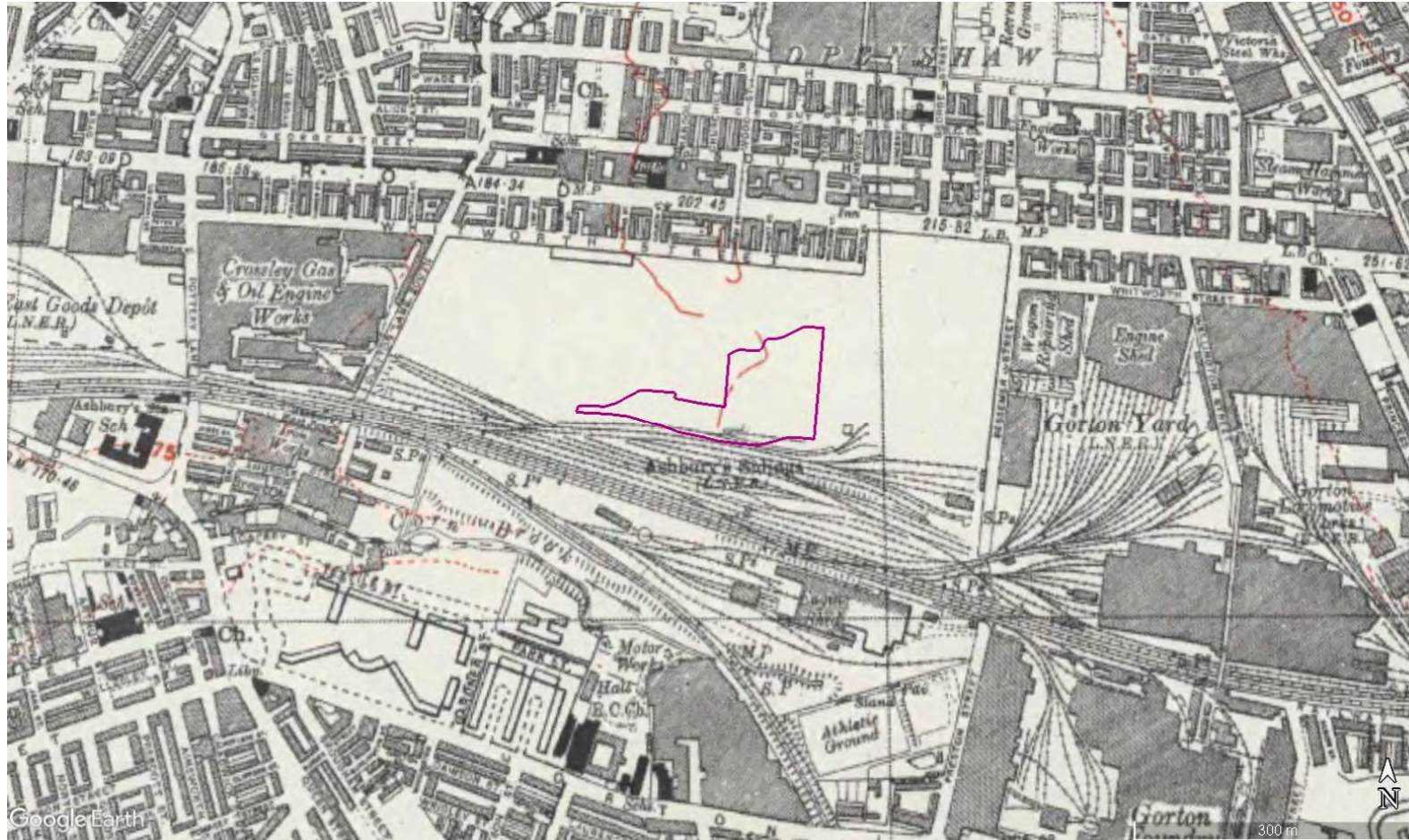
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Appendix 005: Historic Map Suite / Aerial Imagery

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1938 OS map showing the AOI and surrounding area. The Armstrong –Whitworth works had been demolished by at least as early as 1936 (see image below) .

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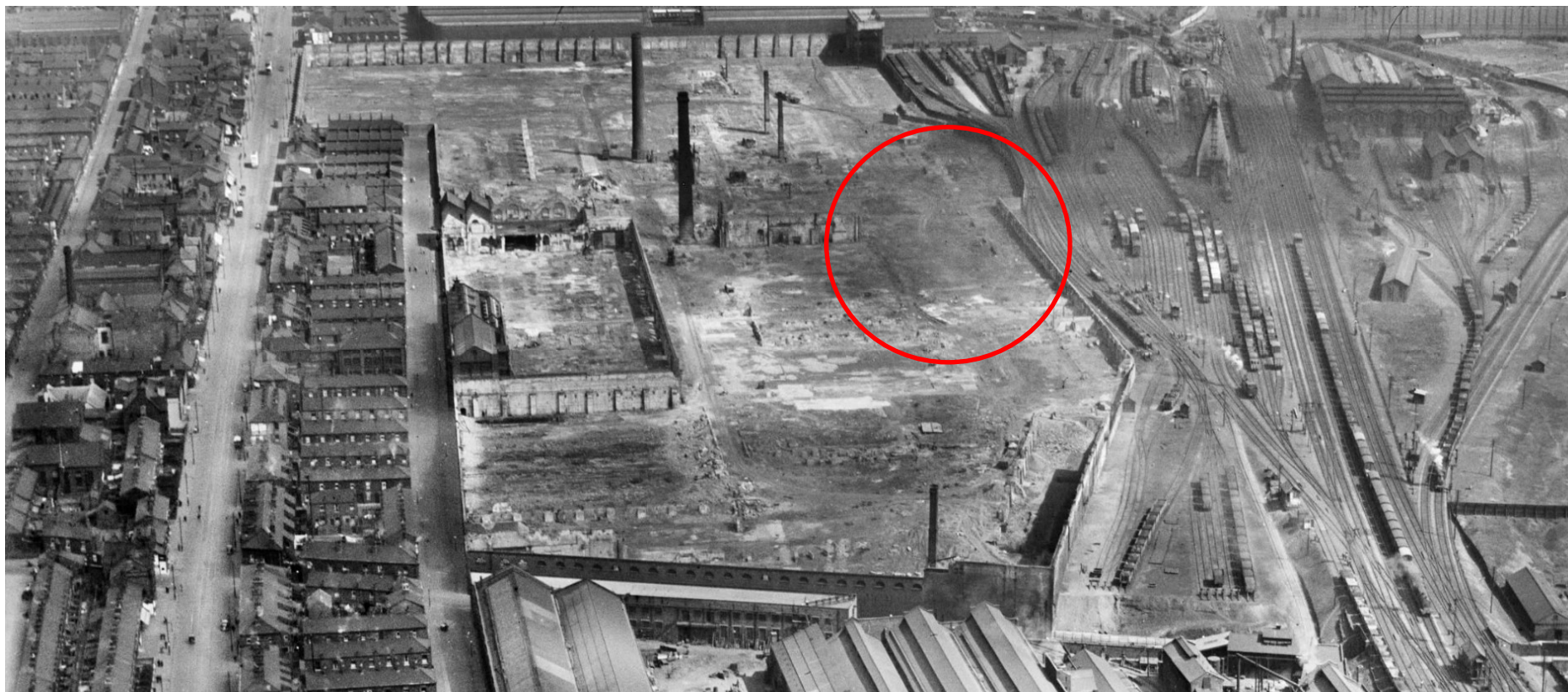
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Aerial image taken in 1936 from west of the AOI, showing the Crossley works and the demolished remains of the Armstrong-Whitworth works.
The approximate location of the AOI is indicated by a red circle. (EPW 050062)

