Tween Bridge Solar Farm

Environmental Statement
Appendix 9.3: Detailed Unexploded Ordnance Risk Assessment

Planning Act 2008
Infrastructure Planning (Applications: Prescribed Forms and Procedure) Regulations 2009

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June 2026

Revision 1

Detailed
Unexploded Ordnance (UXO)
Risk Assessment

Project Name	Tween Bridge Solar, Doncaster
Client	RWE Renewable UK Solar and Storage Ltd
Site Address	East of Doncaster, North Lincolnshire
Report Reference	DA18705a-00
Date	23rd March 2026
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1ST LINE DEFENCE

Executive Summary

Site Location and Description

The site is located in a rural area, with the majority – in the west - within the Metropolitan Borough of the City of Doncaster, South Yorkshire, and the remainder in the east within the Civil Parishes of Belton and Crowle, North Lincolnshire. Recent aerial imagery indicates that the site predominantly comprises undeveloped land. The site's immediate surrounds are largely undeveloped, with Crowle to the east, Sandtoft to the south, and Thorne to the west, with the former RAF Sandtoft bordering the site in the southeast.

The site is approximately centred on the OS grid reference: **SE 72019 11479**.

Proposed Works

It is understood that a solar farm is planned for the site, including a battery storage facility, cabling, high voltage equipment and ancillaries. This will be facilitated with intrusive geotechnical works and other surveys including solar frame pull-out testing and boreholing.

Geology and Bomb Penetration Depth

It has not been possible to determine maximum bomb penetration capabilities at this stage due to the limitations of site-specific geotechnical information provided for the purpose of this report. An assessment can be made once further information becomes available or by an UXO Specialist on-site.

Site-specific geotechnical information was not available to 1st Line Defence at the time of the production of this report. An assessment of maximum bomb penetration depth can be made once such data becomes available, or by a UXO specialist during on-site support.

It should be noted that the maximum depth that a bomb could reach may vary across a site and will be largely dependent on the specific underlying geological strata and its density.

UXO Risk Assessment

1st Line Defence has assessed that there is an overall **Medium-High Risk** from items of Allied UXO in proximity to a former airfield bomb store, an overall **Medium Risk** from Allied UXO on part of the site near a runway and the former airfield perimeter, and an overall **Low Risk** from Allied UXO across the remainder of the site of proposed works. There is an assessed **Low Risk** from German air delivered UXO

The Risk from Allied UXO

- The majority of the site was undeveloped, and no direct evidence to confirm that it had any military usage could be identified.
- The southeastern section of the site lies adjacent to the former RAF Sandtoft. The airfield became operational in February 1944 as a Group 1 Bomber Command station and was used as a satellite base for the larger RAF Lindholme. The airfield was the base of the No. 1667 Heavy Conversion Unit, used to train pilots in the operation of heavy bombers such as the Halifax and Lancaster. The Unit was disbanded in November 1945, and the airfield went into Care and Maintenance shortly after. Selling off the airfield premises began in 1955.
- The southeastern corner of the site is partially located on, and in proximity to, the airfield bomb stores. This is shown across 1944 site plans of RAF Sandtoft (see **Annex F**), with the bomb stores on site observable within 1948 aerial imagery (see **Annex H3**). This part of the site in the southeast also passes through, and is in proximity to, the airfield perimeter. The closest dispersal pans were approximately 200m distant from the site boundary.
- As a pilot training airfield, numerous crashes are recorded in the vicinity of the site, although the majority of these occurred on the airfield premises. However, one Lancaster – on a 'Bullseye' night bombing exercise – reportedly crashed near Windsor Lane, Crowle, in 1945.
- Records indicate that Sandtoft maintained its own anti-aircraft defences. Despite this, no indication could be found to suggest the precise location of any gun sites. The closest recorded anti-aircraft position was located approximately 7.25km to the east of the site in the vicinity of Burringham.
- Online research indicates the presence of a WWI-era landing ground near the northwestern boundary of the site. As this was a basic grass landing field with minimal infrastructure, and possibly saw limited use, any extant UXO risk associated with this feature is considered to be low.

- In summary, the risk from Allied UXO is not considered homogenous across the site: see UXO Risk Mapping in **Annex N**.
- The section of the site comprising part of the airfield bomb stores and adjacent undeveloped land has been assessed as holding an overall **Medium-High Risk** from Allied UXO. Substantial quantities of ordnance were stored at bomb dumps, and the result of previous on-site UXO support conducted by 1st Line Defence – including at the former RAF Full Sutton in 2021 – illustrates that land formerly comprising bomb dumps, or land adjacent to them, may remain contaminated with ordnance in the present day. Photography of some of the finds at Full Sutton is presented in **Annex O**.
- Land separated from the bomb dump by a water drain, but in proximity to the airfield perimeter and the end of a runway – both of which potentially were a source of UXO contamination due to crashes and dumping of unneeded ordnance over the perimeter – has been assigned an overall **Medium Risk** from Allied UXO.
- The remainder of the site is not in proximity to any significant sources of UXO risk, so has been assigned an overall **Low Risk** from Allied UXO. However, a large number of bomber crashes are recorded in the vicinity of RAF Sandtoft, and training activities involving military personnel based in the area may have occurred on site. Therefore, **UXO Safety Awareness Briefings** are still recommended for the site as a whole, and it is recommended that a **UXO Risk Management Plan** is implemented.

The Risk from German Air-Delivered UXO

- During WWII the site was located within the Rural District of the Isle of Axholme in the east and the Rural District of Thorne in the west, which both sustained an overall very low density of bombing, according to official Home Office bombing statistics. This consisted of a total of just 35 and 33 high explosive bombs across 51,104 and 38,419 acres respectively; an overall average of 0.7 and 0.9 items of ordnance recorded per 1,000 acres. These districts were not a priority target for the Luftwaffe but were subject to occasional 'tip and run' and 'nuisance' raids.
- A range of wartime resources were consulted, including Air Raid Summaries, Damage Files, and Bomb Census Reports, none of which confirmed that bombing took place in proximity to the site. The fact that evidence indicates the presence of a Bomb Decoy in the southeastern corner of the site – deliberately designed to attract bombing – is of concern, although it was operational for a relatively short period between August 1941 and May 1942, after the main 'Blitz' period.
- Post-WWII aerial photography of RAF Sandtoft and adjacent land was available for consultation, in which no potential indicators of bomb damage, such as cratering, scattered earth or damaged buildings can be clearly distinguished.
- Ground cover on site is considered to have been largely unconducive to the detection of UXO. Items of UXO penetrating soft open ground could easily go unnoticed and unreported. A bomb entry hole could be as small as 20cm in diameter and therefore easily obscured in such conditions.
- Situated in a rural area, direct wartime access is anticipated to have been relatively low, although some level of local access would have been facilitated by the site's proximity to roads and residential properties including farms.
- In summary, the site was located in an area with an overall recorded 'very low' density of bombing, with none of the wartime sources consulted confirming that bombing took place in proximity to the site. The presence of a Bomb Decoy in the southeastern corner of the site – deliberately designed to attract bombing – is of concern, although it was operational for a relatively short period between August 1941 and May 1942, after the main 'Blitz' period. Given the lack of positive evidence of bombing having occurred over the site area, the risk from German UXO contamination is not thought to be significantly elevated above the generally low 'background' level for the region. The site has therefore been assigned an overall **Low Risk** from German UXO, although due to the large and undeveloped nature of the site, UXO Safety Awareness Briefings and a UXO Risk Management Plan are recommended.

Post-WWII Redevelopment

- Comparison of historical OS mapping and recent aerial imagery indicate that post-war development across the site has been minor.
- The risk of UXO remaining is considered to be mitigated at the location of and down to the depth of any post-war redevelopment on site. For example, the risk from deep buried UXO will only have been mitigated within the volumes of any post-war pile foundations or deep excavations for basement levels. The risk will however remain within virgin geology below and amongst these post-war works, down to the maximum bomb penetration depth.

Recommended Risk Mitigation Measures

The following risk mitigation measures are recommended to support the proposed works at the Tween Bridge Solar, Doncaster:

Activity	Recommended Risk Mitigation Measure
All Works	• UXO Risk Management Plan • Site Specific UXO Awareness Briefings to all personnel conducting intrusive works.
Open Excavations (trial pits, service pits, bulk excavations, strip foundations etc.) (Medium-High and Medium Risk Areas Only)	• UXO Specialist On-site Support

Note – proactive on-site UXO support/survey should not be necessary for any works taking place at the location of and down to the depths of significantly worked post-war made ground/post-war fill.

UXO Risk Map and Recommended Risk Mitigation Measures

Risk Zone	Activity	Recommended Risk Mitigation Measure
Low	All Works	• UXO Risk Management Plan • Site Specific UXO Awareness Briefings to all personnel conducting intrusive works.
Medium	Open Excavations (trial pits, service pits, bulk excavations, strip foundations etc.)	• UXO Specialist On-site Support
Medium-High		

Glossary

Abbreviation	Definition
AA	Anti-Aircraft
AFS	Auxiliary Fire Service
AP	Anti-Personnel
ARP	Air Raid Precautions
DA	Delay-action
EOC	Explosive Ordnance Clearance
EOD	Explosive Ordnance Disposal
FAA	Fleet Air Arm
FP	Fire Pot
GM	G Mine (Parachute mine)
HAA	Heavy Anti-Aircraft
HE	High Explosive
IB	Incendiary Bomb
JSEODOC	Joint Services Explosive Ordnance Disposal Operation Centre
LAA	Light Anti-Aircraft
LCC	London County Council
LRRB	Long Range Rocket Bomb (V-2)
LSA	Land Service Ammunition
NFF	National Filling Factory
OB	Oil Bomb
PAC	Pilotless Aircraft (V-1)
PB	Phosphorous Bomb
PM	Parachute Mine
POW	Prisoner Of War
RAF	Royal Air Force
RCAF	Royal Canadian Air Force
RFC	Royal Flying Corps
RNAS	Royal Naval Air Service
ROF	Royal Ordnance Factory
SA	Small Arms
SAA	Small Arms Ammunition
SD2	Anti-personnel "Butterfly Bomb"
SIP	Self-Igniting Phosphorous
U/C	Unclassified bomb
UP	Unrotated Projectile (rocket)
USAAF	United States Army Air Force
UX	Unexploded
UXAA	Unexploded Anti-Aircraft
UXB	Unexploded Bomb
UXO	Unexploded Ordnance
V-1	Flying Bomb (Doodlebug)
V-2	Long Range Rocket
WAAF	Women's Auxiliary Air Force
X	Exploded

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1st Line Defence Limited®
Detailed Unexploded Ordnance (UXO) Risk Assessment

Site: Tween Bridge Solar, Doncaster
Client: RWE Renewable UK Solar and Storage Ltd

1. Introduction

1.1. Background

1st Line Defence has been commissioned by RWE Renewable UK Solar and Storage Ltd to conduct a Detailed Unexploded Ordnance (UXO) Risk Assessment for the works proposed at Tween Bridge Solar, Doncaster.

Buried UXO can present a significant risk to construction works and development projects. The discovery of a suspect device during works can cause considerable disruption to operations as well as cause unwanted delays and expense.

UXO in the UK can originate from three principal sources:

1. Munitions resulting from wartime activities including German bombing in WWI and WWII, long range shelling, and defensive activities.
2. Munitions deposited as a result of military training and exercises.
3. Munitions lost, burnt, buried or otherwise discarded either deliberately, accidentally, or ineffectively.

This report will assess the potential factors that may contribute to the risk of UXO contamination. If an elevated risk is identified at the site, this report will recommend appropriate mitigation measures, in order to reduce the risk to as low as is reasonably practicable. Detailed analysis and evidence will be provided to ensure an understanding of the basis for the assessed risk level and any recommendations.

This report complies with the guidelines outlined in CIRIA C681, 'Unexploded Ordnance (UXO) A Guide for the Construction Industry.'

2. Method Statement

2.1. Report Objectives

The aim of this report is to conduct a comprehensive assessment of the potential risk from UXO at Tween Bridge Solar, Doncaster. The report will also recommend appropriate site and work-specific risk mitigation measures to reduce the risk from explosive ordnance during the envisaged works to a level that is as low as reasonably practicable.

2.2. Risk Assessment Process

1st Line Defence has undertaken a five-step process for assessing the risk of UXO contamination:

1. The likelihood that the site was contaminated with UXO.
2. The likelihood that UXO remains on the site.
3. The likelihood that UXO may be encountered during the proposed works.
4. The likelihood that UXO may be initiated.
5. The consequences of initiating or encountering UXO.

In order to address the above, 1st Line Defence has taken into consideration the following factors:

- Evidence of WWI and WWII German air delivered bombing as well as the legacy of Allied occupation.
- The nature and conditions of the site during WWII.
- The extent of post-war development and UXO clearance operations on site.
- The scope and nature of the proposed works and the maximum assessed bomb penetration depth.
- The nature of ordnance that may have contaminated the proposed site area.

2.3. Sources of Information

Every reasonable effort has been made to ensure that relevant evidence has been consulted and presented in order to produce a thorough and comprehensible report for the client. To achieve this the following, which includes military records and archive material held in the public domain, have been accessed:

- The National Archives and the Wakefield Archives.
- RAF site plans obtained from the RAF Museum, Hendon.
- Historical mapping datasets.
- Historic England National Monuments Record.
- Relevant information supplied by RWE Renewable UK Solar and Storage Ltd.
- Available material from 33 Engineer Regiment (EOD) Archive (part of 29 Explosive Ordnance and Disposal and Search Group).
- 1st Line Defence's extensive historical archives, library and UXO geo-datasets.
- Open sources such as published books and internet resources.

3. Background to Bombing Records

3.1. General Considerations of Historical Research

This desktop assessment is based largely upon analysis of historical evidence. Every reasonable effort has been made to locate and present significant and pertinent information. 1st Line Defence cannot be held accountable for any changes to the assessed risk level or risk mitigation measures, based on documentation or other data that may come to light at a later date, or which was not available to 1st Line Defence during the production of this report.

It is often problematic and sometimes impossible to verify the completeness and accuracy of WWII-era records. As a consequence, conclusions as to the exact location and nature of a UXO risk can rarely be quantified and are, to a degree, subjective. To counter this, a range of sources have been consulted, presented and analysed. The same methodology is applied to each report during the risk assessment process. 1st Line Defence cannot be held responsible for any inaccuracies or the incompleteness in available historical information.

3.2. German Bombing Records

During WWII, bombing records were generally gathered locally by the police, Air Raid Precaution (ARP) wardens and military personnel. These records typically contained information such as the date, the location, the amount of damage caused and the types of bombs that had fallen during an air raid. This information was made either through direct observation or post-raid surveys. The Ministry of Home Security Bomb Census Organisation would then receive this information, which was plotted onto maps, charts, and tracing sheets by regional technical officers. The collective record set (regional bomb census mapping and locally gathered incidents records) would then be processed and summarised into reports by the Ministry of Home Security Research and Experiments Branch. The latter were tasked with providing the government 'a complete picture of air raid patterns, types of weapons used and damage caused- in particular to strategic services and installations such as railways, shipyards, factories and public utilities.'

The quality, detail and nature of record keeping could vary considerably between provincial towns, boroughs and cities. No two areas identically collated or recorded data. While some local authorities maintained records with a methodical approach, sources in certain areas can be considerably more vague, dispersed, and narrower in scope. In addition, the immediate priority was mostly focused on assisting casualties and minimising damage at the time. As a result, some records can be incomplete and contradictory. Furthermore, many records were even damaged or destroyed in subsequent air raids. Records of raids that took place on sparsely or uninhabited areas were often based upon third party or hearsay information and are therefore not always reliable. Whereas records of attacks on military or strategic targets were often maintained separately and have not always survived.

3.3. Allied Records

During WWII, considerable areas of land were requisitioned by the War Office for the purpose of defence, training, munitions production and the construction of airfields. Records relating to military features vary and some may remain censored. Within urban environments datasets will be consulted detailing the location of munition production as well as wartime air and land defences. In rural locations it may be possible to obtain plans of military establishments, such as airfields, as well as training logs, record books, plans and personal memoirs. As with bombing records, every reasonable effort will be made to access records of, and ascertain any evidence of, military land use. However, there are occasions where such evidence is not available, as records may not be accessible, have been lost/destroyed, or simply were not kept in the first place.