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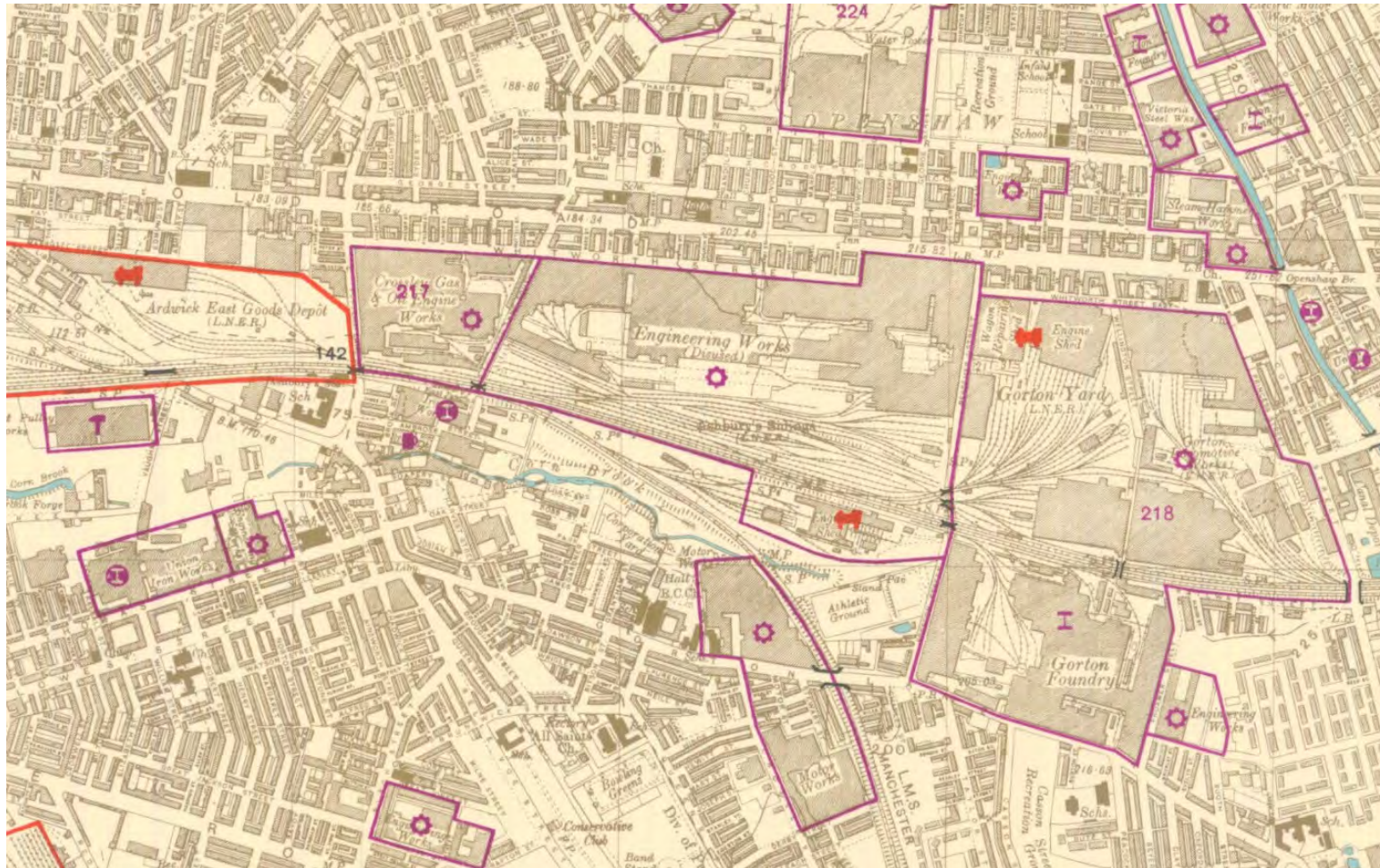
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Appendix 005: Historic Map Suite / Aerial Imagery

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Extract from a Luftwaffe targeting map showing the AOI was regarded as a priority target for air attack, despite having been demolished years before the attack. Other targets in the surrounding area were extant during the war. .

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Appendix 005: Historic Map Suite / Aerial Imagery

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Aerial image taken in 1946 showing the AOI as part of the Crossley New Forge complex. The factory roofs still retain their camouflage paint scheme, indicating they were present during WWII. AOI marked in purple. Although some allowances must be made for georectification, the boundaries of the current AOI appear to respect those of the Crossley New Forge. The two buildings circled red are still present in the AOI (RAF/3G/TUD/UK/185)

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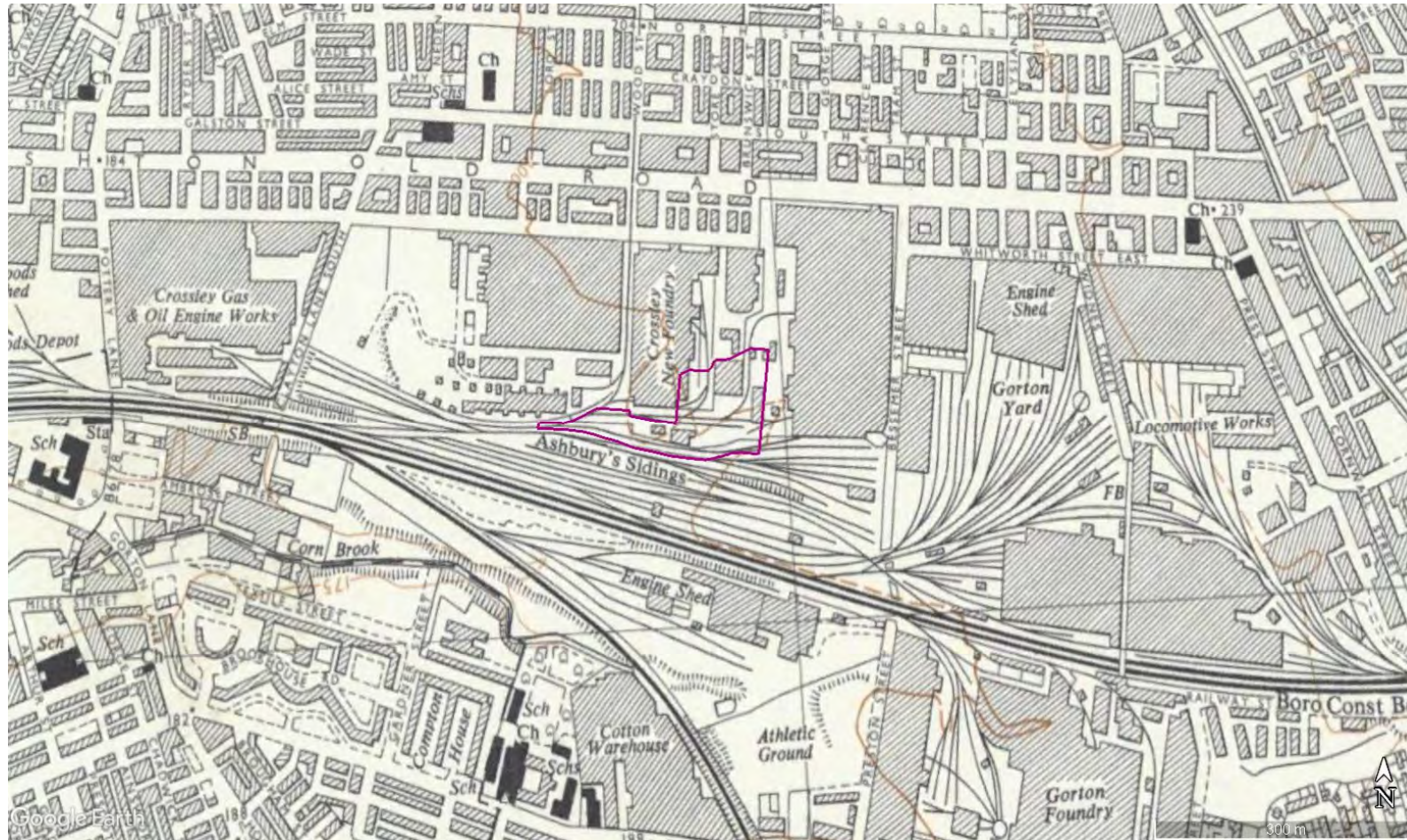
Project Ref: EES1361

Appendix 005: Historic Map Suite / Aerial Imagery

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OS map published in 1956 showing the AOI as part of the Crossley New Forge works. This was essentially the same layout present until the early 2000's.

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Appendix 005: Historic Map Suite / Aerial Imagery

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Current view of the AOI (Google Earth). The two buildings circled red were once part of the Crossley New Forge complex.

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Appendix 005: Historic Map Suite / Aerial Imagery

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Appendix 006

Examples of British Military Positions

WWII Defensive Positions

The term defensive position refers to structures designed to repel invading forces, such as Anti Aircraft Artillery (AAA) positions, infantry and gun emplacements, bunkers and anti-tank positions. In addition, balloon anchorages, searchlight positions, air raid shelters and other military assets are also associated with these types of positions and were targeted by German Forces.



Examples of Pillboxes



Example of a Vickers Gun Emplacement



Example of an Alan Williams Turret emplacement

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Appendix 006: Military Positions



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Anti Aircraft Artillery

AAA batteries were often located around large towns and cities as an integral defence mechanism against the German Air Force bombers. Typically the Royal Artillery would man such defences. The AAA defence around Britain comprised mainly 4.5" Heavy AAA gun batteries and 3.7" AAA batteries.

The significance of AAA positions located close to a site is that firstly the Germans may have attempted to bomb the batteries and secondly un-exploded projectiles or "blinds" may have landed in the general vicinity .



Example of a 20mm Light Anti Aircraft Gun



Example of a Light Anti-aircraft battery



Example of a Bofors Light Anti Aircraft Gun



Example of Heavy Anti Aircraft Artillery

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Appendix 006: Military Positions



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Appendix 007

German Bombing Campaign Overview

WWI German Bombing

During the First World War (WWI) Zeppelin airships followed by 'Gotha' and 'Giant' bombers conducted a succession of attacks dropping high explosive (HE) and incendiary bombs on Britain. The level of enemy bombing seen during WWI does not compare to that of WWII, nevertheless bombs were dropped on Britain.

WWII German Bombing

From the onset of WWII the German Air Force's (Luftwaffe) primary goals were to destroy key military assets such as airfields, during a series of daylight bombing raids. Shortly after, their plans changed to include targets such as economic and industrial sites, railway infrastructure, power stations, weapon manufacturing plants and gas works. Eventually, the amount of daylight raids were reduced and the attacking of targets commenced under the cover of darkness. Ultimately, the Germans resorted to attacking civilian areas through the 'carpet bombing' of major towns and cities, most notably during "The Blitz", which was in retaliation to the Allied bombing campaign.

RPS records indicate that the German bombing campaign during WWII saw the extensive use of a series of High Explosive (HE) filled bombs ranging in size from the relatively small 50kg bomb through to the 250kg, 500kg, 1,000kg and 1,800kg bombs to the largest at 2,500kg. The Luftwaffe also used parachute mines, incendiary/fuel bombs and anti-personnel bomblets. In the later stages of the war, vengeance weapons namely the V1 (doodle bug) and V2 (Long Range Rockets) were used. The V2 rocket contained a 980kg high explosive filled warhead.