4. UK Regulatory Environment and Guidelines

4.1. General

There is no formal obligation requiring a UXO risk assessment to be undertaken for construction projects in the UK, nor is there any specific legislation stipulating the management or mitigation of UXO risk. However, it is implicit in the legislation outlined below that those responsible for intrusive works (archaeology, site investigation, drilling, piling, excavation etc.) should undertake a comprehensive and robust assessment of the potential risks to employees and that mitigation measures are implemented to address any identified hazards.

4.2. CDM Regulations 2015

The Construction (Design and Management) Regulations 2015 (CDM 2015) define the responsibilities of parties involved in the construction of temporary or permanent structures.

The CDM 2015 establishes a duty of care extending from clients, principle designers, and contractors to those working on, or affected by, a project. Those responsible for construction projects may therefore be accountable for the personal or proprietary loss of third parties, if correct health and safety procedure has not been applied.

Although the CDM does not specifically reference UXO, the risk presented by such items is both within the scope and purpose of the legislation. It is therefore implied that there is an obligation for parties to:

- Provide an appropriate assessment of potential UXO risks at the site (or ensure such an assessment is completed by others).
- Put in place appropriate risk mitigation measures if necessary.
- Supply all parties with information relevant to the risks presented by the project.
- Ensure the preparation of a suitably robust emergency response plan.

4.3. The 1974 Health and Safety at Work etc. Act

All employers have a responsibility under the Health and Safety at Work etc. Act 1974 and the Management of Health and Safety at Work Regulations 1999, to ensure the health and safety of their employees and third parties, so far as is reasonably practicable and conduct suitable and sufficient risk assessments.

4.4. CIRIA C681

In 2009, the Construction Industry Research and Information Association (CIRIA) produced a guide to the risk posed by UXO to the UK construction industry (CIRIA C681). CIRIA is a neutral, independent and not-for-profit body, linking organisations with common interests and facilitating a range of collaborative activities that help improve the industry.

The publication provides the UK construction industry with a defined process for the management of risks associated with UXO from WWI and WWII air bombardment. It is also broadly applicable to the risks from other forms of UXO that might be encountered. It focuses on construction professionals' needs, particularly if there is a suspected item of UXO on site, and covers issues such as what to expect from a UXO specialist. The guidance also helps clients to fulfil their legal duty under CDM 2015 to provide designers and contractors with project specific health and safety information needed to identify hazards and risks associated with the design and construction work. This report conforms to this CIRIA guidance and to the various recommendations for good practice referenced therein. It is recommended that this document is acquired and studied where possible to allow a better understanding of the background to both the risk assessment process and the UXO issue in the UK in general.

4.5. Additional Legislation

In the event of a casualty resulting from the failure of an employer/client to address the risks relating to UXO, the organisation may be criminally liable under the Corporate Manslaughter and Corporate Homicide Act 2007.

5. The Role of Commercial UXO Contractors and The Authorities

5.1. Commercial UXO Specialists

The role of a UXO Specialist (often referred to as UXO Consultant or UXO Contractor) such as 1st Line Defence, is defined in CIRIA C681 as the provision of expert knowledge and guidance to the client on the most appropriate and cost-effective approach to UXO risk management at a site.

The principal role of UXO Specialists is to provide the client with an appropriate assessment of the risk posed by UXO for a specific project, and identify and carry out suitable methodology for the mitigation of any identified risks to reduce them to an acceptable level.

The requirement for a UXO Specialist should ideally be identified in the initial stages of a project, and it is recommended that this occur prior to the start of any detailed design. This will enable the client to budget for expenditure that may be required to address the risks from UXO, and may enable the project team to identify appropriate techniques to eliminate or reduce potential risks through considered design, without the need for UXO specific mitigation measures. The UXO Specialist should have suitable qualifications, levels of competency and insurances.

Please note 1st Line Defence has the capability to provide a complete range of required UXO risk mitigation services, in order to reduce a risk to as low as reasonably practicable. This can involve the provision of both ground investigation, and where appropriate, UXO clearance services.

5.2. The Authorities

The police have a responsibility to co-ordinate the emergency services in the event of an ordnance-related incident at a construction site. Upon inspection they may impose a safety cordon, order an evacuation, and call the military authorities Joint Services Explosive Ordnance Disposal Operation Centre (JSEODOC) to arrange for investigation and/or disposal. Within the Metropolitan Police Operational Area, SO15 EOD will be tasked to any discovery of suspected UXO. The request for Explosive Officer (Expo) support is well understood and practiced by all Metropolitan Boroughs. The requirement for any additional assets will then be coordinated by the Expo if required.

In the absence of a UXO specialist, police officers will usually employ such precautionary safety measures, thereby causing works to cease, and possibly requiring the evacuation of neighbouring businesses and properties.

The priority given to the police request will depend on the EOD teams' judgement of the nature of the UXO risk, the location, people and assets at risk, as well as the availability of resources. The speed of response varies; authorities may respond immediately or in some cases it may take several days for the item of ordnance to be dealt with. Depending on the on-site risk assessment the item of ordnance may be removed from the site and/or destroyed by a controlled explosion.

Following the removal of an item of UXO, the military authorities will only undertake further investigations or clearances in high-risk situations. If there are regular UXO finds on a site the JSEODOC may not treat each occurrence as an emergency and will recommend the construction company puts in place alternative procedures, such as the appointment of a commercial contractor to manage the situation.

6. The Site

6.1. Site Location

The site is located in a rural area, with the majority – in the west - within the Metropolitan Borough of the City of Doncaster, South Yorkshire, and the remainder in the east within the Civil Parishes of Belton and Crowle, North Lincolnshire. The site's immediate surrounds are largely undeveloped, with Crowle to the east, Sandtoft to the south, and Thorne to the west, with the former RAF Sandtoft bordering the site in the southeast.

The site is approximately centred on the OS grid reference: **SE 72019 11479**.

Site location maps are presented in **Annex A**.

6.2. Site Description

Recent aerial imagery indicates that the site predominantly comprises undeveloped land.

A recent aerial photograph and site plans are presented in **Annex B** and **Annex C** respectively.

7. Scope of the Proposed Works

7.1. General

It is understood that a solar farm is planned for the site, including a battery storage facility, cabling, high voltage equipment and ancillaries. This will be facilitated with intrusive geotechnical works and other surveys including solar frame pull-out testing and boreholing.

8. Ground Conditions

8.1. General Geology

The British Geological Survey (BGS) map shows the north of the site to be underlain by the Sherwood Sandstone Group – sandstone formed between 252.2 million and 241.5 million years ago during the Triassic period. The east and southeast of the site is underlain by the Mercia Mudstone Group - mudstone formed between 247.1 million and 201.3 million years ago during the Triassic period. The southwest of the site is underlain by the Chester Formation – pebbly (gravelly) sandstone formed between 250 million and 247.1 million years ago.

Superficial deposits are varied, and include the following, beginning in the north and proceeding clockwise:

- Peat, formed between 2.588 million years ago and the present day during the Quaternary period
- Warp – clay and silt formed between 11,800 years ago and the present day
- Alluvium – clat, silt, sand and gravel formed between 2.588 million years ago and the present day
- Sutton Sand Formation – sand formed between 116,000 years ago and the present day
- Hemingbrough Glaciolacustrine Formation – silty clay formed between 116,000 and 11,800 years ago

8.2. Site-Specific Geology

Detailed contemporary borehole logs were not provided by the client during the production of this report.

9. Site History

9.1. Introduction

The purpose of this section is to identify the composition of the site pre and post-WWII. It is important to establish the historical use of the site, as this may indicate the site's relation to potential sources of UXO as well as help with determining factors such as the land use, groundcover, likely frequency of access and signs of bomb damage.

9.2. Historical Summary of RAF Sandtoft

The site lies adjacent to the former RAF Sandtoft. The airfield became operational in February 1944 as a Group 1 Bomber Command station and was used as a satellite base for the larger RAF Lindholme. The airfield was the base of the No. 1667 Heavy Conversion Unit, used to train pilots in the operation of heavy bombers such as the Halifax and Lancaster. The Unit was disbanded in November 1945, and the airfield went into Care and Maintenance shortly after. Selling off of the airfield premises began in 1955.

9.3. Ordnance Survey Historical Mapping

Historical mapping was obtained for this report and is presented in **Annex D**. This map provides an indication of the composition of the site in the WWII era. Later sections of the report present and detail other available mapping, plans and photography and should be read in conjunction with this section as often civilian OS mapping does not show many of the historic features of some military airfields.

WWII-era		
Date	Scale	Description
1946	One Inch to the Mile	In this immediate post-war OS mapping, the site is indicated to predominantly comprise undeveloped land, as are its immediate surrounds. Some areas of residential development are visible around the site, as well as roads and canals. *WWII era airfield plans will generally be censored, appearing as blank fields or as whited out areas. Censorship often extends into the post-war era if the airfield remained in RAF or US control.*

10. Introduction to Allied Ordnance

10.1. General

Whilst airfields often have individual characteristics in terms of their usage, purpose and history, most military airfields utilise Allied ordnance as part of their daily operation. Typically, this ordnance can include SAA, LSA or larger air-dropped bombs, which are stored in designated areas within the station including bomb or pyrotechnic stores. Typical activities and uses that may have led to a legacy of UXO contamination at a military airfield within the UK include weapons training and firing ranges, defence exercises, weapon transport and storage areas and anti-aircraft emplacements, as well as WWII-era demolition charges and Home Guard positions.

10.2. Aircraft Munitions

The table below depicts a selection of typical aircraft ordnance. It should be noted that the range is representative of the weaponry most commonly fitted to/carried by military aircraft, and further types of weaponry may have been present at the airfield. For more examples of British air delivered ordnance, see **Appendices i-ii**.

Typical Aircraft Munitions	
Item	Description
Machine Guns/Small arms	Most military aircraft, including fighter, bomber and helicopter transporter aircraft are equipped with light armaments that employ small arms ammunition. These are typically either machine guns or light cannons, although some larger calibre guns have historically been fitted to aircraft designed specialist roles. Military aircrews are sometimes issued with a sidearm and signal flares for defence and survival should they be shot down or forced to bail out.
Cannon Rounds	Cannons are typically 20-40mm automatic guns that fire filled projectiles, usually HE, Incendiary or a mixture of the two. Cannons provide aircraft with better offensive capability, and are standard equipment for most modern aircraft. Historically, cannons were fitted to aircraft designed for a specialist role, such as ground attack aircraft or fighter interceptors.
General Purpose/Medium Capacity HE Bombs	General purpose HE bombs of various calibres have been the mainstay armament of military aircraft since the First World War. They are fuzed explosive bombs designed to destroy targets with a large blast. General purpose bombs are used for attacking ground targets and depending on the aircraft, large quantities of these can be carried. They were extensively used during WWII, and are still in service within many countries, alongside guided bombs and missiles.
Heavy Bombs	In addition to general purpose HE bombs, aircraft are sometimes capable of carrying especially large bombs designed for specialist roles or certain targets. During WWII the RAF developed a number of specialist 'earthquake bombs' designed to crack heavy fortifications. Modern equivalents of these bombs are also in service with some countries, designed for similar roles.
Incendiary Bombs	Incendiary bombs are also a mainstay of many military aircraft. They are typically smaller, filled with incendiary chemicals and are usually dropped against targets in quantity. Larger incendiary bombs are also sometimes employed, sometimes as area affect weapons against personnel.

10.3. Practice Bombs

Practice bombing is often undertaken by US and RAF aircraft, and has been part of crew training since WWI. Aircrews would load their aircraft with smaller practice bombs, which would often be fitted with a smoke or flash element to mark the position of each bomb. These are then dropped on a ground and sea targets to test accuracy, often under combat conditions. Practice bombing is intended to train pilots and bombardiers, and is often supplemented by live bombing practice at dedicated ranges.

It is possible that practice bombing was undertaken at RAF Sandtoft. Practice bombing is considered to have taken place at most locations under the control of Bomber Command and could even include the landing grounds of RAF stations, which were sometimes used as makeshift target areas during the early stages of WWII; prior to the establishment of dedicated inland ranges. Dedicated records concerning incidents of practice bombing are however rare. Examples of British practice bombs can be found in **Appendices iii-iv**.

10.4. Land Service Ammunition

Land Service Ammunition (LSA) is commonly stored and utilised at most RAF Stations and is used during activities such as defensive exercises and weapons training practice. LSA covers items of ordnance that are propelled, placed, or thrown during land warfare. These items may be filled or charged with explosives, smoke, incendiary, or pyrotechnics and can be divided into five main groups:

Land Service Ammunition (LSA)	
Item	Description
Mortar Rounds	A mortar round is normally nosed-fused and fitted with its own propelling charge. Its flight is stabilised by the use of a fin. They are usually tear-drop shaped (though older variants are parallel sided), with a finned 'spigot tube' screwed or welded to the rear end of the body which houses the propellant charge. Mortars are either High Explosive or Carrier (i.e. smoke, incendiary, or pyrotechnic).
Grenades	A grenade is a short range weapon designed to kill or injure people. It can be hand thrown or fired from a rifle or a grenade launcher. Grenades either contain high explosive or smoke producing pyrotechnic compounds. The common variants have a classic 'pineapple' shape.
Projectiles	A projectile (or shell) is propelled by force, normally from a gun, and continues in motion using its kinetic energy. The gun a projectile is fired from usually determines its size. A projectile contains a fuzing mechanism and a filling. Projectiles can be high explosive, carrier or Shot (a solid projectile).
Rockets	Rockets were commonly designed to destroy heavily armoured military vehicles (anti-tank weapon). The device contains an explosive head (warhead) that can be accelerated using internal propellants to an intended target. Anti-aircraft rocket batteries were also utilised as part of air defence measures.
Landmines	A landmine is designed to be laid on or just below the ground to be exploded by the proximity or contact of a person or vehicle. Landmines were often placed in defensive areas of the UK to obstruct potential invading adversaries. Landmines were often placed at airfields during WWII, most commonly in the form of pipemines, known as McNaughton tubes, for anti-invasion area denial.

Images of the most commonly found items of LSA are presented in **Appendices v - vii**.

10.5. Small Arms Ammunition

Small Arms Ammunition (SAA) refers to the complete round or cartridge designed to be discharged from varying sized hand-held weapons such as rifles, machine guns and pistols. SAA can include bullets, cartridge cases and primers/caps. Example imagery of SAA are presented in **Appendix viii.**

Military airfields often have SAA present from a variety of different sources. In both WWI and WWII, the primary armament of military aircraft was a machinegun or cannon. These came in various forms, including guns fixed within the wings, nose, and also flexible mounts and turrets, which were operated manually by aircrew. Prior to the 1950s, airfields were also often defended by AA machineguns and cannons, and often a purpose-built SAA range was present within an airfield for marksmanship practice or testing aircraft armaments.

Following the end of WWII and the advancement of technology in the post-war period, machineguns were no longer an effective AA defence. However, it should be noted that small-arms may have been retained for marksmanship practice at dedicated ranges.

10.6. Anti-Aircraft Artillery (AAA)

It is not uncommon for military airbases to maintain their own anti-aircraft defences. Most notably during WWII when RAF stations were targeted by the Luftwaffe and active anti-aircraft defences, including both projectile gun sites and machine gun posts, were regularly employed in the defence of airbases.

During WWII three main types of gun sites existed: heavy anti-aircraft (HAA), light anti-aircraft (LAA) and 'Z' batteries (ZAA). If the projectiles and rockets fired from these guns failed to explode or strike an aircraft they would descend back to land. The table below provides further information on the operation and ordnance associated with these type of weapons.

Anti-Aircraft Artillery				
Item	**Description**			
HAA	These large calibre guns such as the 3.7" QF (Quick Firing) were used to engage high flying enemy bombers. They often fired large HE projectiles, which were usually initiated by integral fuzes, triggered by impact, area, time delay or a combination of aforementioned mechanisms.			
LAA	These mobile guns were intended to engage fast, low flying aircraft. They were typically rotated between locations on the perimeters of towns and strategically important industrial works. As they could be moved to new positions with relative ease when required, records of their locations are limited. The most numerous of these were the 40mm Bofors gun which could fire up to 120 x 40mm HE projectiles per minute to over 1,800m.			
Variations in HAA and LAA Ammunition	**Gun type**	**Calibre**	**Shell Weight**	**Shell Dimensions**
	3.0 Inch	76mm	7.3kg	76mm x 356mm
	3.7 Inch	94mm	12.7kg	94mm x 438mm
	4.5 Inch	114mm	24.7kg	114mm x 578mm
	40mm	40mm	0.9kg	40mm x 311mm
Z-AA	Rockets were commonly designed to destroy heavily armoured military vehicles (anti-tank weapon). The device contains an explosive head (warhead) that can be accelerated using internal propellants to an intended target. Anti-aircraft rocket batteries were also utilised as part of air defence measures.			

Illustrations of Anti-Aircraft artillery, projectiles and rockets are presented at **Appendix ix**.

11. The Likelihood of Contamination from Allied Ordnance

11.1. Introduction

When undertaking construction work within or immediately adjacent to a site with previous and/or current military use, it is often considered likely to contain an elevated risk of contamination from Allied UXO. This assumption of risk is based on the following reasoning:

- The clearance of ordnance from military camps, depots, storage facilities, ranges and training areas were not always effectively managed, or undertaken to equivalent degrees of certainty. In addition, search and detection equipment used over seventy years following WWII has proved ineffective both for certain types of UXO and at depths beyond capability.
- In the vast majority of cases, explosive ordnance would have been stored and available for use at military installations. Ordnance ranged from small arms and land service ammunition to weapons components and larger, air delivered items. During periods of heightened activity, ordnance was also frequently lost in transit, particularly between stores and assigned training locations.
- The military generally did not anticipate that their land would be later sold for civilian development, and consequently appropriate ordnance disposal procedure was not always adhered to. It was not uncommon for excess or unwanted ordnance to be buried or burnt within the perimeters of a military establishment as a means of disposal. Records of such practice were rarely kept.

There are several factors that may serve to either affirm, increase, or decrease the level of risk within an airfield. Such factors are typically dependent upon the proximity of the proposed area of works to a number of airfield features. The risk from Allied ordnance may also relate to the function of the airfield, the presence of any military training activities and any aviation incidents recorded within, or proximate to an airfield.

This section will examine the history of the airfield and assess to what degree, if any, the site could have become contaminated as a result of the historic/current military use of the surrounding area.

11.2. Operational Usage of RAF Sandtoft

11.2.1. RAF Sandtoft During WWII

Heavy Conversion Units were formed in late 1941 and were used to train crews with previous experience of medium bombers to operate heavy bombers in order to be posted to operational squadrons. Some of the heavy conversion units were involved in bombing operations over Germany. RAF Sandtoft opened in early 1944, with No, 1667 HCU stationed there. It continued in this role until November 1945.

Operations Record Books indicate that RAF Sandtoft was defended by a Paratrooper regiment forming the Station Anti-Aircraft Flight. The regiment were likely to have been equipped with a range of LSA, and may have undertaken training in the vicinity of the base. Training was frequently undertaken at RAF bases as they were large open military controlled areas. Such ground training exercises would often have to potential to lead to contamination from UXO – items of LSA/SAA being discarded, mis-fired, lost or disposed of within the airfield perimeters – especially in open and more remote areas of a station.

Records account for home guard activity in the vicinity of the site. Home guard frequently used RAF bases as they were large and relatively safe/controlled training areas. As with other ground training exercises, it was not uncommon for the Home Guard to leave a legacy of contamination within airfield sites – again, either through mis-fire or loss, or more commonly through poor disposal of unwanted/unused weaponry.

Imagery detailing RAF Sandtoft's operational usage are presented in **Annex E.**

11.3. Site Plans of RAF Sandtoft

Plans RAF Sandtoft were obtained from the RAF Museum, Hendon, and published literature. The plans identify the buildings of the airfield and explains what they were used for. The plans for the airfield is presented in **Annex F.**

Date Range	Comments
December 1944 (**Annex F1)**	This late-war plan of limited detail indicates the premises of the airfield including the perimeter in a dashed line. The southeastern corner of the site passes through the airfield premises to the north of the main taxiway.
January 1944 (**Annex F2)**	This Annex provides a view of the section of a detailed site plan in proximity to the site. The site boundary passes through the airfield bomb store.

11.4. RAF Sandtoft Operations Record Books

Written records regarding the daily life and operation of Sandtoft have been obtained from the National Archives. These sources recorded the day-to-day operations of an airfield, as well as training exercises in the immediate and surrounding area. Photographs of these, highlighting relevant information, are shown in **Annex G1**. General military activity during the war is presented below.

It should be noted that the transcript below is only a selection of the numerous events accounted for in the record book.

Date Range	Comments
February 1944	Discusses the opening of the station and its role as a base for No. 1667 Heavy Conversion Unit. .
March 1944	Example entries of Sandtoft as a backup for diverted aircraft based at other airfields.
April 1944	Example entry of base defences, which included heavy machine guns.

11.5. RAF Sandtoft Operations Record Books – Aircraft Crashes

Aircraft crashes have been historically common at military airfields, especially during wartime. These incidents most commonly occurred during take-off and landing. Consequently there is an increased level of risk associated to areas situated at the ends of airfield runways. The risk of contamination resulting from crashes depends on the nature of the incident and the aircraft involved. Airfields were not used solely by the aircraft stationed at that base, and an airfield may have been used by any aircraft during an emergency.

Various crashes are recorded in the airfield ORB, which are presented in **Annexes G2 – G4** and described below. Crashes were categorised from AC – meaning usually repairable at site – to category E, which was a total write-off.

Date Range	Comments
25/03/44	'Halifax V GG/M (DG 293) making difficult landing on 2 engines struck stationary aircraft (EB 144 CAT E) when on ground after landing off runway at 0105 hrs. (CAT E) no casualties'.
27/03/44	'Halifax V GG /D (DG 305) swung off runway on take off with burst tyre and under carriage collapsed at 0023 hrs. (CAT E) no casualties'.
01/04/44	'At 18.04 hours Halifax V. "G" DG.355 whilst taking off swung to port and undercarriage collapsed. No casualty Cat. E'.
13/04/44	'At 17.26 hours Halifax V. "U" DG. 351 was attempting landing with port outer engine feathered made three overshoots and on the third attempt after overshoot, pilot lost height and crash-landed in a field with undercarriage up Cat. E. No casualty'.
14/04/44	'At 01.46 hours Halifax V. "P" DG.345 whilst taking off, swung to port, starboard undercarriage collapsed. No casualty Cat AC'.
22/04/44	'At 03.10 hours Halifax V. A2.DK.186 taxied off perimeter track into ditch'.
28/04/44	'At 00.56 hours Halifax V. "J" DG.317 taxied into rear of "O" DG.347 whilst taxying round the perimeter track to take off. "O" was stationary at the marshalling post undergoing inspection by tyre checkers'.
08/05/44	'Halifax V LL391. At 21.59 hours during take-off on high cross country, aircraft commenced to swing to starboard; pilot overcorrected swing and aircraft swung to port. Undercarriage collapsed and starboard outer engine caught fire'.
13/05/44	'Halifax V IX. 991. At 17.24 hours pupil came in to land too high, and when corrected by Instructor failed to keep sufficient throttle on to ease aircraft on to runway. Instructor took over but could not correct altitude of aircraft in time to prevent stall on to runway. Undercarriage collapsed'.
13/05/44	'Halifax V DG.309. At 20.44 hours whilst on circuits and landings, aircraft swung violently to port on sixth take off and pilot failed to correct it; undercarriage collapsed'.
13/05/44	'Halifax D/L.K. 991 crashed on landing. P/O Parson's (pupil Pilot) F/Sgt. Lister A/G. admitted S.S.Q. with injuries to back.
06/06/44	'Halifax V DG345. Coming off runway on landing and crashed into EB 194 which was stationary on a dispersal. Pilot of DG345 F/O. Tritton stated that throttles were jammed when coming into land'.
30/06/44	'Halifax V DG338 burst tyre on take-off and swung off runway'.
25/07/44	'Halifax V DG 310 At Sandtoft. Heavy landing caused shearing of pins securing self-centring cam on tail oleo leg. Lower sleeve and tail wheel dropped out on next take-off. Aircraft landed on rear fuselage'.
18/08/44	'Halifax V LL226 at Sandtoft; Starboard undercarriage collapsed on landing due to failure of outboard radius rod. Fracture apparently due to drift while landing on previous heavy landing'.
06/09/44	Halifax V. DK. 133. Struck ground shortly after take-off on night flying detail. All crew killed A/C Cat. E burnt out'.

24/09/44	Halifax V.DK 173. Starboard inner failed shortly after take-off. Pilot alleged port inner was failing on the downwind leg. Did belly landing on grass, Starboard inner failed due to severe internal coolant leak followed by valves sticking and disintegration of flame traps'.
12/11/44	'Halifax V. LL. 389 was returning from a cross country detail and attempted to land in bad weather- approached too fast- held off too much- and ballooned- stalled and dropped on the runway bursting the port tyre and damaging the port undercarriage. A/C swung off runway and port undercarriage collapsed causing severe damage to the port wing'.
07/01/45	'Lancaster ND477 skidded on the ice when turning off the runway on to the perimeter track. The port wheel struck a patch of frozen ground broadside on with considerable force causing the wheel to break off and the undercarriage to collapse'.
20/03/45	'Lancaster W4154 bounced on landing and came down on the grass about 50 yds. from the runway. The aircraft ran parallel to runway for some distance, but struck the end of a ditch with starboard wheel causing undercarriage to collapse and aircraft to swing round violently'.
February 1945	'The engines had cut due to mis-manipulation of fuel cocks causing a tank to run dry. After trying to re-start Pilot attempted two engine landing at Sandtoft, but overshot. Two remaining engines cut during further circuit due to other tank running dry and Pilot landed at Lindholme'.
05/04/45	'Lancaster I.N.D 639 at night dived into ground at high speed- cause of accident obscure. Crew all killed'.[1]
09/04/45	Lancaster I.D.V. 165 swung on take off. Fire when engines struck ground on collapse of undercarriage'.
15/04/45	'Lancaster I.P.B. 565 dived into ground during daylight- cause obscure. Crew all killed'. The location is not provided.
07/05/45	'Lancaster I.HK.751. The aircraft bounced on landing and through faulty manipulation of throttles was allowed to stall which caused the starboard undercarriage to collapse'.

11.6. Historic Aerial Photography

High-resolution scans of WWII-era aerial photography for the site area were obtained from the National Monuments Record (Historic England). Imagery dated 1948 is presented in **Annex H**.

Considering the size of the site and its location in a rural area, WWII-era aerial photography was only available for a small section of the site – largely in proximity to RAF Sandtoft.

Date	Comments
18th May 1948	This post-WWII imagery provides a view of part of the eastern section of the site, which is predominantly undeveloped. The only Allied feature that can be clearly distinguished is part of the airfield bomb stores, in the bottom right corner.
21st September 1948	This photograph provides a view of the site in proximity to RAF Sandtoft. The bomb stores, highlighted in **Annex H3**, are visible partially within the site boundary.

[1] Location not provided, but online research indicates that this crash occurred near Windsor Lane, Crowle. Aircraft returning from a 'Bullseye' night target-finding exercise., which sometimes involved the dropping of bombs. https://www.bcar.org.uk/search-crash-logs.php?q=sandtoft&Submit=start+search.

11.7. Evaluation of Contamination Risk from Allied UXO

1st Line Defence has considered the following potential sources of Allied ordnance contamination:

Allied UXO Records Summary	
Sources of Allied UXO Contamination	**Conclusion**
Site Usage *Airfields contain a number of features that may increase the risk of UXO contamination. Physical proximity to such a feature is usually indicative of risk.*	The site lies adjacent to the former RAF Sandtoft. The airfield became operational in February 1944 as a Group 1 Bomber Command station and was used as a satellite base for the larger RAF Lindholme. The airfield was the base of the No. 1667 Heavy Conversion Unit, used to train pilots in the operation of heavy bombers such as the Halifax and Lancaster. The Unit was disbanded in November 1945, and the airfield went into Care and Maintenance shortly after. Selling off the airfield premises began in 1955. The majority of the remainder of the site was undeveloped, and no direct evidence to confirm that it had any military usage could be identified.
Ordnance Stores/Armoury *Ordnance stores contained large quantifiers of munitions. Adjacent areas may have been used to bury or dispose of excess ordnance.*	The southeastern corner of the site is partially located on, and in proximity to, the airfield bomb stores.
Proximity to Perimeter Fence *Although seemingly innocuous, areas of open ground adjacent to the perimeter fence are considered of elevated risk as they were considered prime locations for ordnance burial.*	Part of the site in the southeast passes through, and is in proximity to, the airfield perimeter.
Military Facilities *Other military facilities besides RAF Sandtoft.*	Online research indicates the presence of a WWI-era landing ground near the northwestern boundary of the site.[2] As this was a basic grass landing field with minimal infrastructure, and possibly saw limited use, any extant UXO risk associated with this feature is considered to be low.
Aircraft Crashes *Aircraft crashes were common at airfields. The most common places for aircraft to crash was at the ends of runways. Airfield in the south of England were often used by damaged aircraft for the purposes of emergency landings. Crashes can be sources for potential UXO contamination, especially if the aircraft was en-route to or returning from operations.*	As a pilot training airfield, numerous crashes are recorded in the vicinity of the site, although the majority of these occurred on the airfield premises. However, one Lancaster – on a 'Bullseye' night bombing exercise – reportedly crashed near Windsor Lane, Crowle, in 1945.
Dispersal Pans *Dispersal pans were used to re-equip aircraft between sorties. Frequently temporary stores were located at dispersal pans.*	The closest dispersal pans were approximately 200m distant from the site boundary.
Defensive Positions *Airfields were frequently defended by numerous defensive positions. It is not uncommon for items of LSA and SAA to be encountered in the vicinity of such locations.*	There is no evidence of any defensive structures such as pillboxes or trenches within the vicinity of the site.
Firing Ranges *Firing ranges were common at most airfields. Many firing range also feature grenade pits.*	No evidence of firing ranges, practice butts or any other areas could be identified within the boundary of the site.

[2] https://northlincsweb.net/RAFElshamWolds/html/thorne.html.

Demolition Charges *Many airfields were undermined by demolition mines such as McNaughton Tubes and Pipe Mines. Many of these devices were not removed or lost.*	No evidence of the use of demolition charges such as pipe mines and other area-denial weaponry at RAF Sandtoft could be found within available records.
Training Exercises / Home Guard Activity *It was common for defence training activities to be undertaken in the vicinity of airfields. Such exercises frequently involved the deployment of live ordnance.*	Evidence of Home Guard activity is often difficult to locate, owing to the ad-hoc nature of Home Guard activity within each local area. Such training was often conducted on a small scale at the discretion of individual commanders and as such was seldom recorded officially. No positive evidence could be found to confirm the presence of HG units within proximity to RAF Sandtoft. Despite this, it should be noted that HG units were sometimes employed to defend or police RAF installations. Training was frequently undertaken at RAF bases as they were large, open military controlled areas. Such training has the potential to have involved the usage of land service ammunition such as grenades and mortars, which have the potential to have been defective or else incorrectly deployed and not recovered.
Anti-Aircraft Defences *Airfields were defended by a range of AAA. Ordnance is frequently encountered in the vicinity of AA batteries.*	Records indicate that Sandtoft maintained its own anti-aircraft defences. Despite this, no indication could be found to suggest the precise location of any gun sites. The closest recorded anti-aircraft position was located approximately 7.25km to the east of the site in the vicinity of Burringham.

12. Introduction to German Air Delivered Ordnance

12.1. General

During the summer of 1940 the Luftwaffe launched a major offensive against British airfields. The campaign, known as the Battle of Britain, saw the Luftwaffe attempt to attain air superiority prior to the invasion of Great Britain. To this end they extensively bombed British airfields, especially within the South and East of England. Although the objectives of the Luftwaffe altered in September 1940 to encompass towns, cities and industry, airfields were regularly targeted by the Luftwaffe until the conclusion of the war. The specifics of any bombing within the RAF station or the surrounding area is discussed in the following sections.

The main focus of research for this section of the report will concern German air delivered ordnance dropped during WWII, although WWI bombing will also be considered.

12.2. Generic Types of WWII German Air Delivered Ordnance

To provide an informed assessment of the hazards posed by any items of unexploded ordnance that may remain in situ on site, the table below provides information on the types of German air delivered ordnance most commonly used by the Luftwaffe during WWII. Images and brief summaries of the characteristics of these items of ordnance are listed in **Appendices x-xii**.