Available records suggest that the most numerous bombs dropped over the majority of targets during WWII were 50kg to 500kg HE bombs and incendiary devices. It is a general industry accepted rule, where no specific statistics are available, that on average, around 10% of the German HE bombs dropped during WWII failed to explode. This percentage is based on empirical data collected and collated during WWII by the ARP, and derived from bombing records. This statistic is primarily based on statistics from the London area (where the actual statistics vary widely across the region), but on average the failure rate resulted to around 10%.

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Appendix 007: German Bombing Overview



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Appendix 008

Air-Raid Records

Source	Air Raid date	Location	Notes
HO 203/5	22/12/1940	Clayton, Manchester	
HO 203/9	12/10/1941	Clayton, Manchester + Miles Platting + Baguley Fold	
HO 203/11	27/07/1942	Great Ancoats Street, Manchester	
HO 203/6	09/01/1941	Levenshulme + Manchester	
HO 203/4	29/08/1940	Manchester	
HO 203/4	04/09/1940	Manchester	
HO 203/4	15/09/1940	Manchester	
HO 203/5	01/10/1940	Manchester	
HO 203/5	02/10/1940	Manchester	
HO 203/5	07/10/1940	Manchester	
HO 203/5	09/10/1940	Manchester	
HO 203/5	11/10/1940	Manchester	
HO 203/5	13/10/1940	Manchester	
HO 203/5	20/10/1940	Manchester	
HO 203/5	26/10/1940	Manchester	
HO 203/5	28/11/1940	Manchester	
HO 203/5	16/12/1940	Manchester	
HO 203/5	22/12/1940	Manchester	
HO 203/5	23/12/1940	Manchester	
HO 203/5	23/12/1940	Manchester	
HO 203/6	01/01/1941	Manchester	
HO 203/6	05/01/1941	Manchester	
HO 203/6	11/03/1941	Manchester	
HO 203/7	07/05/1941	Manchester	
HO 203/8	01/06/1941	Manchester	
HO 203/8	04/06/1941	Manchester	

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Appendix 008: Details of air raids



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Source	Air Raid date	Location	Notes
HO 203/4	31/08/1940	Ardwick, Manchester	

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Appendix 008: Details of air raids



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Appendix 009

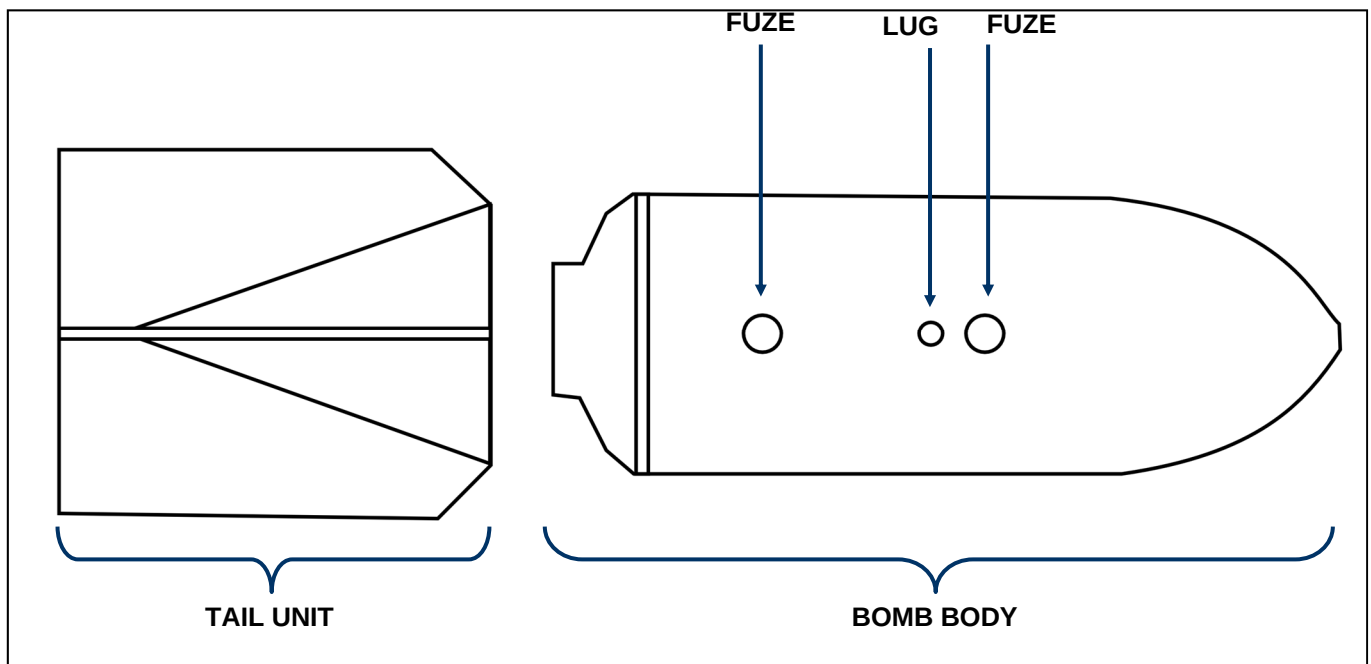
Examples of German Bombs

High Explosive / General Purpose Bombs

General-purpose bombs come in many shapes and sizes depending on the intention of the bombing mission. Generally, all these bombs are constructed the same and consist of a metal container (iron construction), a fuze (mainly transverse i.e. in the middle of the bomb), and a stabilizing device. The metal container (called the bomb body) holds the high explosive content. The body may be in one or in multiple pieces.

The main components of a bomb are:

- **Bomb Body** – This is the main item referred to as an Unexploded Bomb (UXB). The General Purpose bombs will have a typical bomb shape with parallel sides. Given the age and environmental conditions most bombs are found corroded. It is possible to mistake them for old gas cylinders or boiler tanks.
- **Tail Unit** – As the UXB enters the ground this section is removed. The presence of a tail unit may indicate that an UXB is buried at depth in the region.
- **Fuze** – With a German UXB it is most likely that the bomb would have a mechanical or electrical transverse fuse. In some case a bomb may contain two fuses. On a German UXB the fuzes were of an alloy construction and therefore a visual contrast from the bomb body.



TYPICAL WWII GERMAN AERIAL DELIVERED BOMB COMPONENTS

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Appendix 009: Examples of WWII German Bombs

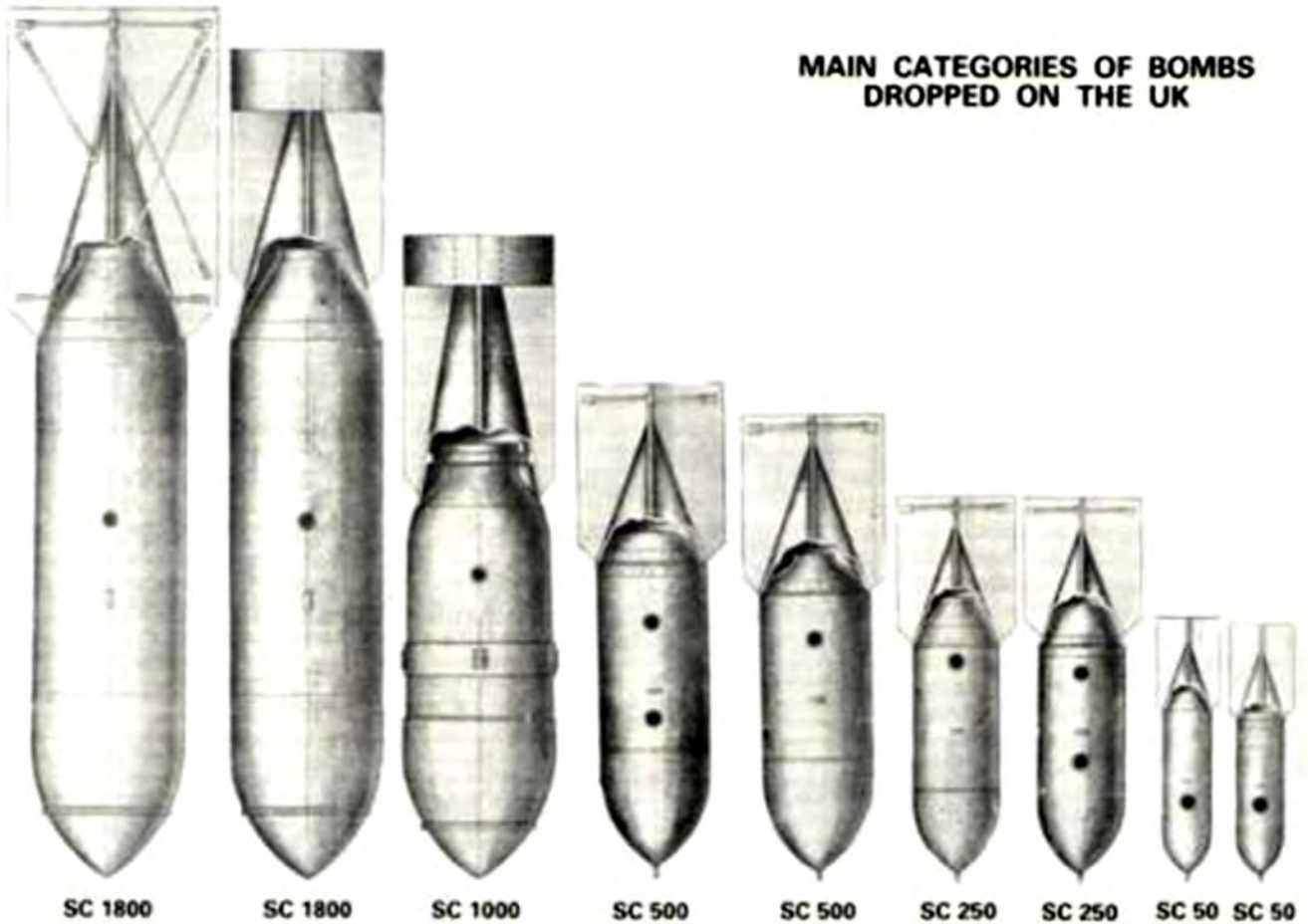
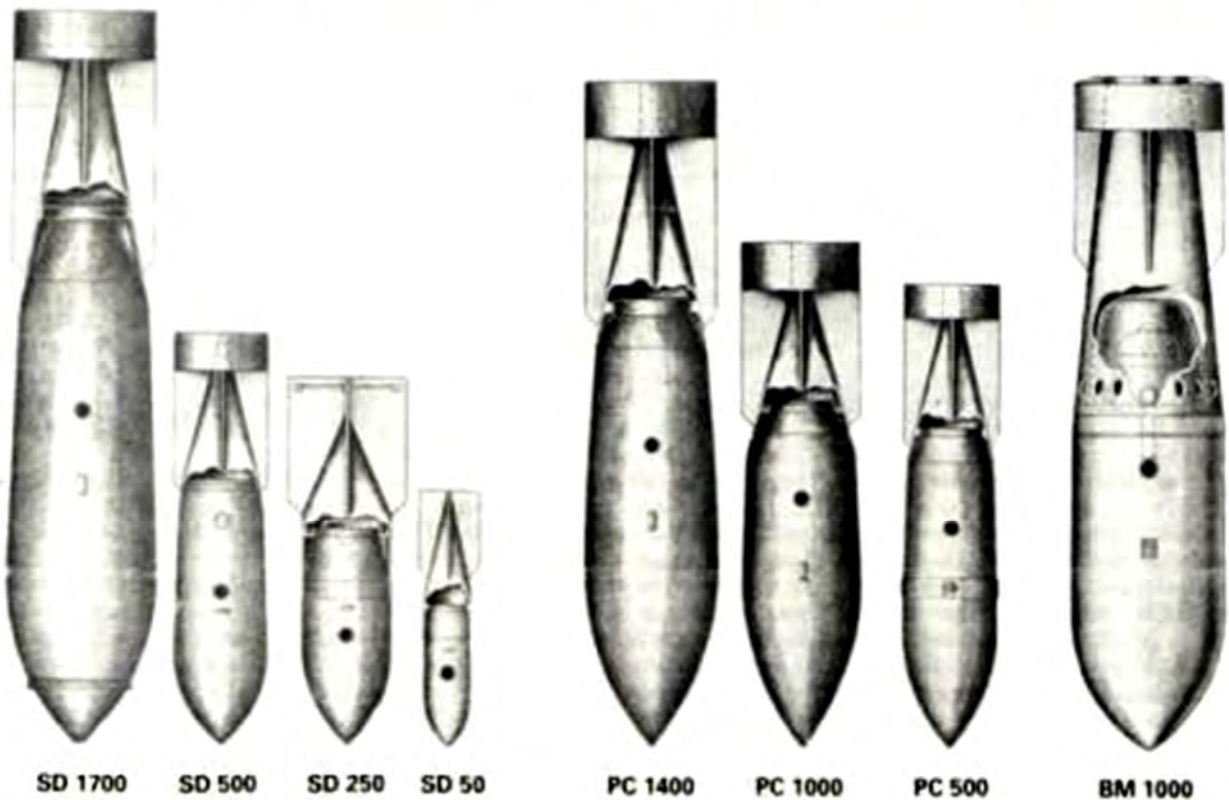


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MAIN CATEGORIES OF BOMBS DROPPED ON THE UK



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Appendix 009: Examples of WWII German Bombs



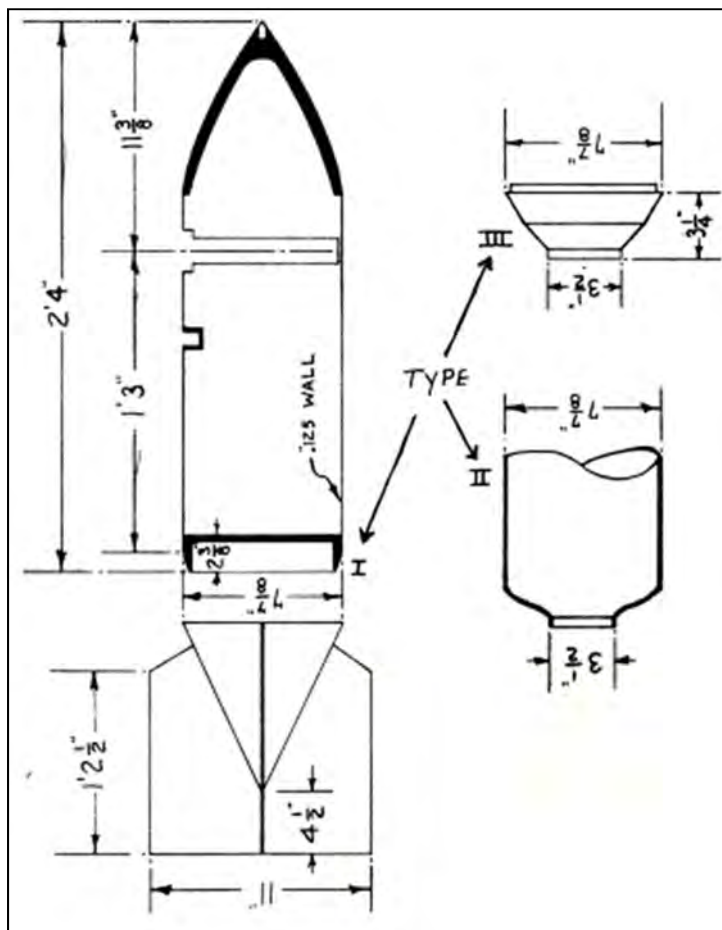
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An Example of a 50kg German Bomb



50kg SC High Explosive Bomb Schematic



50kg SC HE Bomb discovered by RPS on a construction site in London (2006)

SC50 Data

Bomb Body Weight = 40-54kg

Body Length = 2' 4.5" to 2' 7"

Body Diameter = 200mm (7.87")

Explosive = TNT or Amatol

NEQ = 25kg (55lb)

Fuze = Impact Fuzing

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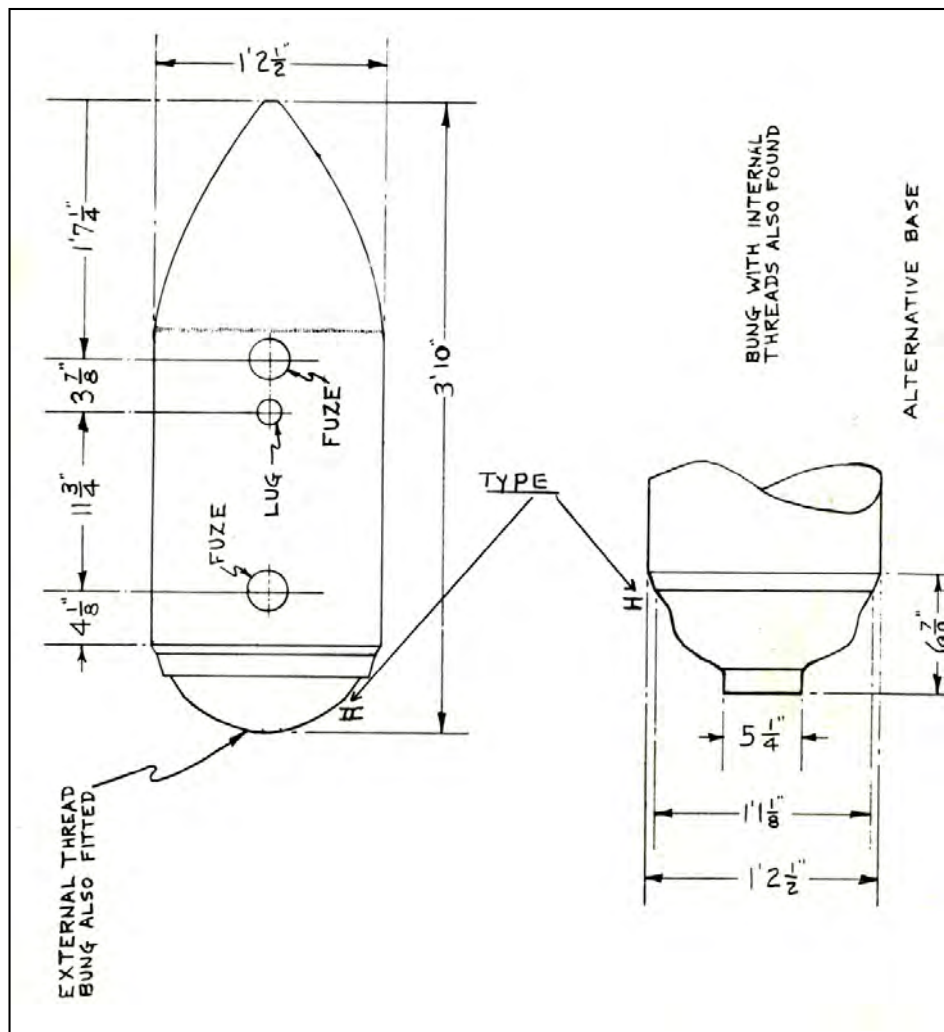
Appendix 009: Examples of WWII German Bombs