Generic Types of WWII German Air Delivered Ordnance		
Type	Frequency	Likelihood of Detection
High Explosive (HE) bombs	In terms of weight of ordnance dropped, HE bombs were the most frequently deployed by the Luftwaffe during WWII.	Although efforts were made to identify the presence of unexploded ordnance following an air raid, often the damage and destruction caused by detonated bombs made observation of UXB entry holes impossible. The entry hole of an unexploded bomb can be as little as 20cm in diameter and was easily overlooked in certain ground conditions (see **Annex I**). Furthermore, ARP documents describe the danger of assuming that damage, actually caused by a large UXB, was due to an exploded smaller bomb. UXBs therefore present the greatest risk to present–day intrusive works.
1kg Incendiary bombs (IB)	In terms of the number of weapons dropped, small IBs were the most numerous. Millions of these were dropped throughout WWII.	IBs had very limited penetration capability and in urban areas would often have been located in post-raid surveys. If they failed to initiate and fell in water, on soft vegetated ground, or bombed rubble, they could easily go unnoticed.
Large Incendiary bombs (IB)	These were not as common as the 1kg IBs, although they were more frequently deployed than PMs and AP bomblets.	If large IBs did penetrate the ground, complete combustion did not always occur and in such cases they could remain a risk to intrusive works.
Aerial or Parachute mines (PM)	These were deployed less frequently than HE and IBs due to size, cost and the difficulty of deployment.	If functioning correctly, PMs would generally have had a slow rate of descent and were very unlikely to have penetrated the ground. Where the parachute failed, mines would have simply shattered on impact if the main charge failed to explode. There have been extreme cases when these items have been found unexploded. However, in these scenarios, the ground was either extremely soft or the munition fell into water.
Anti-personnel (AP) bomblets	These were not commonly used and are generally considered to pose a low risk to most works in the UK.	SD2 bomblets were packed into containers holding between 6 and 108 submunitions. They had little ground penetration ability and should have been located by the post-raid survey unless they fell into water, dense vegetation or bomb rubble.

12.3. Failure Rate of German Air Delivered Ordnance

It has been estimated that 10% of WWII German air delivered HE bombs failed to explode as designed. Reasons for why such weapons might have failed to function as designed include:

- Malfunction of the fuze or gain mechanism (manufacturing fault, sabotage by forced labour or faulty installation).
- Many were fitted with a clockwork mechanism that could become immobilised on impact.
- Failure of the bomber aircraft to arm the bombs due to human error or an equipment defect.
- Jettisoning the bomb before it was armed or from a very low altitude. This most likely occurred if the bomber aircraft was under attack or crashing.

From 1940 to 1945, bomb disposal teams reportedly dealt with a total of 50,000 explosive items of 50kg, over 7,000 anti-aircraft projectiles and 300,000 beach mines. Unexploded ordnance is still regularly encountered across the UK, see press articles in **Annex J**.

12.4. UXB Ground Penetration

An important consideration when assessing the risk from a UXB is the likely maximum depth of burial. There are several factors which determine the depth that an unexploded bomb will penetrate:

- Mass and shape of bomb.
- Height of release.
- Velocity and angle of bomb.
- Nature of the ground cover.
- Underlying geology.

Geology is perhaps the most important variable. If the ground is soft, there is a greater potential of deeper penetration. For example, peat and alluvium are easier to penetrate than gravel and sand, whereas layers of hard strata will significantly retard and may stop the trajectory of a UXB.

12.4.1. The J-Curve Principle

J-curve is the term used to describe the characteristic curve commonly followed by an air delivered bomb dropped from height after it penetrates the ground. Typically, as the bomb is slowed by its passage through underlying soils, its trajectory curves towards the surface. Many UXBs are found with their nose cone pointing upwards as a result of this effect. More importantly, however, is the resulting horizontal offset from the point of entry. This is typically a distance of about one third of the bomb's penetration depth, but can be higher in certain conditions (see **Annex I**).

12.4.2. WWII UXB Ground Penetration Studies

During WWII the Ministry of Home Security undertook a major study on actual bomb penetration depths, carrying out statistical analysis on the measured depths of 1,328 bombs as reported by bomb disposal (BD) teams. Conclusions were drawn predicting the likely average and maximum depths of penetration of different sized bombs in different geological strata.

For example, the largest common German bomb (500kg) had a likely concluded penetration depth of 6m in sand or gravel but 11m in clay. The maximum observed depth for a 500kg bomb was 11.4m and for a 1,000kg bomb 12.8m. Theoretical calculations suggested that significantly greater penetration depths were probable.

12.4.3. Site Specific Bomb Penetration Considerations

When considering an assessment of the bomb penetration at the site of proposed works the following parameters should be used:

- WWII geology – Various, see Section 8.2
- Impact angle and velocity – 10-15° from vertical and 270 metres per second.
- Bomb mass and configuration – The 500kg SC HE bomb, without retarder units or armour piercing nose (this was the largest of the common bombs used against Britain).

It has not been possible to determine maximum bomb penetration capabilities at this stage due to the limitations of site-specific geotechnical information provided for the purpose of this report. An assessment can be made once further information becomes available or by an UXO Specialist on-site.

12.5. V-Weapons

Hitler's 'V-weapon' campaign began from mid-1944. It used newly developed unmanned cruise missiles and rockets. The V-1, known as the flying bomb or pilotless aircraft, and the V-2, a long range rocket, were launched from bases in Germany and occupied Europe. A total of 9,251 V-1s and 1,115 V-2s were recorded in the United Kingdom.

Although these weapons caused considerable damage, their range was limited by their position of deployment across Europe and as a result the vast majority of V-weapon strikes were directed against targets in the south-east of England, predominantly in the London Boroughs and Home Counties. This limitation of capability meant targets in Lincolnshire were generally too far to be considered for V-weapon strikes by the Luftwaffe. The risk from V-weapons is therefore considered negligible and will not be further addressed in this report.

12.6. Introduction to WWII-era Bombing Decoy Sites

The decoy principal – drawing German bombers away from their designated targets onto dummy sites five or six miles away – began in WWI to protect RAF stations. In 1939, a new department was set up to investigate and coordinate the concept of defence by deception. A whole range of decoy sites were developed – some of them became very elaborate and covered large areas.

Common WWII Decoy Site Variants	
Decoy Type	Description
K-site	Daytime dummy airfield. Dummy aircraft and infrastructure.
Q-site	Night time dummy airfield. Intended to represent the working lights of an airfield after dark.
QL	Night time dummy infrastructure. Replicating the lights and workings of marshalling yards, naval installations, armament factories etc.
QF	Fire based decoy. Initially for aircraft factories, RAF maintenance units and ordnance works to simulate them on fire following bombing.
Oil QF	Simulation of burning oil tanks.
Starfish	Replicating a city under incendiary attack.

By June 1944, decoy sites had been attacked on 730 occasions. Attacks ranged from a single night-time bomber dropping its load onto a "Q" site, to the mass attacks on Starfish sites. In misleading air attacks away from intended targets, they were responsible for protecting cities, key Allied installations and saved the lives of thousands of people.

As WWII decoys were specifically designed to be bombed, proposed works planned in the vicinity of such installations can be at an elevated risk from German air delivered UXBs. It was not uncommon for evidence of UXBs at a decoy site to be overlooked following an air raid. Given that such installations were on open ground, sometimes agricultural fields, UXB entry holes were not always evident.

13. The Likelihood of Contamination from German Air Delivered UXBs

13.1. World War I

During WWI Britain was targeted and bombed by Zeppelin Airships as well as Gotha and Giant fixed-wing aircraft. The objective of these raids was to unnerve the British public, to destroy strategic targets and to ultimately attempt to coerce Britain's capitulation from the war. A WWI map of air raids and naval bombardments across the UK was consulted, see **Annex K**. This source does not record any incidents near the site.

WWI bombs were generally smaller and dropped from a lower altitude than those used in WWII. This resulted in limited UXB penetration depths. Aerial bombing was often such a novelty at the time that it attracted public interest and even spectators to watch the raids in progress. For these reasons there is a limited risk that UXBs passed undiscovered in the urban environment. When combined with the relative infrequency of attacks and an overall low bombing density, the risk from WWI UXBs is considered low and will not be further addressed in this report.

13.2. World War II Bombing of North Lincolnshire

Luftwaffe bombing tactics at the start of WWII prioritised on the destruction of strategic military targets, which if destroyed would pave the way for Operation Sea Lion, the planned amphibious invasion of Britain. Accordingly, in the years preceding WWII, German military intelligence meticulously mapped and photographed RAF stations designating them as strategic bombing targets. When the German strategic bombing campaign began in July 1940, fighter and bomber stations as well as RAF Chain Home radar stations were systematically targeted, severely limiting the RAF's capability to defend the country.

By the end of August 1940 the RAF was in disarray and close to collapse, with airfields badly damaged and aircrew losses critical. However, retaliatory bombing raids on Berlin by RAF Bomber Command throughout August had angered Hitler, and on 4th September 1940 Hitler announced in a speech his directive to 'erase' Britain's cities. This change in tactics gave the RAF a chance to rebuild and rearm, and ultimately, despite the civilian cost, prevented German air dominance in Britain's skies.

During WWII the site was located within the Rural District of the Isle of Axholme in the east and the Rural District of Thorne in the west, which both sustained an overall very low density of bombing, as represented by bomb density data figures, see Section 13.3. These districts were not a priority target for the Luftwaffe but were subject to occasional 'tip and run' and 'nuisance' raids. The Scunthorpe Steel Works, approximately 12.8km east of the site, was identified in Luftwaffe target mapping which is presented in **Annex L**.

Records of bombing incidents in the civilian areas of the district were typically collected by Air Raid Precautions wardens and collated by Civil Defence personnel. Some other organisations, such as port and railway authorities, maintained separate records. Records would be in the form of typed or hand written incident notes, maps and statistics. Bombing data was carefully analysed, not only due to the requirement to identify those parts of the country most needing assistance, but also in an attempt to find patterns in the Germans' bombing strategy in order to predict where future raids might take place.

Records of bombing incidents are presented in the following sections.

13.3. WWII Home Office Bombing Statistics

The following table summarises the quantity of German air delivered bombs (excluding 1kg incendiaries and anti-personnel bombs) dropped on the Rural Districts of the Isle of Axholme and Thorne respectively between 1940 and 1945.

Record of German Ordnance Dropped on the Rural District of the Isle of Axholme		
Area Acreage		51,104
Weapons	High Explosive bombs (all types)	35
	Parachute mines	0
	Oil bombs	0
	Phosphorus bombs	0
	Fire pots	0
	Pilotless aircraft (V-1)	0
	Long range rocket bombs (V-2)	0
Total		0
Number of Items per 1,000 acres		0.7
Source: Home Office Statistics This table does not include UXO found during or after WWII.		

Record of German Ordnance Dropped on the Rural District of Thorne		
Area Acreage		38,419
Weapons	High Explosive bombs (all types)	33
	Parachute mines	0
	Oil bombs	0
	Phosphorus bombs	0
	Fire pots	0
	Pilotless aircraft (V-1)	0
	Long range rocket bombs (V-2)	0
Total		33
Number of Items per 1,000 acres		0.9
Source: Home Office Statistics This table does not include UXO found during or after WWII.		

Detailed records of the quantity and locations of the 1kg incendiary and anti-personnel bombs were not routinely maintained by the authorities as they were frequently too numerous to record. Although the risk relating to IBs is lesser than that relating to larger HE bombs, they were similarly designed to inflict damage and injury. Anti-personnel bombs were used in much smaller quantities and are rarely found today but are potentially more dangerous. Although Home Office statistics did not record these types of ordnance, both should not be overlooked when assessing the general risk to personnel and equipment.

13.4. WWII-era Bombing Decoy Sites Mapping

As introduced in Section 12.6, bombing decoys were employed to attract German bombing and draw aircraft away from genuine strategic targets.

WWII-era mapping plotting the location of bombing decoy sites was obtained from the National Archives and is presented in **Annex M**. One copy of the map plots a bomb decoy in proximity to the southeast corner of the site. The Heritage Gateway records this as Decoy Q87a, a 'Q-type' night decoy which displayed a series of lights designed to mimic an active airfield, built to deflect enemy bombing from RAF Lindholme, noted as active between August 1941 and May 1942.[3] A grid reference is also provided, placing the Decoy at SE7590010000, in the southeast corner of the site – this is also highlighted in **Annex M**.

13.5. Post-WWII Aerial Photography

WWII-era aerial photography for the site area was obtained from the National Monuments Record Office (Historic England). This photography provides a record of the potential composition of the site during the war, as well as its condition immediately following the war (see **Annex H**).

Considering the size of the site and its location in a rural area, WWII-era aerial photography was only available for a small section of the site – largely in proximity to RAF Sandtoft.

WWII-Era Aerial Photography	
Date/Title	Description
18th May 1948	This post-WWII imagery provides a view of part of the eastern section of the site, which is predominantly undeveloped. It shows parts of the site in proximity to the bomb decoy, which was immediately to the east of this photograph. No potential indicators of bomb damage, such as cratering, scattered earth or damaged buildings can be clearly distinguished.
21st September 1948	This photograph provides a view of the site in proximity to RAF Sandtoft. No potential indicators of bomb damage can be clearly distinguished.

13.6. Other Resources

A range of wartime sources recording bombing in the region were consulted. These included Lincolnshire Air Raid Damage Files, North Midland Air Raid Summaries and Damage & Casualty Reports, West Riding of Yorkshire Bomb Census Tracings and an Air Raid Precautions Record of Occurrences, Yorkshire Bomb Census Reports, and online resources.

No record of bombing in proximity to the site could be identified across the sources consulted.

13.7. Abandoned Bombs

A post air-raid survey of buildings, facilities, and installations would have included a search for evidence of bomb entry holes. If evidence of an entry hole was encountered, Bomb Disposal Officer Teams would normally have been requested to attempt to locate, render safe, and dispose of the bomb. Occasionally, evidence of

[3] https://www.heritagegateway.org.uk/Gateway/Results_Single.aspx?uid=caffa307-26d1-4d94-b4ef-de213c838bb2&resourceID=19191
https://www.heritagegateway.org.uk/Gateway/Results_Single.aspx?uid=MLS18438&resourceID=1034

UXBs was discovered but due to a relatively benign position, access problems, or a shortage of resources the UXB could not be exposed and rendered safe. Such an incident may have been recorded and noted as an 'abandoned bomb'.

Given the inaccuracy of WWII records, and the fact that these bombs were 'abandoned', their locations cannot be considered definitive or the lists exhaustive. The MoD states that 'action to make the devices safe would be taken only if it was thought they were unstable'. It should be noted that other than the 'officially' abandoned bombs, there will inevitably be UXBs that were never recorded.

1st Line Defence holds no records of officially registered abandoned bombs at or near the site of the proposed works.

13.8. Bomb Disposal Tasks

The information service from the Explosive Ordnance Disposal (EOD) Archive Information Office at 33 Engineer Regiment (now part of 29 EOD & Search Group) no longer processes commercial requests for information. It has therefore not been possible to include any updated official information regarding bomb disposal/clearance tasks with regards to this site. A database of known disposal/clearance tasks has been referred to which does not make reference to such instances occurring within the site of proposed works. If any relevant information is received at a later date, RWE Renewable UK Solar and Storage Ltd will be advised.

13.9. Evaluation of German Air Delivered UXO Records

German Air Delivered UXO Records Summary	
Factors	Conclusion

Density of Bombing *It is important to consider the bombing density when assessing the possibility that UXBs remain in an area. High bombing density could allow for error in record keeping due to extreme damage caused to the area.*	During WWII the site was located within the Rural District of the Isle of Axholme in the east and the Rural District of Thorne in the west, which both sustained an overall very low density of bombing, according to official Home Office bombing statistics. This consisted of a total of just 35 and 33 high explosive bombs across 51,104 and 38,419 acres respectively; an overall average of 0.7 and 0.9 items of ordnance recorded per 1,000 acres. These districts were not a priority target for the Luftwaffe but were subject to occasional 'tip and run' and 'nuisance raids. The Scunthorpe Steel Works, approximately 12.8km east of the site, was identified in Luftwaffe target mapping which is presented in **Annex L**. The site was located in an area with an overall recorded 'Very Low' density of bombing. A range of wartime resources were consulted, including Air Raid Summaries, Damage Files, and Bomb Census Reports, none of which confirmed that bombing took place in proximity to the site. The fact that evidence indicates the presence of a Bomb Decoy in the southeastern corner of the site – deliberately designed to attract bombing – is of concern, although it was operational for a relatively short period between August 1941 and May 1942, after the main 'Blitz' period.
Damage *If buildings or structures on a site sustained bomb or fire damage, any resulting rubble and debris could have obscured the entry holes of unexploded bombs dropped during the same or later raids. Similarly, a high explosive bomb strike in an area of open agricultural land will have caused soil disturbance, increasing the risk that a UXB entry hole would be overlooked.*	Post-WWII aerial photography of RAF Sandtoft and adjacent land was available for consultation, in which no potential indicators of bomb damage, such as cratering, scattered earth or damaged buildings can be clearly distinguished.
Ground Cover *The nature of the ground cover present during WWII would have a substantial influence on any visual indication that may indicate UXO being present.*	Ground cover on site is considered to have been largely unconducive to the detection of UXO. Items of UXO penetrating soft open ground could easily go unnoticed and unreported. A bomb entry hole could be as small as 20cm in diameter and therefore easily obscured in such conditions.
Access Frequency *UXO in locations where access was irregular would have a greater chance of passing unnoticed than at those that were regularly occupied. The importance of a site to the war effort is also an important consideration as such sites are likely to have been both frequently visited and subject to post- raid checks for evidence of UXO.*	Situated in a rural area, direct wartime access is anticipated to have been relatively low, although some level of local access would have been facilitated by the site's proximity to roads and residential properties including farms.
Bomb Failure Rate	There is no evidence to suggest that the bomb failure rate in the locality of the site would have been dissimilar to the 10% normally used.
Abandoned Bombs	1st Line Defence holds no records of abandoned bombs at or within the site vicinity.
Bombing Decoy sites	WWII-era bomb decoy mapping plots a bomb decoy in the southeast corner of the site. The Heritage Gateway records this as Decoy Q87a, a 'Q-type' night decoy which displayed a series of lights designed to mimic an active airfield, built to deflect enemy bombing from RAF Lindholme, noted as active between August 1941 and May 1942.