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SC250 Data

Bomb Body Weight = 245-256kg

Body Length = 5' 1" to 5' 5"

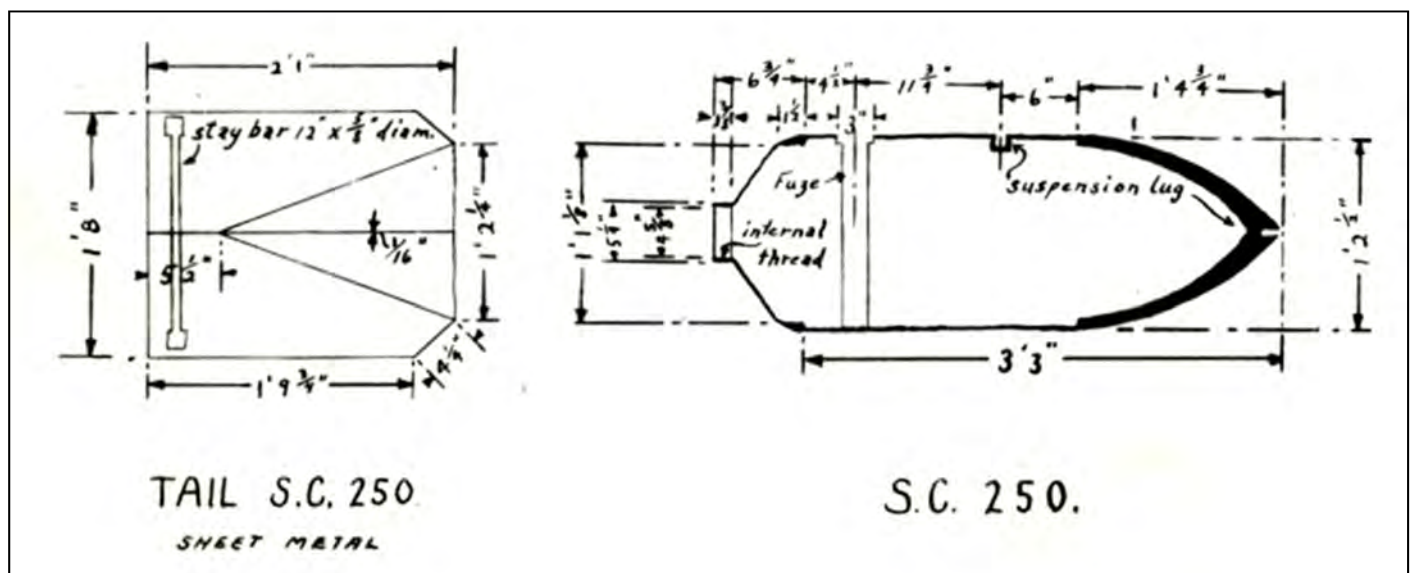
Body Diameter = 368mm (14.5")

Explosive = TNT or Amatol

NEQ = 125-130kg (276-287lb)

Fuze = Any (Commonly Type 7 Time Fuze)

250kg SC High Explosive Bomb Schematics



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Appendix 009: Examples of WWII German Bombs

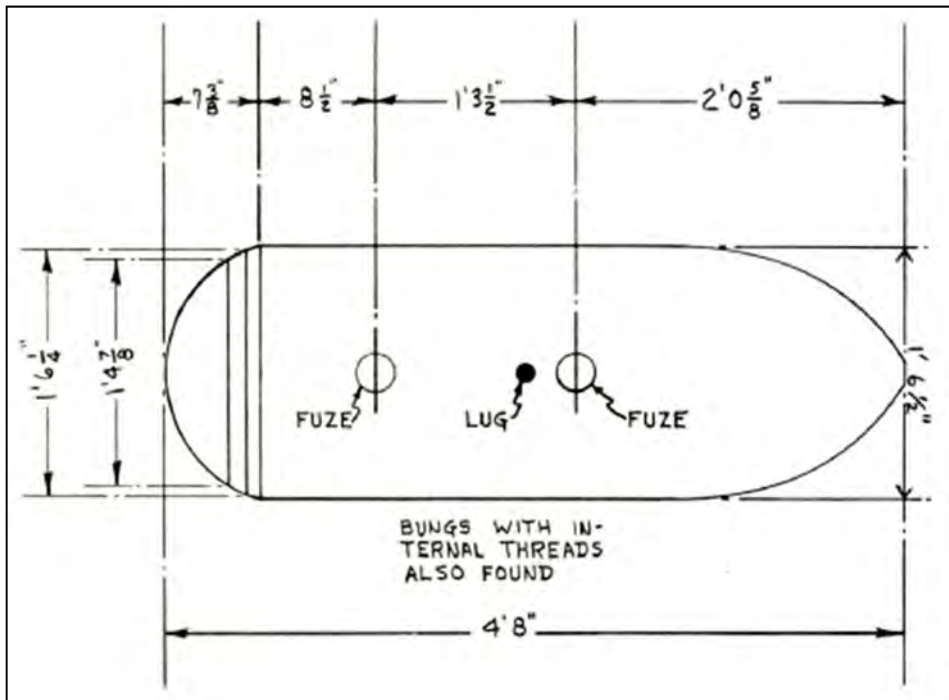
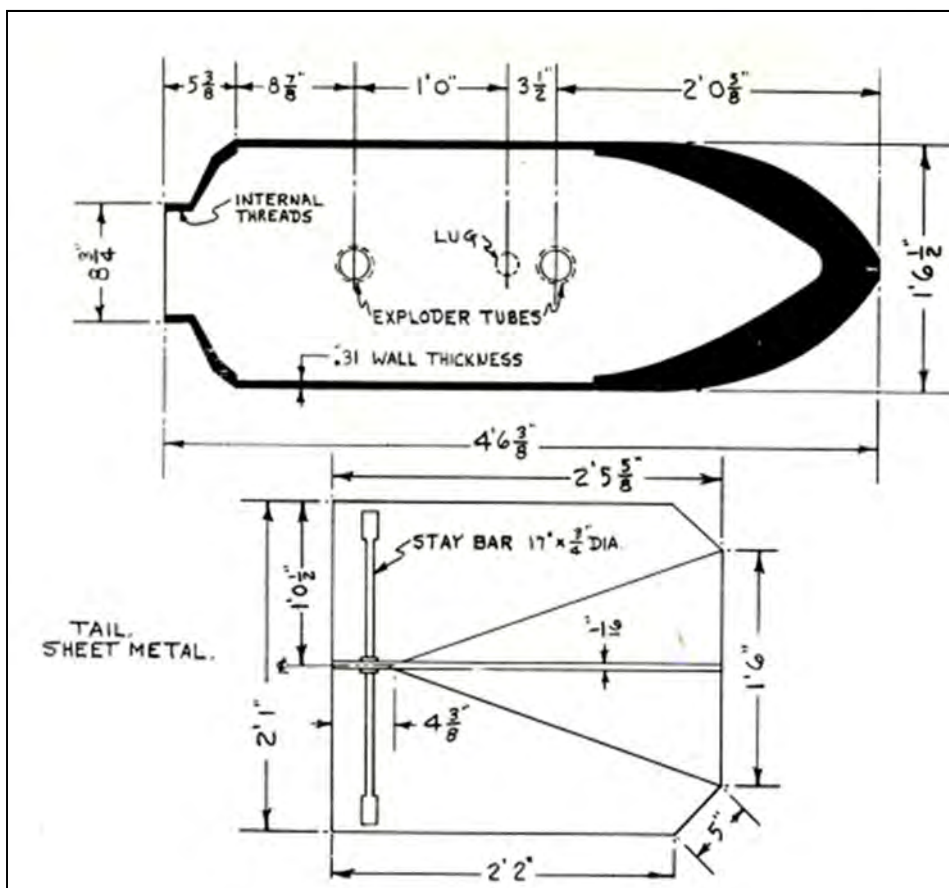


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500kg SC High Explosive Bomb Schematics



SC500 Data

Bomb Body Weight = 480-520kg

Body Length = 4' 6" to 5' 0"

Body Diameter = 470mm (18.5")

Explosive = TNT or Amatol

NEQ = 125-130kg (276-287lb)

Fuze = Electrical Impact Fuzing

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Appendix 009: Examples of WWII German Bombs



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Appendix 010

Examples of German Bomblets

German Bomblets & Containers

In addition to the larger individually deployed bombs, smaller HE bombs or “Bomblets” were also deployed by the Luftwaffe. The small bomblets were generally between 1-3kg or 10kg in weight and dropped in larger container bombs and most of these of these had simple impact fuzes. Many containers' were shaped in a bomb form, with the aim of fitting into the existing bomb racks. If operating properly, they were designed to eject their cargo at predetermined height above ground level thereby spreading the bomblets over a wide area.

Some bomblets are considered the forerunners of cluster munitions which are very sensitive and considered more prone to initiate. These were used against civilians and can be considered an area denial weapon.

These weapons have been encountered in infill or rubble in larger cities and in other re-deposited contexts. They possess limited ground penetration (approximately 1-3m in a medium deposit) similar to the smaller Incendiary Bomblets discussed below. However, the small bomblets may be considered to have a greater potential to cause casualties than general incendiary bomblets based upon their fuze and explosive makeup.

German Incendiary Bomblets

In early stages of the war, the incendiary bombs dropped over the UK were of the "Oil Bomb" variation, where a flammable liquid was used with an explosive charge. The idea was to cause some blast damage with the explosive, but mainly to spray the burning liquid over a wide area and cause widespread fires. This bomb weighs approximately 50kg. The body diameter is 8 inches, and the over-all length 43.2 inches. The filling is 15 litres of a mixture of 86 per cent benzene, 10 per cent rubber, and 4 per cent phosphorus. It has a bursting charge of picric acid.

By 1942, Oil Bombs had been superseded by a smaller and more intensely burning incendiary bomblet made of magnesium. These weighed only 1kg, so could be dropped in containers carrying hundreds of individual bomblets. Some were coupled with a small High Explosive charge that went off when the magnesium was alight to spread the fire over a wider area. A corroded 1kg incendiary bomb can closely resemble a short section of scaffold tube.

- **1kg Incendiary Bomb** - The diameter is 2 inches, and over-all length 13.6 inches. The filling is 0.44lb of thermite.
- **2kg Incendiary Bomb** - The filling includes TNT or amatol in addition to thermite. The diameter is 2 inches, and the overall length is 20.7 inches.

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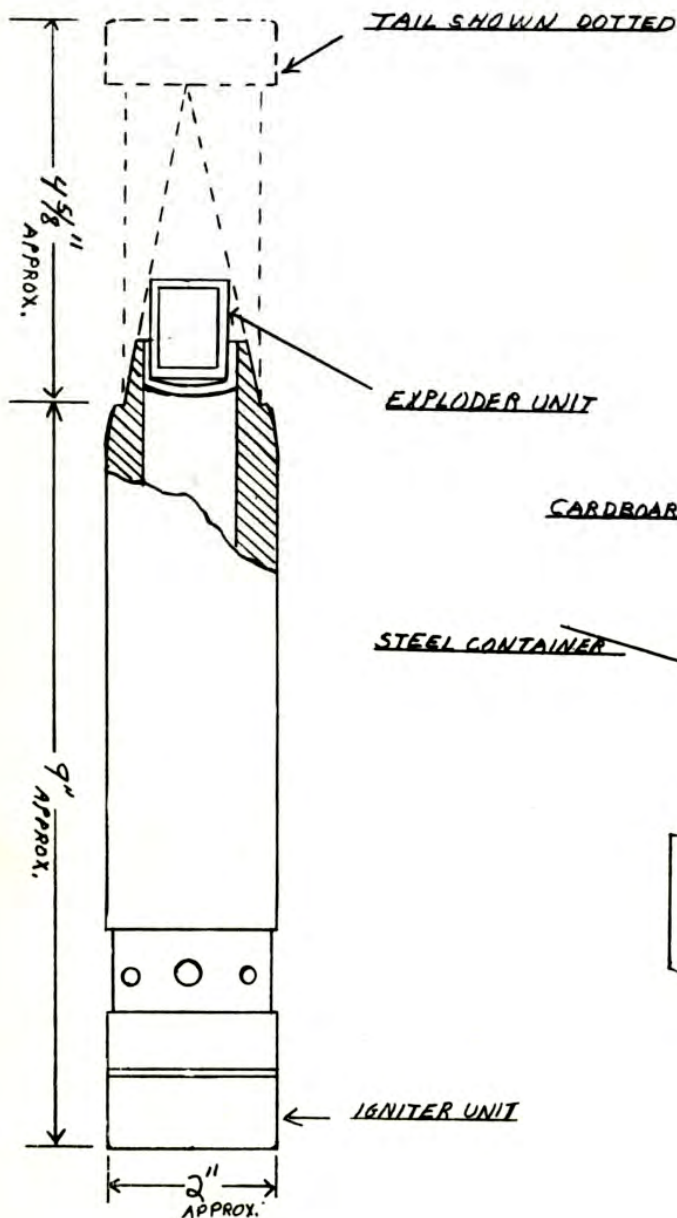
Appendix 010: Examples of WWII German Bomblets



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B-1 & B-1.3 E Data

Bomb Body Weight = 1kg

Construction = Electron casing with steel nosecap

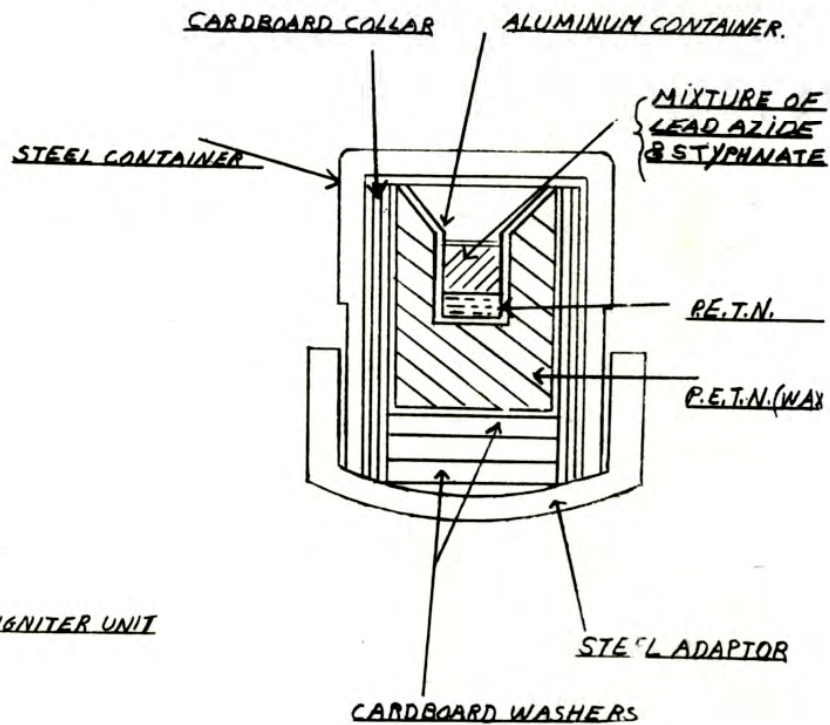
Length = 350mm

Body Diameter = 50mm (1.97")

Explosive = None

Fill = 680g (1.3lb) Thermit

Fuze = Impact



B-1 1kg Incendiary Bomblet



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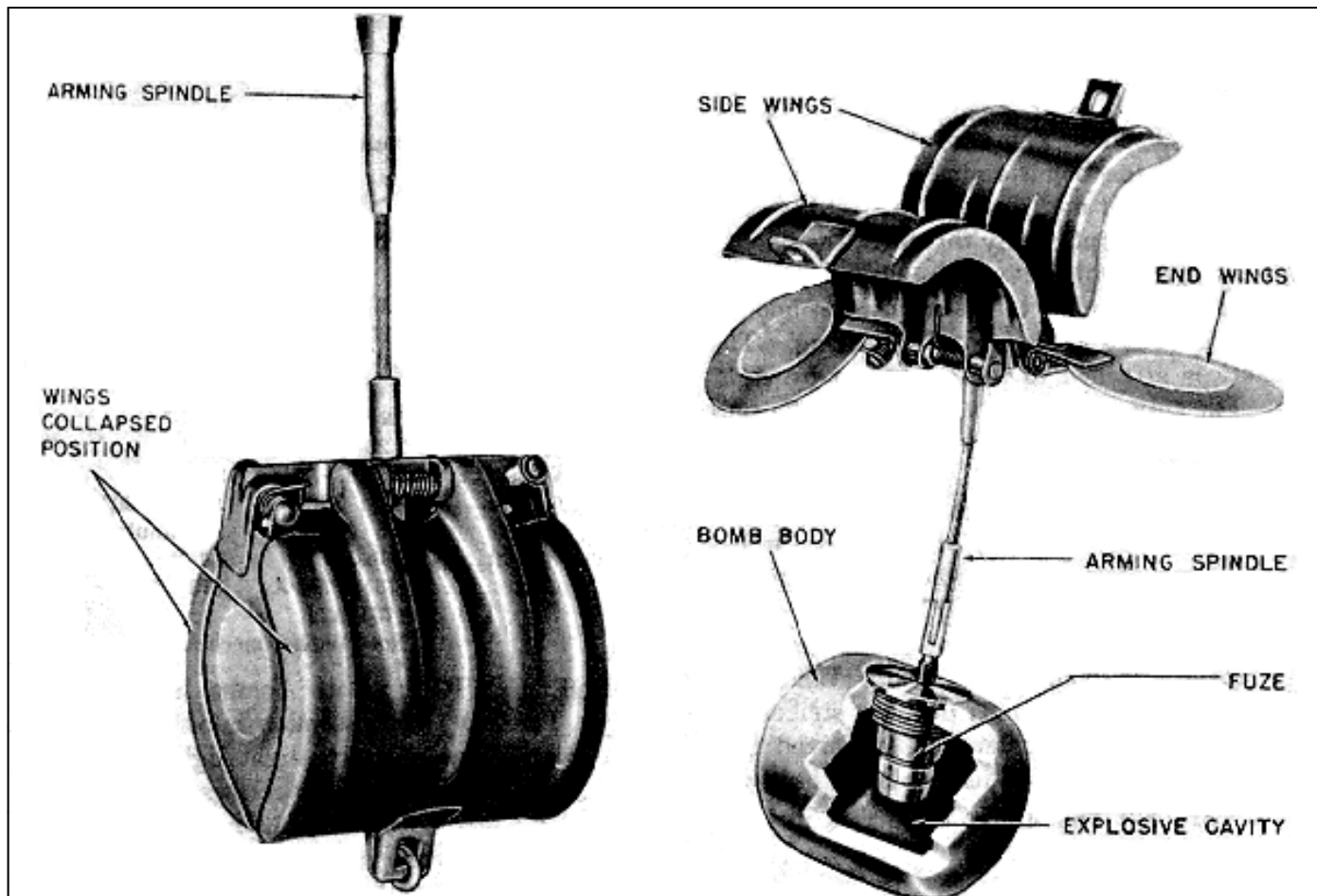
Appendix 010: Examples of WWII German Bomblets