Bomb Disposal Tasks	1st Line Defence could find no evidence of bomb disposal tasks within the site boundary and immediate area.

14. The Likelihood of UXO Contamination Summary

The following table assesses the likelihood that the site was contaminated by items of German air delivered and Allied ordnance. Factors such as the risk of UXO initiation, remaining, and encountering will be discussed later in the report.

UXO Contamination Summary	
Quality of the Historical Record	The research has evaluated WWII-era Ordnance Survey maps, records relating to RAF Sandtoft including Operations Record Books, plans, photos and published literature, post-WWII aerial photography, WWI UK incident mapping, Luftwaffe target mapping, UK Bomb Decoy Sites Mapping, and online resources. The record set is of generally adequate quality given there are limited local records available to consult for the purposes of this report, owing to the very low bombing density of the districts.
Allied Ordnance	• The majority of the site was undeveloped, and no direct evidence to confirm that it had any military usage could be identified. • The southeastern section of the site lies adjacent to the former RAF Sandtoft. The airfield became operational in February 1944 as a Group 1 Bomber Command station and was used as a satellite base for the larger RAF Lindholme. The airfield was the base of the No. 1667 Heavy Conversion Unit, used to train pilots in the operation of heavy bombers such as the Halifax and Lancaster. The Unit was disbanded in November 1945, and the airfield went into Care and Maintenance shortly after. Selling off the airfield premises began in 1955. • The southeastern corner of the site is partially located on, and in proximity to, the airfield bomb stores. This is shown across 1944 site plans of RAF Sandtoft (see **Annex F**), with the bomb stores on site observable within 1948 aerial imagery (see **Annex H3**). This part of the site in the southeast also passes through, and is in proximity to, the airfield perimeter. The closest dispersal pans were approximately 200m distant from the site boundary. • As a pilot training airfield, numerous crashes are recorded in the vicinity of the site, although the majority of these occurred on the airfield premises. However, one Lancaster – on a 'Bullseye' night bombing exercise – reportedly crashed near Windsor Lane, Crowle, in 1945. • Records indicate that Sandtoft maintained its own anti-aircraft defences. Despite this, no indication could be found to suggest the precise location of any gun sites. The closest recorded anti-aircraft position was located approximately 7.25km to the east of the site in the vicinity of Burringham. • Online research indicates the presence of a WWI-era landing ground near the northwestern boundary of the site. As this was a basic grass landing field with minimal infrastructure, and possibly saw limited use, any extant UXO risk associated with this feature is considered to be low. • In summary, the risk from Allied UXO is not considered homogenous across the site: see UXO Risk Mapping in **Annex N**. • The section of the site comprising part of the airfield bomb stores and adjacent undeveloped land has been assessed as holding an overall **Medium-High Risk** from Allied UXO. Substantial quantities of ordnance were stored at bomb dumps, and the result of previous on-site UXO support conducted by 1st Line Defence – including at the former RAF Full Sutton in 2021 – illustrates that land formerly comprising bomb dumps, or land adjacent to them, may remain contaminated with ordnance in the present day. Photography of some of the finds at Full Sutton is presented in **Annex O**. • Land separated from the bomb dump by a water drain, but in proximity to the airfield perimeter and the end of a runway – both of which potentially were a source of UXO contamination due to crashes and dumping of unneeded ordnance over the perimeter – has been assigned an overall **Medium Risk** from Allied UXO. • The remainder of the site is not in proximity to any significant sources of UXO risk, so has been assigned an overall **Low Risk** from Allied UXO. However, a large number of bomber crashes are recorded in the vicinity of RAF Sandtoft, and training activities involving military personnel based in the area may have occurred on site. Therefore, **UXO Safety**

	Awareness Briefings are still recommended for the site as a whole, and it is recommended that a **UXO Risk Management Plan** is implemented.
German Air-Delivered Ordnance	• During WWII the site was located within the Rural District of the Isle of Axholme in the east and the Rural District of Thorne in the west, which both sustained an overall very low density of bombing, according to official Home Office bombing statistics. This consisted of a total of just 35 and 33 high explosive bombs across 51,104 and 38,419 acres respectively; an overall average of 0.7 and 0.9 items of ordnance recorded per 1,000 acres. These districts were not a priority target for the Luftwaffe but were subject to occasional 'tip and run' and 'nuisance' raids. • A range of wartime resources were consulted, including Air Raid Summaries, Damage Files, and Bomb Census Reports, none of which confirmed that bombing took place in proximity to the site. The fact that evidence indicates the presence of a Bomb Decoy in the southeastern corner of the site – deliberately designed to attract bombing – is of concern, although it was operational for a relatively short period between August 1941 and May 1942, after the main 'Blitz' period. • Post-WWII aerial photography of RAF Sandtoft and adjacent land was available for consultation, in which no potential indicators of bomb damage, such as cratering, scattered earth or damaged buildings can be clearly distinguished. • Ground cover on site is considered to have been largely unconducive to the detection of UXO. Items of UXO penetrating soft open ground could easily go unnoticed and unreported. A bomb entry hole could be as small as 20cm in diameter and therefore easily obscured in such conditions. • Situated in a rural area, direct wartime access is anticipated to have been relatively low, although some level of local access would have been facilitated by the site's proximity to roads and residential properties including farms. • In summary, the site was located in an area with an overall recorded 'very low' density of bombing, with none of the wartime sources consulted confirming that bombing took place in proximity to the site. The presence of a Bomb Decoy in the southeastern corner of the site – deliberately designed to attract bombing – is of concern, although it was operational for a relatively short period between August 1941 and May 1942, after the main 'Blitz' period. Given the lack of positive evidence of bombing having occurred over the site area, the risk from German UXO contamination is not thought to be significantly elevated above the generally low 'background' level for the region. The site has therefore been assigned an overall **Low Risk** from German UXO, although due to the large and undeveloped nature of the site, UXO Safety Awareness Briefings and a UXO Risk Management Plan are recommended.

15. The Likelihood that UXO Remains

15.1. Introduction

It is important to consider the extent to which any explosive ordnance clearance (EOC) activities or extensive ground works have occurred on site. This may indicate previous ordnance contamination or reduce the risk that ordnance remains undiscovered.

15.2. UXO Clearance

Former military sites (or at least certain areas within their footprint) are often subject to clearance before they are returned to civilian use by the MoD. If a site is retained by the military, it is possible that no clearance operations have ever been undertaken. However, UXO is sometimes still discovered even on sites where clearance operations are known to have been undertaken. The detail and level of survey and targeted investigation undertaken by the military will depend on the former use of the site and purpose of the clearance (i.e. disposal, redevelopment, return to agriculture, etc.). The level of clearance will also depend on the available technology, resources and practices of the day.

It therefore cannot be assumed that the risk of UXO remaining has been completely mitigated, even though EOC tasks have been undertaken at a former military site.

15.3. Post-War Redevelopment

Comparison of historical OS mapping and recent aerial imagery indicate that post-war development across the site has been minor.

The risk of UXO remaining is considered to be mitigated at the location of and down to the depth of any post-war redevelopment on site. For example, the risk from deep buried UXO will only have been mitigated within the volumes of any post-war pile foundations or deep excavations for basement levels. The risk will however remain within virgin geology below and amongst these post-war works, down to the maximum bomb penetration depth.

16. The Likelihood of UXO Encounter

16.1. Introduction

For UXO to pose a risk at a site, there should be a means by which any potential UXO might be encountered on that site.

The likelihood of encountering UXO on the site of proposed works would depend on various factors, such as the type of UXO that might be present and the intrusive works planned on site. In most cases, UXO is more likely to be present below surface (buried) than on surface.

In general, the greater the extent and depth of intrusive works, the greater the risk of encountering. The most likely scenarios under which items of UXO could be encountered during construction works is during piling, drilling operations or bulk excavations for basement levels. The overall risk will depend on the extent of the works, such as the numbers of boreholes/piles (if required) and the volume of the excavations.

Generally speaking, the risk of encountering any type of UXO will be minimal for any works planned within the footprint and down to the depth of post-war foundations and excavations.

16.2. Encountering Air Delivered Ordnance

Since an air delivered bomb may come to rest at any depth between just below ground level and its maximum penetration depth, there is a chance that such an item (if present) could be encountered during shallow excavations (for services or site investigations) into the original WWII ground level as well as at depth.

16.3. Land Service/Small Arms Ammunition Encounter

Items of LSA and SAA are mostly encountered in areas previously used for military training. Such items could have been lost, burnt, buried or discarded during being in use by the military. Due to this, LSA are most likely to be encountered at relatively shallow depths – generally in the top 1m below ground level. Therefore, such items are most likely to be encountered during open excavation works. In some cases, there is the potential that LSA or SAA may be present on the surface of the ground – especially in areas with active military use or were recently in use by the MoD.

17. The Likelihood of UXO Initiation

17.1. Introduction

UXO does not spontaneously explode. Older UXO devices will require an external event/energy to create the conditions for detonation to occur. The likelihood that a device will function can depend on a number of factors including the type of weaponry, its age and the amount of energy it is struck with.

17.2. Initiating Air Delivered Ordnance

Unexploded bombs do not spontaneously explode. All high explosive filling requires significant energy to create the conditions for detonation to occur.

In recent decades, there have been a number of incidents in Europe where Allied UXBs have detonated, and incidents where fatalities have resulted. There have been several hypotheses as to the reason why the issue is more prevalent in mainland Europe – reasons could include the significantly greater number of bombs dropped by the Allied forces on occupied Europe, the preferred use by the Allies of mechanical rather than electrical fuzes, and perhaps just good fortune. The risk from UXO in the UK is also being treated very seriously in many sectors of the construction industry, and proactive risk mitigation efforts will also have affected the lack of detonations in the UK.

There are certain construction activities which make initiation more likely, and several potential initiation mechanisms must be considered:

UXB Initiation	
Direct Impact	Unless the fuze or fuze pocket is struck, there needs to be a significant impact e.g. from piling or large and violent mechanical excavation, onto the main body of the weapon to initiate a buried iron bomb. Such violent action can cause the bomb to detonate.
Re- starting the Clock	A small proportion of German WWII bombs employed clockwork fuzes. It is probable that significant corrosion would have taken place within the fuze mechanism over the last 70+ years that would prevent clockwork mechanisms from functioning. Nevertheless, it was reported that the clockwork fuze in a UXB dealt with by 33 EOD Regiment in Surrey in 2002 did re-start.
Friction Impact	The most likely scenario resulting in the detonation of a UXB is friction impact initiating the shock-sensitive fuze explosive. The combined effects of seasonal changes in temperature and general degradation over time can cause explosive compounds to crystallise and extrude out from the main body of the bomb. It may only require a limited amount of energy to initiate the extruded explosive which could detonate the main charge.

17.3. Land Service /Small Arms Ammunition Initiation

Items of LSA generally do not become inert or lose their effectiveness with age. Time can cause items to become more sensitive and less stable. This applies equally to items submerged in water or embedded in silts, clays, or similar materials. The greatest risk occurs when an item of ordnance is struck or interfered with. This is likely to occur when mechanical equipment is used or when unqualified personnel pick up munitions.

If left alone, an item of LSA will pose little/no risk of initiation. Therefore, if it is not planned to undertake construction/intrusive works at the site, the risk of initiation of any LSA that may be present would be negligible. Similarly, those accessing a contaminated area would be at minimal risk if they do not interfere with any UXO present on the ground. Clearly for many end uses, however, the presence of UXO anywhere on a site would not be acceptable as it could not be guaranteed that the items will not be handled, struck or otherwise affected, increasing the likelihood of initiation.

Items of SAA are much less likely to detonate than LSA or UXBs, but can be accidentally initiated by striking the casing, coming into contact with fire, or being tampered with/dismantled. It is likely that the detonation of an item of SAA would result in a small explosion, as the pressure would not be contained within a barrel. Detonation would only result in local overpressure and very minor fragmentation from the cartridge case.

18. Consequences of Initiation/Encounter

18.1. Introduction

The repercussions of the inadvertent detonation of UXO during intrusive ground works, or if an item or ordnance is interfered with or disturbed, are potentially profound, both in terms of human and financial cost. A serious risk to life and limb, damage to plant and total site shutdown during follow-up investigations are potential outcomes. However, if appropriate risk mitigation measures are put in place, the chances of initiating an item of UXO during ground works is comparatively low.

The consequences of encountering UXO can be particularly notable in the case of high-profile sites (such as airports and train stations) where it is necessary to evacuate the public from the surrounding area. A site may be closed for anything from a few hours to a week with potentially significant cost in lost time. It should be noted that even the discovery of suspected or possible item of UXO during intrusive works (if handled solely through the authorities), may also involve significant loss of production.

18.2. Consequences of Detonation

When considering the potential consequences of a detonation, it is necessary to identify the significant receptors that may be affected. The receptors that may potentially be at risk from a UXO detonation on a construction site will vary depending on the site specific conditions but can be summarised as follows:

- People – site workers, local residents and general public.
- Plant and equipment – construction plant on site.
- Services – subsurface gas, electricity, telecommunications.
- Structures – not only visible damage to above ground buildings, but potentially damage to foundations and the weakening of support structures.
- Environment – introduction of potentially contaminating materials.

19. 1st Line Defence Risk Assessment

19.1. Risk Assessment Stages

Taking into account the quality of the historical evidence, the assessment of the overall risk from unexploded ordnance is based on the following five considerations:

1. That the site was contaminated with unexploded ordnance.
2. That unexploded ordnance remains on site.
3. That such items will be encountered during the proposed works.
4. That ordnance may be initiated by the works operations.
5. The consequences of encountering or initiating ordnance.

19.2. Assessed Risk Level

1st Line Defence has assessed that there is an overall **Medium-High Risk** from items of Allied UXO in proximity to a former airfield bomb store, an overall **Medium Risk** from Allied UXO on part of the site near a runway and the former airfield perimeter, and an overall **Low Risk** from Allied UXO across the remainder of the site of proposed works. There is an assessed **Low Risk** from German air delivered UXO

Southeast corner of site adjacent to bomb dump

Ordnance Type	Risk Level			
	Negligible	Low	Medium	High
German Unexploded HE Bombs		✓		
German 1kg Incendiary Bombs		✓		
Anti-Aircraft Artillery Projectiles		✓		
Allied Munitions			✓	

Southeast corner of site adjacent to airfield runway and perimeter

Ordnance Type	Risk Level			
	Negligible	Low	Medium	High
German Unexploded HE Bombs		✓		
German 1kg Incendiary Bombs		✓		
Anti-Aircraft Artillery Projectiles		✓		
Allied Munitions			✓	

Remainder of site

Ordnance Type	Risk Level			
	Negligible	Low	Medium	High
German Unexploded HE Bombs		✓		
German 1kg Incendiary Bombs		✓		
Anti-Aircraft Artillery Projectiles		✓		
Allied Munitions		✓		

Please note – although the risk from some forms of unexploded ordnance on this site has been assessed as 'Low', this does not mean there is 'no' risk of encountering UXO. This report has been undertaken with due diligence, and all reasonable care has been taken to access and analyse relevant historical information. By necessity, when dealing historical evidence, and when making assessments of UXO risk, various assumptions have to be made which we have discussed and justified throughout this report. Our reports take a common-sense and practical approach to the assessment of risk, and we strive to be reasonable and pragmatic in our conclusions.

It should however be stressed that if any suspect items are encountered during the proposed works, 1st Line Defence should be contacted for advice/assistance, and to re-assess the risk where necessary. The mitigation measures outlined in the next section are recommended as a minimum precaution to alert ground personnel to the history of the site, what to look out for, and what measures to take in the event that a suspect item is encountered. It should also be noted that the conclusions of this report are based on the scope of works outlined in the 'Proposed Works' section of this report. Should the scope of works change or additional works be proposed, 1st Line Defence should be contacted to re-evaluate the risk.

20. Proposed Risk Mitigation Methodology

20.1. General

The following risk mitigation measures are recommended to support the proposed works at Tween Bridge Solar, Doncaster:

Recommended Risk Mitigation Measures	
Activity	**Recommended Risk Mitigation Measure**
All Works	• **UXO Risk Management Plan** It is recommended that a site-specific plan for the management of UXO risk be written for this site. This plan should be kept on site and be referred to in the event that a suspect item of UXO is encountered at any stage of the project. It should detail the steps to be taken in the event of such a discovery, considering elements such as communication, raising the alarm, nominated responsible persons etc. Contact 1st Line Defence for help/more information. • **Site Specific UXO Awareness Briefings to all personnel conducting intrusive works.** As a minimum precaution, all personnel working on the site should be briefed on the basic identification of UXO and what to do in the event of encountering a suspect item. This should in the first instance be undertaken by a UXO Specialist. Posters and information on the risk of UXO can be held in the site office for reference.
Open Excavations (trial pits, service pits, bulk excavations, strip foundations etc.) (Medium-High and Medium Risk Areas Only)	• **Unexploded Ordnance (UXO) Specialist Presence on Site to support open excavations** When on site the role of the UXO Specialist would include: ◦ Monitoring works using visual recognition and instrumentation, including immediate response to reports of suspicious objects or suspected items of ordnance that have been recovered by the ground workers on site. ◦ Providing UXO awareness briefings to any uninformed staff and advise staff of the need to modify working practices to take account of the ordnance risk. ◦ To aid incident management which would involve liaison with the local authorities and police should ordnance be identified and present an explosive hazard.

In making this assessment and recommending these risk mitigation measures, if known, the works outlined in the 'Scope of the Proposed Works' section were considered. Should the planned works be modified or additional intrusive engineering works be considered, 1st Line Defence should be consulted to see if a re-assessment of the risk or mitigation recommendations is necessary.

1st Line Defence Limited **23rd March 2026**

This Report has been produced in compliance with the Construction Industry Research and Information Association (CIRIA) C681 guidelines for the writing of Detailed UXO Risk Assessments.

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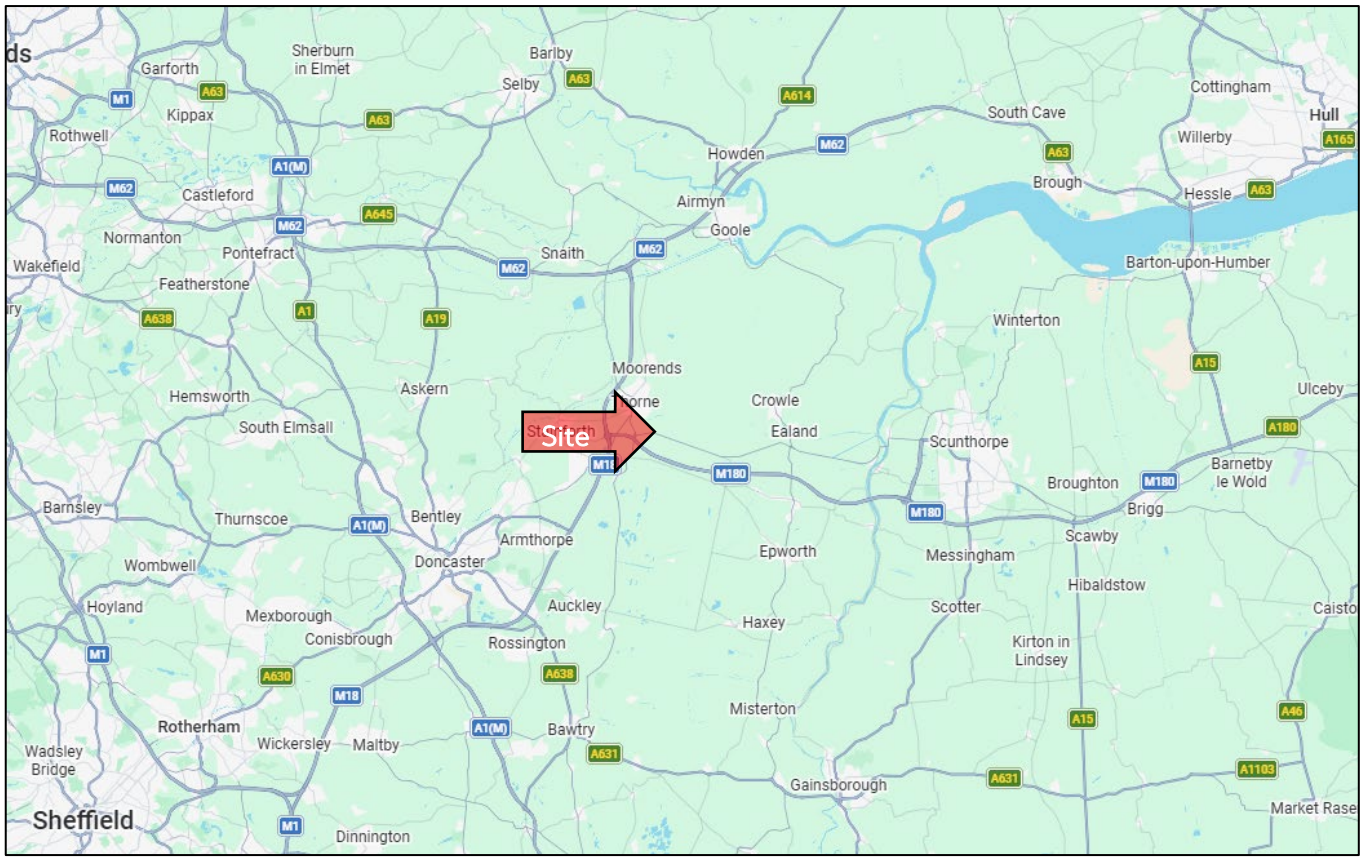
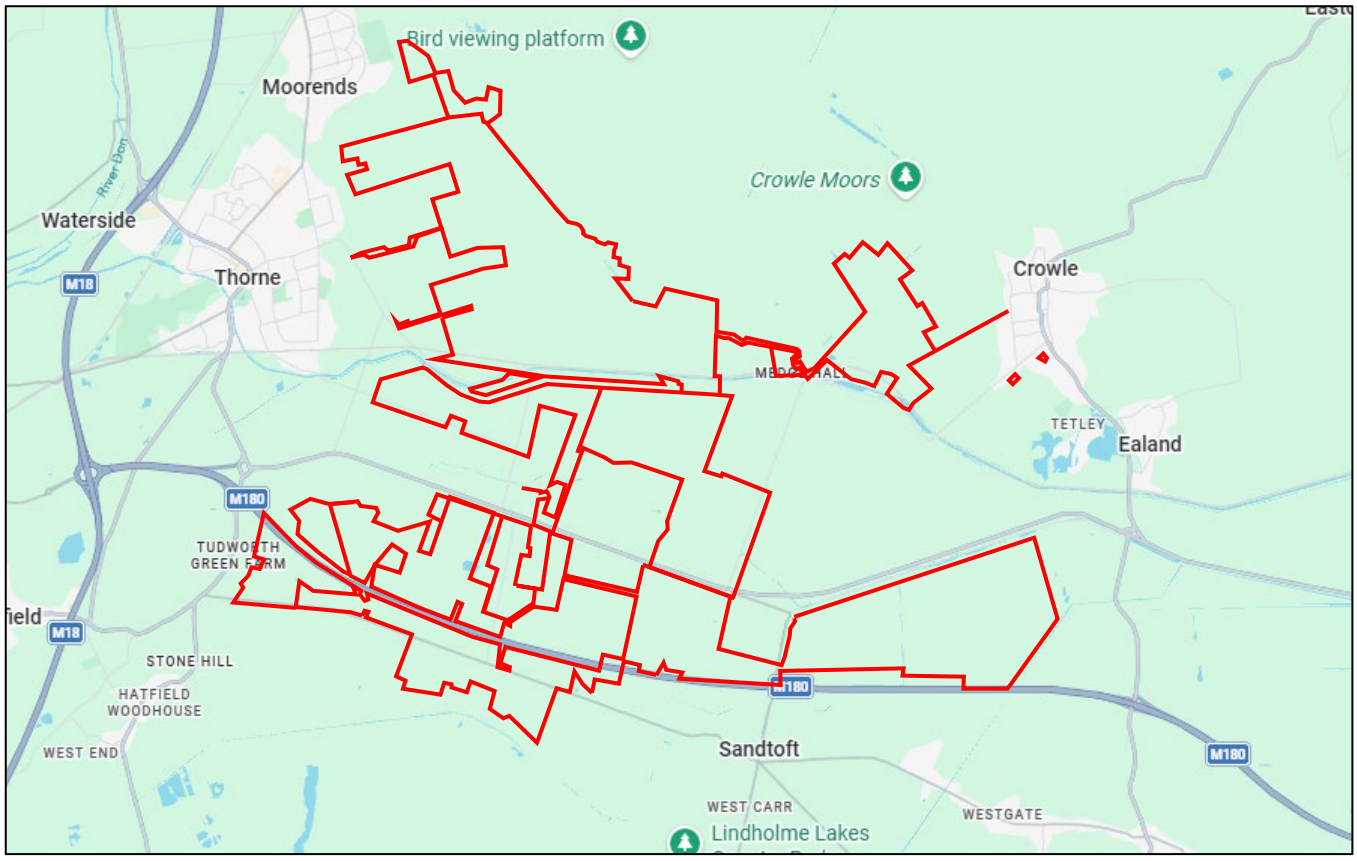
This report has been prepared by 1st Line Defence Limited with all reasonable care and skill. The report contains historical data and information from third party sources. 1st Line Defence Limited has sought to verify the accuracy and comprehensiveness of this information where possible but cannot be held accountable for any inherent errors. Furthermore, whilst every reasonable effort has been made to locate and access all relevant historical information, 1st Line Defence cannot be held responsible for any changes to risk level or mitigation recommendations resulting from documentation or other information which may come to light at a later date.

Site Location Maps

Annex: A





1ST LINE DEFENCE

Unit 3, Maple Park,
Essex Road, Hoddesdon,
Hertfordshire. EN11 0EX
Email: info@1stlinedefence.co.uk
Tel: +44 (0)1992 245 020

Client: RWE Renewable UK Solar and Storage Ltd

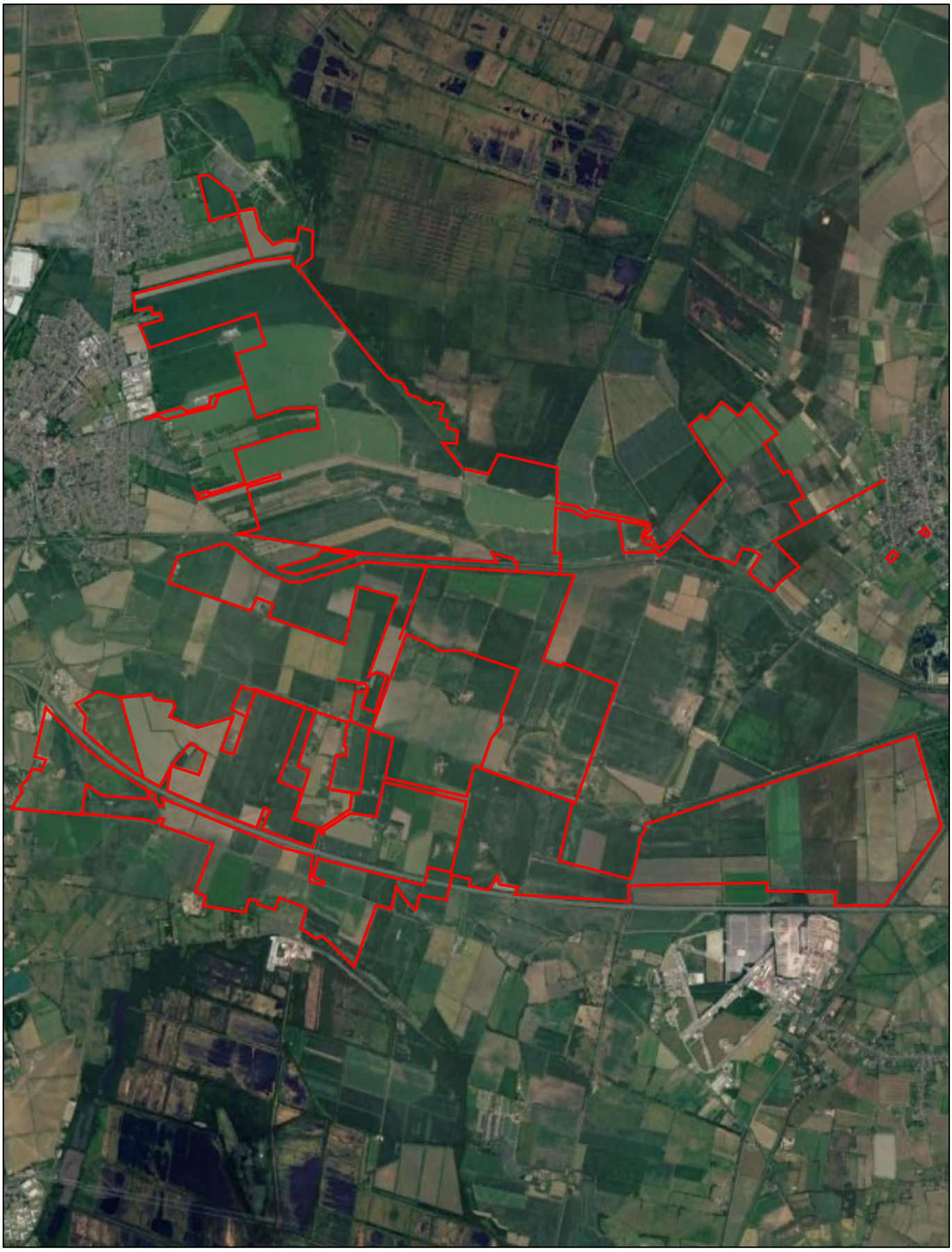
Project: Tween Bridge Solar, Doncaster

Ref: DA18705a-00

Source: Google Maps

Approximate site boundary

N



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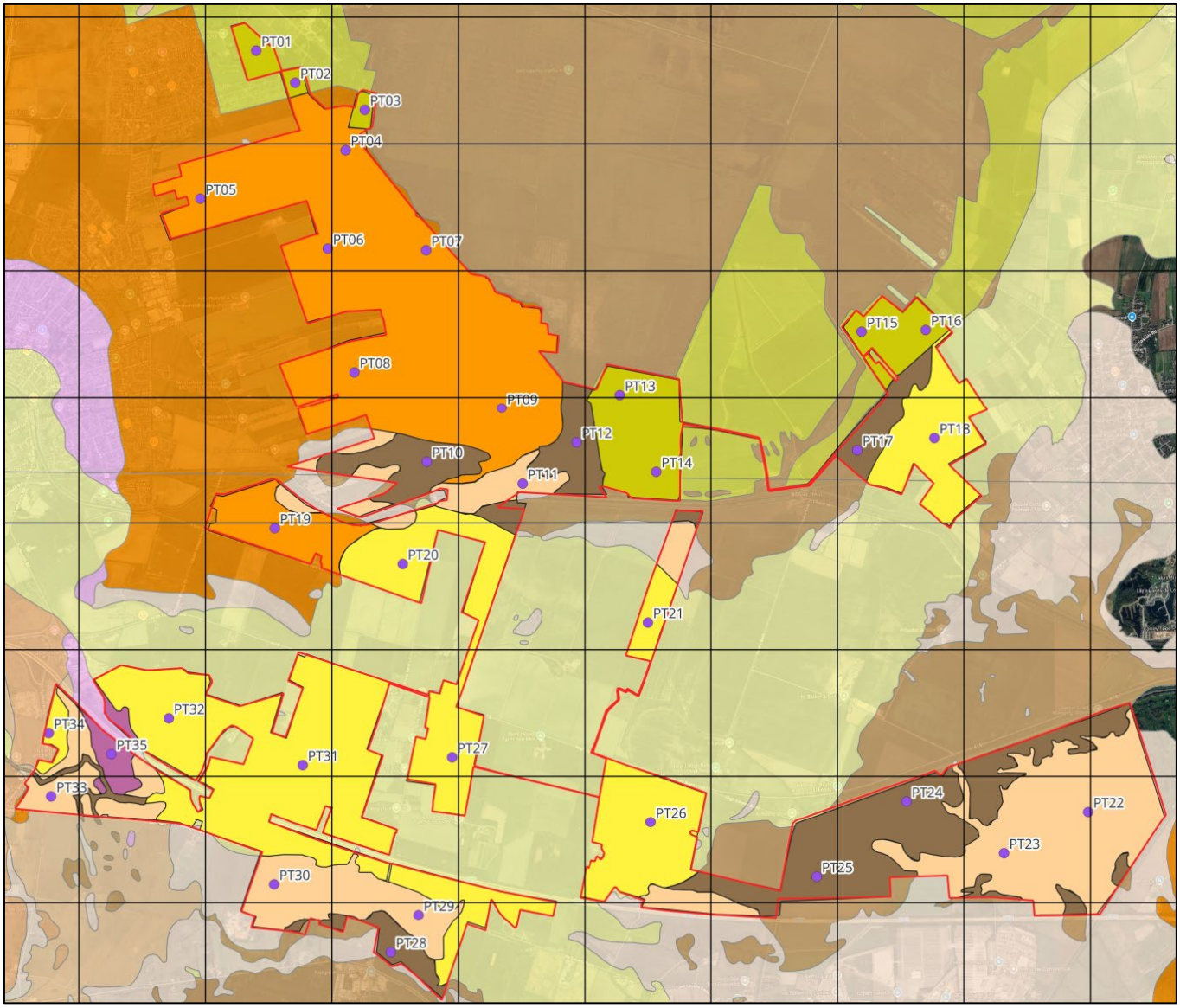
Source: Google Earth