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Butterfly Bomblet (SD2) Anti Personnel Device



SD-2 Data

Bomb Body Weight = 2kg

Length = 200mm (Including Arming Spindle)

Body Diameter = 80mm

Explosive = Fp 60/40

NEQ = 0.225kg (0.496lb)

Fuze = Mechanical Clockwork / Mechanical Time or B1/B2 Harassment

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Appendix 010: Examples of WWII German Bomblets



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Appendix 011

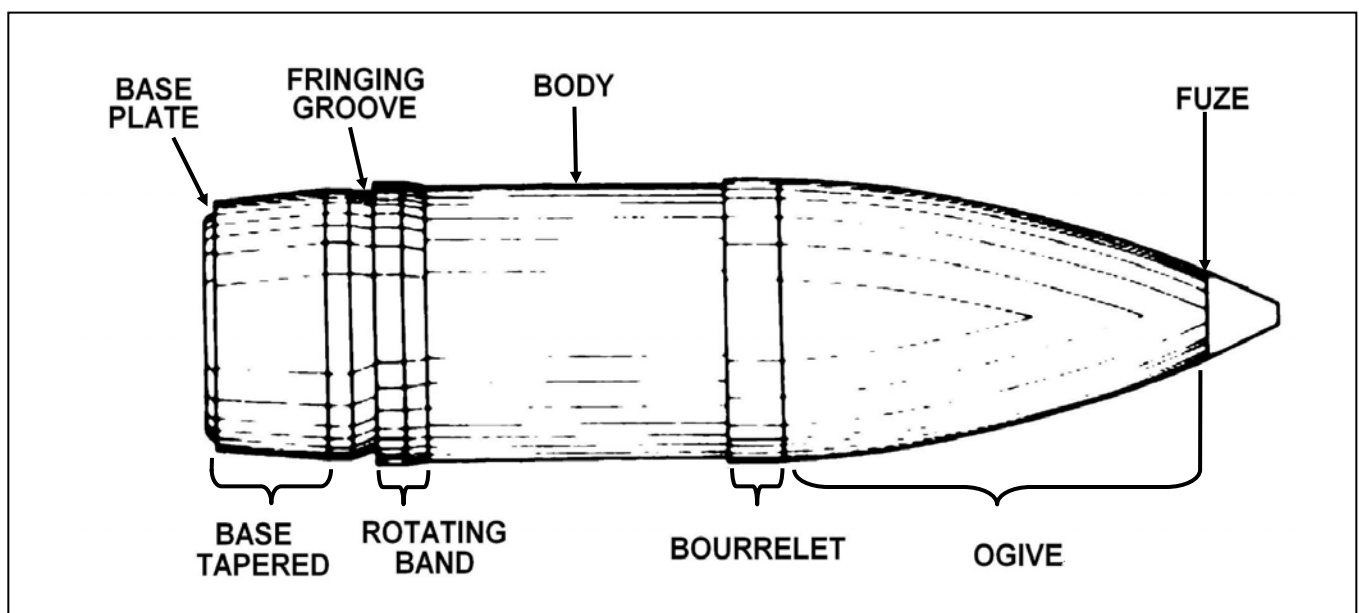
Examples of AAA

Anti Aircraft Artillery Projectiles

During WWII, the munitions commonly used by the British AAA were the 4.5" and 3.7" varieties. An artillery munition generally consists of four main sections:

- **Fuze** – The part of the device which initiates the detonation of the payload. Usually artillery munitions have nose fuzes, although some do have base fuzes. When used with HE shells, 'airburst' fuzes usually have a combined airburst and impact function.
- **Projectile** – This is the part of the munition that generally contains the main payload, and will be ejected from the main munition during firing. Artillery shell projectiles can range between bursting, base ejection or nose ejection.
- **Propellant** – Propellant in artillery munitions is always low explosive.
- **Primer** – The primers purpose is to initiate the propellant upon firing.

In most cases, the part of the munition that is likely to remain as UXO, as a result of malfunction during firing, is the Projectile (potentially with fuze), as this is the part of the device that is fired through the air.



TYPICAL PROJECTILE COMPONENTS

"Z" Batteries, often manned by Home Guard units fired Rockets as part of the integrated aerial defences. These 'projectiles' were essentially fin stabilised rockets which contained a small propellant charge to ignite the rocket motor. Throughout WWII two variations of the rocket were utilised, the first being a 2" rocket which was later replaced by a 3" rocket after being discovered that it was far more effective.

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Appendix 011: Examples of WWII Anti-Aircraft Artillery



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3.7" Anti Aircraft Artillery Projectile



40mm Anti Aircraft Artillery Round

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Appendix 011: Examples of WWII Anti-Aircraft Artillery



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Appendix 012

Background to Bomb Penetration Depth

Background on Bomb Penetration Depths

There are a number of reasons/factors applicable to bomb penetration depths, which can lead to variations in the bomb penetration depths for aerial delivered ordnance, as follows:

- **Shape & Weight of Ordnance** – variations in the design of the delivered ordnance has a large impact on the depths to which it is able to penetrate. Generally speaking, the heavier the ordnance, the deeper the penetration, and when constructed in a streamlined shape this can also lead to an increased penetration depth.
- **Geological Strata** – variations in the composition, thickness and homogeneity of the geological strata can lead to significant variations in penetration depths.
- **Height of delivery** – the altitude at which the ordnance was released can lead to variations in the final penetration depth. For example, in low level attacks, or where a fleeing aircraft has had to ditch its payload, it is likely for penetration to have been much less due to any ordnance having not reached its terminal velocity and appropriate penetration angle (for maximum depth burial).
- **Deflection** – should an item of ordnance impacted onto an obstruction/structure prior to penetration into the ground, it may have deflected and as such behaved anomalously upon penetration, and thus the final resting position may potentially be atypical to what is normally expected.

The following table provides a guide on average & probable maximum penetration depths of bombs in geological conditions that are typical in most areas of the United Kingdom. This is based on a survey & calculations undertaken by the Ministry of National Security in October 1949.

The following table is based on sums conducted by the Ministry on a data set from 1,304 bombs dealt with between January 1st to May 14th, 1941 (along with 24 bombs experimentally dropped on chalk). Only incidents with a definitive soil type, without structures on the surface, were used.

Weight of Bomb Kg	Sandstone		Sand		Gravel (Mixed)		Chalk (Soft)		Clay (Wet)		Average Penetration	Average Probable Maximum Penetration
	Average Penetration	Probable Maximum	Average Penetration	Probable Maximum	Average Penetration	Probable Maximum	Average Penetration	Probable Maximum	Average Penetration	Probable Maximum		
	m	m	m	m	m	m	m	m	m	m	m	m
50	2.7	6.1	2.8	7.8	2.8	7.8	3.5	7.6	4.0	9.1	3.2	7.7
250	4.6	10.4	4.8	13.7	4.8	13.7	6.0	13.1	6.9	15.8	6.9	13.4
500	5.8	13.1	6.0	17.4	6.0	17.4	7.6	16.5	8.7	19.8	8.7	16.8
1000	7.3	16.5	7.6	21.9	7.6	21.9	9.6	20.7	11.0	25.0	11.0	21.2
1400	8.2	18.3	8.5	24.4	8.5	24.4	10.7	23.2	12.3	27.7	12.3	23.6
1800	9.0	20.3	9.4	27.0	9.4	27.0	11.8	25.5	13.5	30.5	13.5	26.0

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Appendix 012: Bomb Penetration

UXB 'Offset'

A typical high altitude release bomb will enter the ground at between 10° and 15° (to the vertical), and will travel on this trajectory until momentum is nearly lost. The bomb will then turn abruptly to the horizontal before coming to rest. The distance between the centre of the entry hole and the centre of the bomb at the rest is known as the 'offset'. A marked lateral movement from the original line of entry is not uncommon.

The average offset is one third of the penetration depth, i.e. an offset of some 2.0m may be expected for a 50kg bomb in clay.

Hard standing on the impact zone can result in an offset increasing by some four times. It should be noted that bombs striking buildings might be deflected to give wider variation in the impacted area.

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Appendix 012: Bomb Penetration

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Appendix 013

UXO Detonation Characteristics

UXO Detonations

The major effects of partial or full detonation of a device are shock, blast, heat and shrapnel damage. It should be noted that the detonation of a 50kg buried bomb would damage brick or concrete structures up to 16m away and unprotected personnel on the surface up to 70m away. Larger ordnance is obviously more destructive, with an accepted safety distance for a 500kg HE device being 1km.

Once initiated, the effects of the detonation of explosive ordnance such as shells or bombs are usually extremely fast, often catastrophic and invariably traumatic to the personnel involved. The degradation of a shell or bomb may also offer a source of explosive contamination into the underlying soils. Although this contamination may still present an explosion hazard, it is not generally recognised that explosives offer a significant toxicological risk at concentrations well below that at which a detonation risk exists.