Approximate site boundary

N

Client Provided Site Plan

Annex: C1



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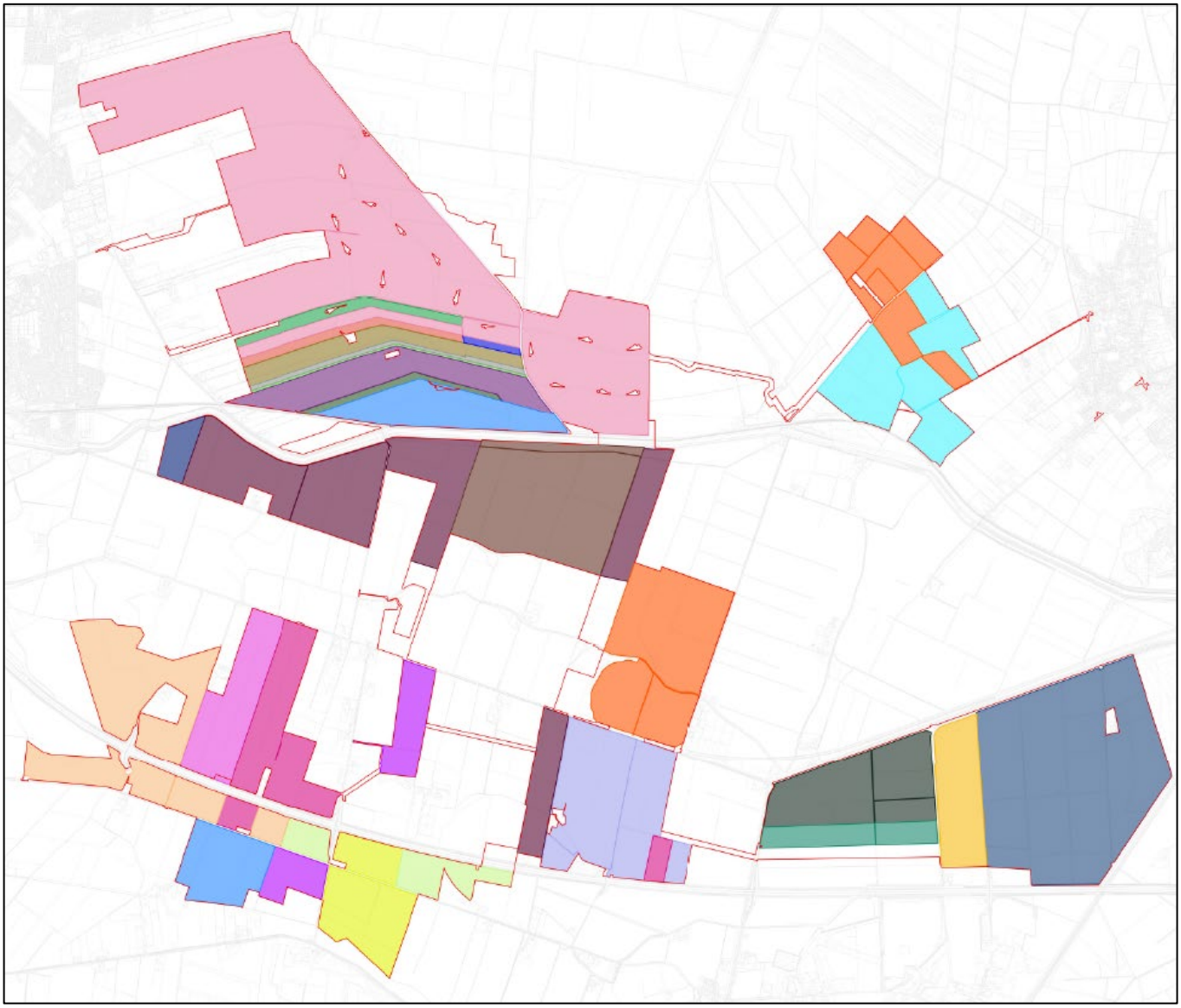
Client:	RWE Renewable UK Solar and Storage Ltd	Approximate site boundary	N
Project:	Tween Bridge Solar, Doncaster		
Ref:	DA18705a-00	**Source:** RWE Renewable UK Solar and Storage Ltd	

Client Provided Site Plan

Annex: C2



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Client: RWE Renewable UK Solar and Storage Ltd

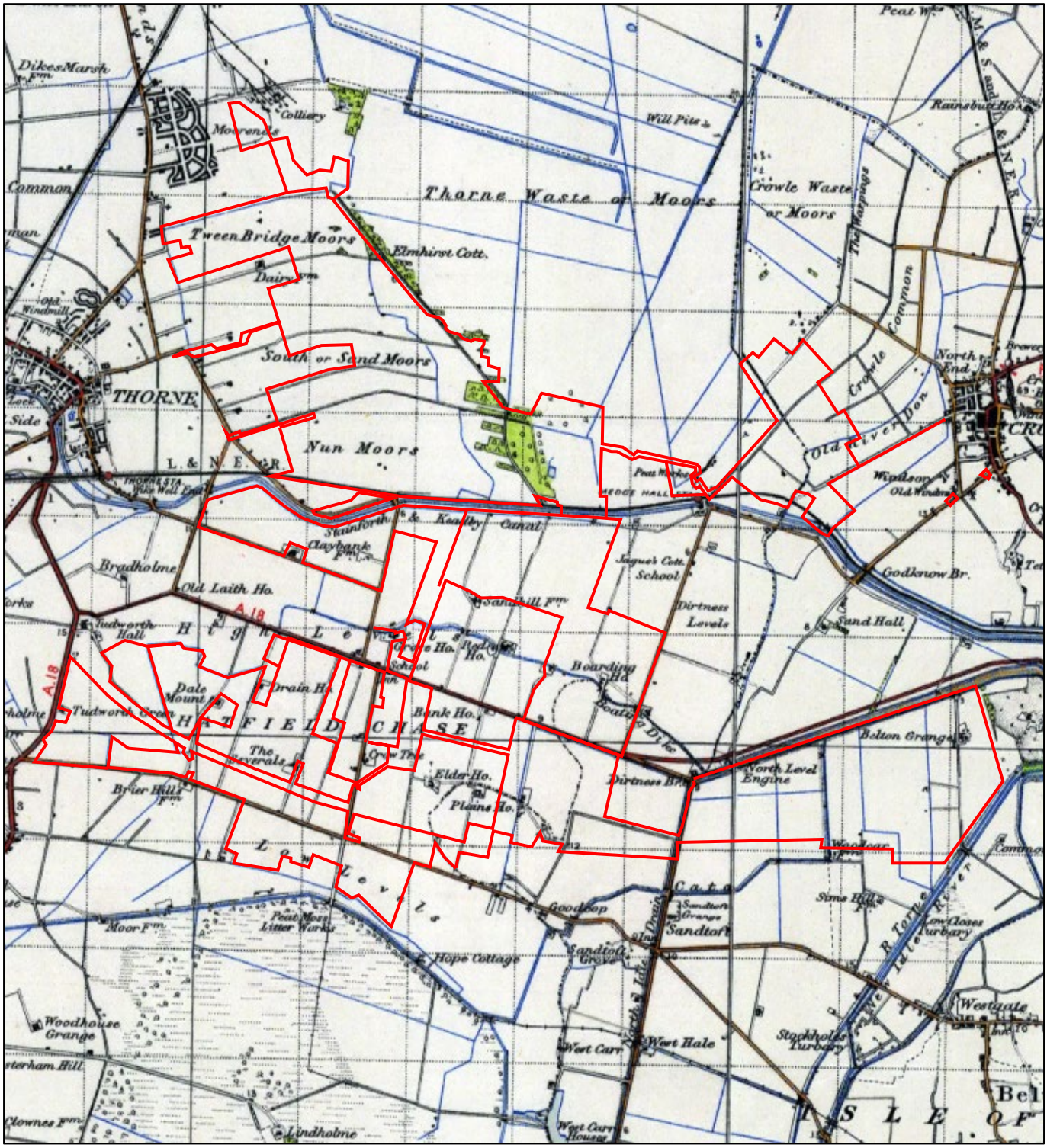
Project: Tween Bridge Solar, Doncaster

Ref: DA18705a-00

Source: RWE Renewable UK Solar and Storage Ltd

Approximate site boundary

N



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Project: Tween Bridge Solar, Doncaster

Ref: DA18705a-00

Source: In-house Record Set

Approximate site boundary

N

Below: Halifax bomber landing at RAF Sandtoft, 1944.

Below: bomber crew at Sandtoft, early 1944.

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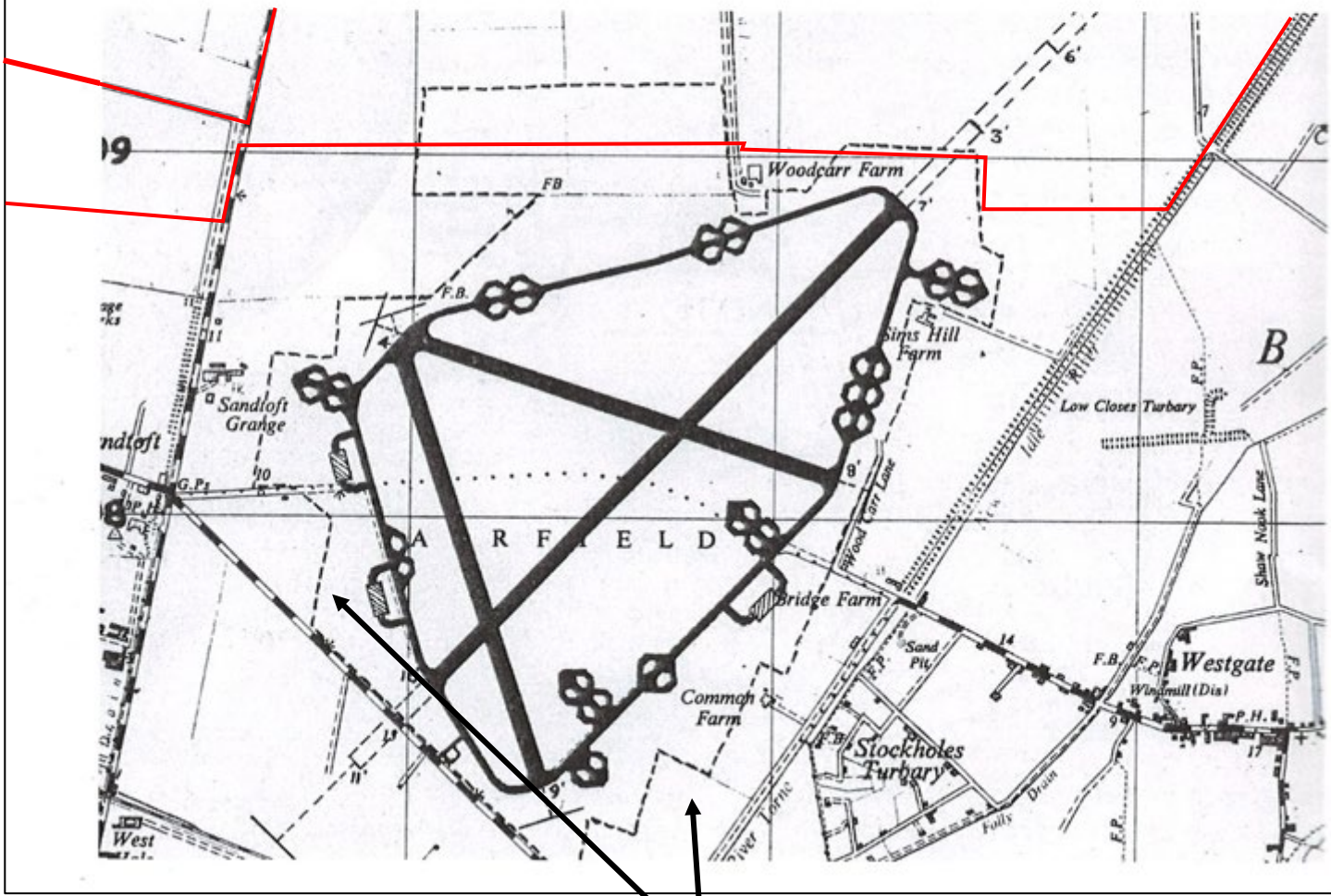
AIRFIELD DATA DEC 1944

Command:	Bomber Command	Runway surface:	Concrete with tarmac ends
Function:	Operational station	Hangars:	T.2 × 3
Runways:	240 deg 2,000 × 50yd	Dispersals:	36 × spectacle
	120 deg 1,400 × 50yd	Personnel:	Officers – 259 (10 WAAF)
	170 deg 1,400 × 50yd		Other ranks – 2,024 (352 WAAF)



Airfield perimeter

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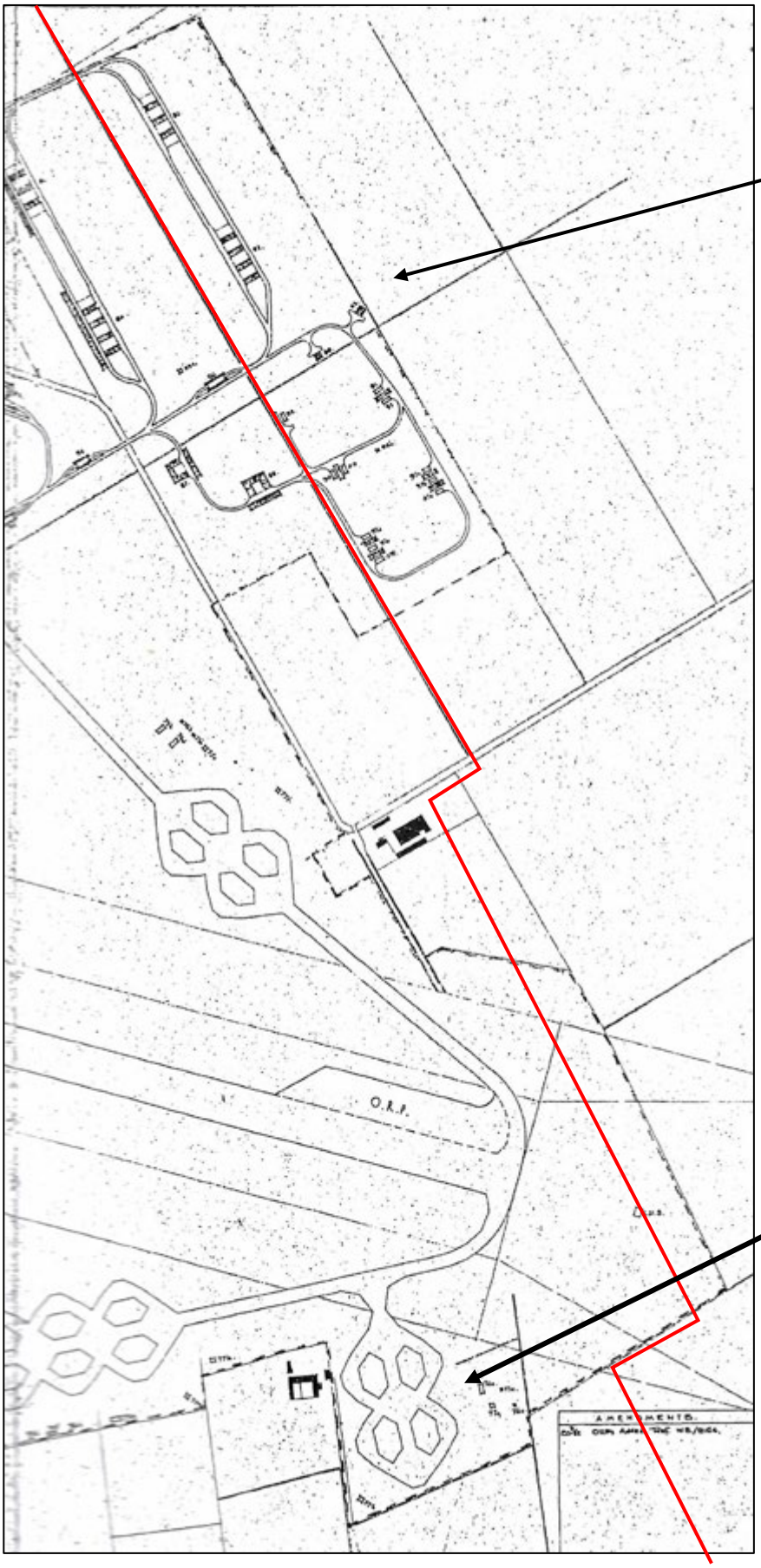
Ref: DA18705a-00

Source: B. Barrymore Halpenny, Acton Stations 4: Military Airfields of Yorkshire, PSL, 1982

Approximate site boundary

N



BOMB STORES.