Unexploded ordnance does not spontaneously explode in the conditions experienced in the UK. UXBs have lain un-disturbed for some 60 years and should not detonate unless they are significantly disturbed. All HE requires significant energy to create the conditions for detonation to occur. Intense impacts in intrusive engineering such as drilling / piling and mechanical excavations could initiate a detonation. There are a number of scenarios that may occur on sites which may potentially lead to the detonation of an encountered item of UXO, as follows:

- **Direct on the main body of the UXO** – needs to be significant impact e.g. In the case of piling or large scale excavations.
- **Re starting clock timer in a fuze** – contact or vibration applied to a clock timer, in certain situations, may cause it to reinitiate. However, in the case of WWII (and pre-WWII) ordnance it is likely that such devices would be corroded and no longer able to function.
- **Initiating Fuze Explosive** – environmental factors, such as introduction of temperature fluctuations and water, can lead to degradation of explosives within items of UXO, which may then exude from the main body of the device and crystallise. Certain resultant compounds from such processes can be very sensitive and volatile, and through application of a small amount of movement / energy through either vibration or impact may result in detonation of the main charge.

Apart from the explosives risk, the main concerns from UXBs are threefold, these are:

- Heavy metal (Copper, Zinc etc) contamination from the bomb's casing.
- Organic aromatics (Toluene, Nitrosamines, daughter products etc) contamination from the degradation of the explosive charge.
- Heavy metal (Lead, Mercury) contamination from the degradation of the detonator charge.

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Appendix 013: UXO Detonation Characteristics



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Appendix 014

Risk Assessment Matrix

CONSEQUENCE LEVEL	POTENTIAL CONSEQUENCES OF DETONATION				
	People	Environment	Assets		Reputation
			Plant and Equipment	Structures	
1	First aid injury	Minor disturbance.	No noticeable effect	No noticeable effect	No significant impact
2	Lost time injury < 3 days	Significant disturbance.	Slight superficial damage	Slight superficial damage	Slight Impact
3	Serious debilitating injury	Moderate damage to habitats.	Minor component replacement repair	Repairs - non-structural	Moderate Impact
4	Localised fatalities	Moderate damage of habitats. Some long term effects.	Significant component replacement repair	Repairs - structural	Major Impact
5	Multiple fatalities over extended area	Localised destruction of habitats. Moderate long-term effects.	Unit loss, un-repairable damage	Localised structural failure and collapse	Massive Impact

PROBABILITY OF ENCOUNTER		CONSEQUENCE LEVEL				
		1	2	3	4	5
1	Improbable <i>(Vey Low: Not likely to encounter)</i>	1	2	3	4	5
2	Remote <i>(Low: Slight chance of encounter)</i>	2	4	6	8	10
3	Probable <i>(Moderate: likely to encounter)</i>	3	6	9	12	15
4	Highly Probable <i>(High: highly likely to encounter)</i>	4	8	12	16	20
5	Almost Certain <i>(Very High: almost certain to encounter)</i>	5	10	15	20	25

Risk Level Key:

1 to 2	Negligible	3 to 6	Low	8 to 12	Moderate	15 to 25	High
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Appendix 015: Risk Assessment Matrices

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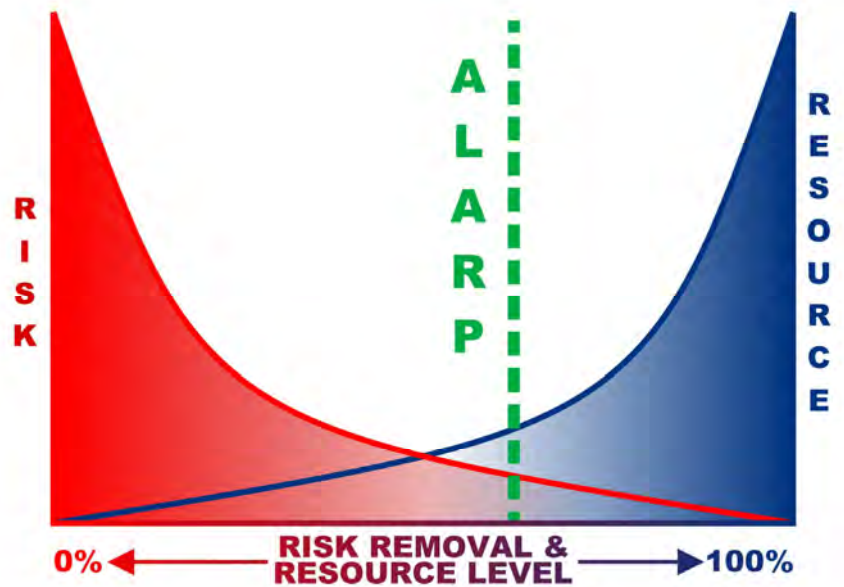
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Appendix 015

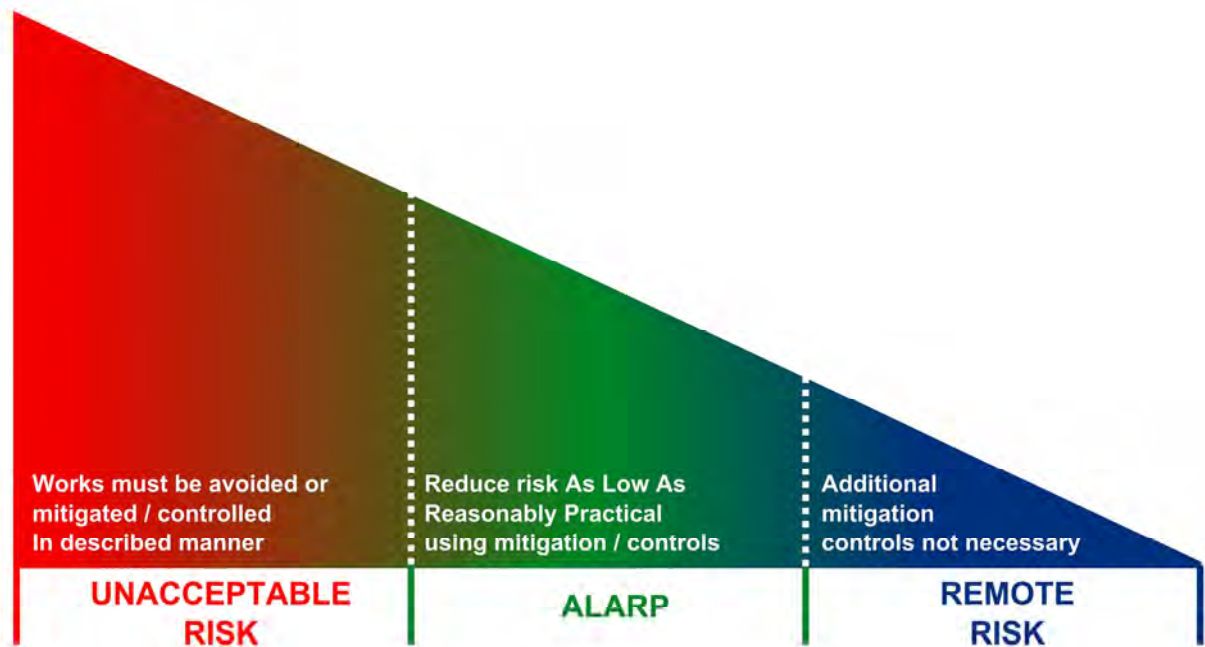
‘ALARP’ Principle

'ALARP PRINCIPLE'

ALARP has particular connotations in UK Health and Safety law and the core concept of what is "*reasonably practicable*". This involves weighing a risk against the effort, time and costs needed to control it. For a risk to be reduced in line with ALARP it must be possible to demonstrate that the cost involved in reducing the risk further would be "*grossly disproportionate*" to the benefit gained. The ALARP principle arises from the fact that it would be possible to spend infinite time, effort and money attempting to reduce a risk to zero. Importantly, it is not simply a quantitative measure of benefit against detriment but a common practice of "*judgment*" of the balance of risk and social benefit.



ALARP Resource Graph



ALARP Diagram Approach

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Appendix 016

Recommendations

RPS Explosives Safety & Awareness Briefings / Site Safety Guidelines

It is recommended that all personnel conducting intrusive works, in any part of the site, should attend an **RPS Explosives Safety & Awareness Briefing**. This should comprise part of the standard site induction briefing and would form a component of the Health and Safety Plan for the site adhering to the requirements of CDM regulations 2015. All personnel working on site would be briefed on UXO recognition and made aware of the possible risks. They would be informed of the actions to take to alert the site manager and to keep people and equipment away from the hazard.

RPS feels it may be cost effective and prudent to produce a set of ***RPS Explosives Site Safety Guidelines (ESSG)***, which would be provided to the client along with training. The guidelines are designed to aid the Project Team to plan the proposed works and potentially deal with the event of a suspicious item / UXO discovery incident. The guidelines would also enable the client to incorporate the Explosives Safety & Awareness Briefings into their standard site inductions.

The guidelines would address the risk to all of the specific proposed works and will inform all personnel how to undertake the works safely, and will refer to the specific risk items/hazards that have been identified for the site.

The guidelines would typically be provided to the client in the form of a 'Guidelines Document' along with a supporting PowerPoint slideshow.

However, it should be noted that if a significant/elevated risk is subsequently identified then a fully qualified Explosives Engineer should manage the situation on behalf of the client.

Project: Welcomb Street, Openshaw
Project Ref: EES1361



Explosives Engineering Services

Appendix 016: Mitigation Recommendation Details

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