80-83.	1212/43.	4	D.	Bomb Stores. (with Tail Unit Area)
84.	4780/42.	1		Fused & Spare Bomb Store.
85&86.	4733/42.	2.	B.	Component Stores.
87&88.	4734/42	2.	C.	Incendiary Bomb Stores.
89-92	4734/42	4	B	do.
93.	12725/41.	1	A.	Pyro. Store.
94&95	G177/43.	2.	Ultra Heavy Heavy-Light	Fusing Point Building
96	G176/43	1		do.
97-f.	4779/42.	6.		S.B.C. Stores
98.	2169/43.	1	D	Flame Float Store
99a-b	1946/43.	2.		Blast Shelter, 10 persons.

Aircraft hardstandings

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Project: Tween Bridge Solar, Doncaster

Ref: DA18705a-00

Source: RAF Museum Hendon

Approximate site boundary

OPERATIONS RECORD BOOK

K.R. and A.C.I. chapter XX and

of (Unit or Formation) R.A.F. Station Sandtoft and No. 1667 Conversion Unit.

No. of pages us

SECRET.

Date	Time	Summary of Events
		See 1667 Conversion unit
FEB.1944.		INTRODUCTION. Circumstances leading up to the opening up and formation of the Station
		February 1st to February 19th.
		R.A.F. Station Sandtoft is situated on the borders of Lincolnshire and Yorkshire, the Station actually being situate in Lincolnshire. Map Reference 211279.
		The Station forms part of No.11 Base in No. 1 Group. On the first of the month the following Officers were doing duty on the Station. Squadron Leader Administrative S/Ldr. R.H.E. [redacted] Equipment Officer F/Lt. G.J. Knight and Catering Officer F/O G. Sims. Approximately 100 Other Ranks had been posted in. On February 6th a conference was held in the Resident Engineers Office to decide when the Station would be ready to open up and receive No. 1667 Heavy Conversion Unit. This conference

		DIVERSIONS
2.3.44.		Halifax A. 466 Sqdn. LECONFIELD landed at 0745 hrs. from an operational sortie on STUTTGART.
7.3.44.		Spitfires K and H, HIBALDSTOW landed owing to bad weather.
16.3.44.		Lancaster Q 103 Sqdn. KIRMINGTON 0325 hrs. and Lancaster H2, 576 Sqdn. ELSHAM WOLDS 0338 hrs. landed from operational sorties on STUTTGART.
17.3.44.		Mosquito HR 855 landed 1239 hrs on Cross Country from DYCE owing to weather.
27.3.44.		Lightning 207 landed 1314 hrs from LOSSIEMOUTH en route to MOUNT FARM, for weather check.

29.4.44		W/Cdr. C.H. Cronkshaw. M.B.E. - No. 1. Group - Engineering Officer, visited the Engineering Section.
	(h)	The Station Anti-Aircraft Flight has been formed, seven Twin Browning Guns mounted on Motley Stalk Mountings have been erected and these can now be manned at approximately 20 seconds warning. A Station Anti-Sabotage Raid Scheme has been put into operation. This means that the Airfield has protection from Paratroops 24 hours a day.

(CAT. E). 4 of crew killed 3 injured.

25.3.44. Halifax V GG/M (DG 293) making difficult landing on 2 engines struck stationary aircraft (EB 144 CAT E) when on ground after landing off runway at 0105 hrs. (CAT E) no casualties.

27.3.44. Halifax V GG/D (DG 305) swung off runway on take off with burst tyre and under carriage collapsed at 0023 hrs. (CAT E) no casualties.

Courts of Inquiry were held as follows-

(Q) Educational classes were started on the W.A.A.F. Site.

1.4.44. (f) At 18.04 hours Halifax V. "G" DG·355 whilst taking off swung to port and undercarriage collapsed. No casualty Cat. E.

13.4.44. At 17.26 hours Halifax V. "U".DG351 was attempting landing with port outer engine feathered made three overshoots and on the third attempt after overshoot, pilot lost height and crash-landed in a field with undercarriage up Cat. E. No casualty.

14.4.44. At 01.46 hours Halifax V. "P" DG345 whilst taking off, swung to port, starboard undercarriage collapsed· No casualty Cat AC.

22.4.44. At 03.10 hours Halifax V. A2.DK.186 taxied off perimeter track into ditch.

crew made successful jumps. Cat. "E".

28.4.44. At 00.56 hours Halifax V· "J" DG. 317 taxied into rear of "O" DG. 347 whilst taxying round the perimeter track to take off. "O" was stationary at the marshalling post undergoing inspection by tyre checkers. No casualty DG·317 Cat. AC· DG. 347 Cat. B.

30.4.44 Court of Enquiry was held as follows:

Halifax V. "B" EB. 146.

President S/Ldr. [redacted] D.F.C. Member F/Lt. E.J. Le Good.

SECRET.

SANDTOFT.	8.5.44	(F)	Halifax V LL391. At 21.59 hours during take off on night cross country, aircraft commenced to swing to starboard; pilot overcorrected swing and aircraft swung to port. Undercarriage collapsed and starboard outer engine caught fire. Cat. B. No casualty.
	10.5.44		Halifax V LL389. At 02.16 hours pilot was landing on three engines at R.A.F. Halfpenny Green, was forced to overshoot as runway was blocked, struck some slight object; mainplane damaged. Cat. AC. No casualty.
	13.5.44		Halifax V LK.991. At 17.24 hours pupil came in to land too high, and when corrected by instructor failed to keep sufficient throttle on to ease aircraft on to runway. Instructor took over but could not correct altitude of aircraft in time to prevent stall on to runway. Undercarriage collapsed. Cat. E. No casualty.
	13.5.44		Halifax V DG309. At 20.44 hours whilst on circuits and landings, aircraft swung violently to port on sixth take off and pilot failed to correct it; undercarriage collapsed. No casualty. Cat. B.
	14.5.44		Halifax V DG.284. At 15.55 hours starboard outer engine cut and pilot [illegible]

injuries . Dead.

13.5.44. Halifax D/L.K. 991 crashed on landing . P/O Parson's (pupil Pilot) F/Sgt. Lister A/G. admitted S.S.Q. with injuries to back.

(f) Aircraft Accidents.

1.6.44 Halifax V LL414 crashed at 0200 hrs. at Shielin, Caenlochlan Forest, Angus, Scotland. Cat. E. Pilot P/O. [redacted]

6.6.44 Halifax V DG345 . Coming off runway on landing and crashed into EB194 which was stationary on a dispersal. Pilot of DG345 F/O. Tritton stated that throttles were jammed when coming into land. None of crew were injured. A/C. DG345 Cat. E.

26.6.44 Halifax V DG395 crashed near Thorne. Pilot, F/O. Smyth and crew all killed.

30.6.44 Halifax V DG338 burst tyre on take off and swung off runway. Pilot, P/O. Baker. No casualty. Cat. B.

A Court of Inquiry was held on accident to Halifax LL414.

crew killed with the exception of the mid-upper and rear gunners. Cat. E 2.

25.7.44. Halifax V DG 310 At Sandtoft. Heavy landing caused shearing of pins securing self-centring cam on tail oleo leg. Lower sleeve and tail wheel dropped out on next take-off. Aircraft landed on rear fuselage, crew not injured. Cat. AC.

18.8.44 Halifax V LL226 at Sandtoft; Starboard undercarriage collapsed on landing due to failure of outboard radius rod. Fracture apparently due to drift while landing on previous heavy landing. A/C. Cat. AC crew uninjured.

19.8.44 Halifax V LL415 diverted to Cornaby. Screened pilot unable to

28.9.44. The opening meeting of the W.A.A.F. Christmas Club was held.

(f) AIRCRAFT ACCIDENTS.

6.9.44. Halifax V. DK.133. struck ground shortly after take-off on night flying detail. All crew killed A/C. Cat. E burnt out.

24.9.44. Halifax V. DK.173. Starboard inner failed shortly after take-off. Pilot alleged port inner was failing on the downwind leg. Did belly landing on grass. Starboard inner failed due to severe internal coolant leak followed by valves sticking and disintegration of flame traps.

COPIES OF

of the aircraft before it broke up in the air. A/C. Cat. E2. All killed.

12.11.44. Halifax V. LL.389 was returning from a cross country detail and attempted to land in bad weather - approached too fast - held-off too much - and ballooned - stalled and dropped on the runway bursting the port tyre and damaging the port undercarriage. A/C. swung off runway and port undercarriage collapsed causing severe damage to the port wing. A/C. Cat.E. Crew uninjured.

transport and weather difficulties interfered with swimming activities.

(F) AIRCRAFT ACCIDENTS.

7.1.45. Lancaster ID477 skidded on the ice when turning off the runway on to the perimiter track. The port wheel struck a patch of frozen ground broadside on with considerable force causing the wheel to break off and the undercarriage to collapse (Cat. AC. Crew unhurt).

20.3.45. Lancaster WA154 bounced on landing and came down on the grass about 50 yds. from the runway. The aircraft ran parallel to runway for some distance, but struck the end of a ditch with starboard wheel causing undercarriage to collapse and aircraft to swing round violently (Cat. B. Crew unhurt).

SANDTOFT February Two engines had out due to mis-manipulation of fuel cocks causing a tank to run dry. After trying to re-start Pilot attempted two engined landing at Sandtoft, but overshot. Two remaining engines out during further circuit due to other tank running dry and Pilot landed at Lindholme which was the nearest airfield. Flight Engineer thought he was on No. 2 tanks but had apparently forgotten to change over from No. 1's. Crew uninjured.

still a good attendance.

(F) AIRCRAFT ACCIDENTS.

5.4.45. Lancaster I. N.D. 639 at night dived into ground at high speed - cause of accident obscure. Crew all killed.

9.4.45. Lancaster I.D.V.165 swung on take off. Fire when engines struck ground on collapse of undercarriage. Crew uninjured.

15.4.45. Lancaster I. P.B.565 dived into ground during daylight - cause obscure. Crew all killed.

[illegible] are played regularly by all ranks.

(F) AIRCRAFT ACCIDENTS.

7.5.45. Lancaster I HK.751. The aircraft bounced on landing and through faulty manipulation of throttles was allowed to stall which caused the starboard undercarriage to collapse. The aircraft was rendered cat. pl and removed from the unit by contractors.

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Approximate site boundary

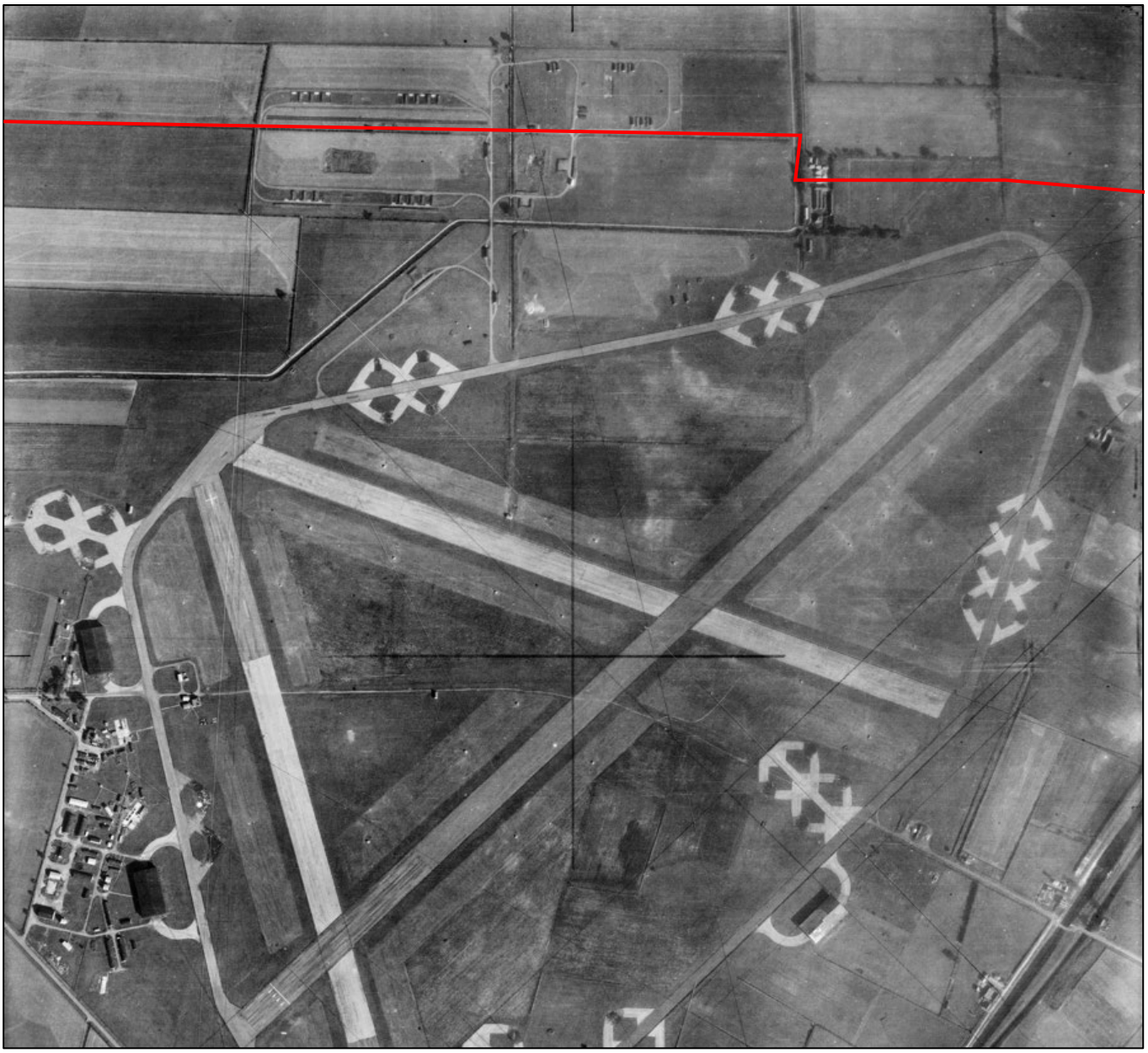
Project: Tween Bridge Solar, Doncaster

N

Ref: DA18705a-00

Source: National Monuments Record Office (Historic England)

RAF Sandtoft Aerial Photography, 21st September 1948



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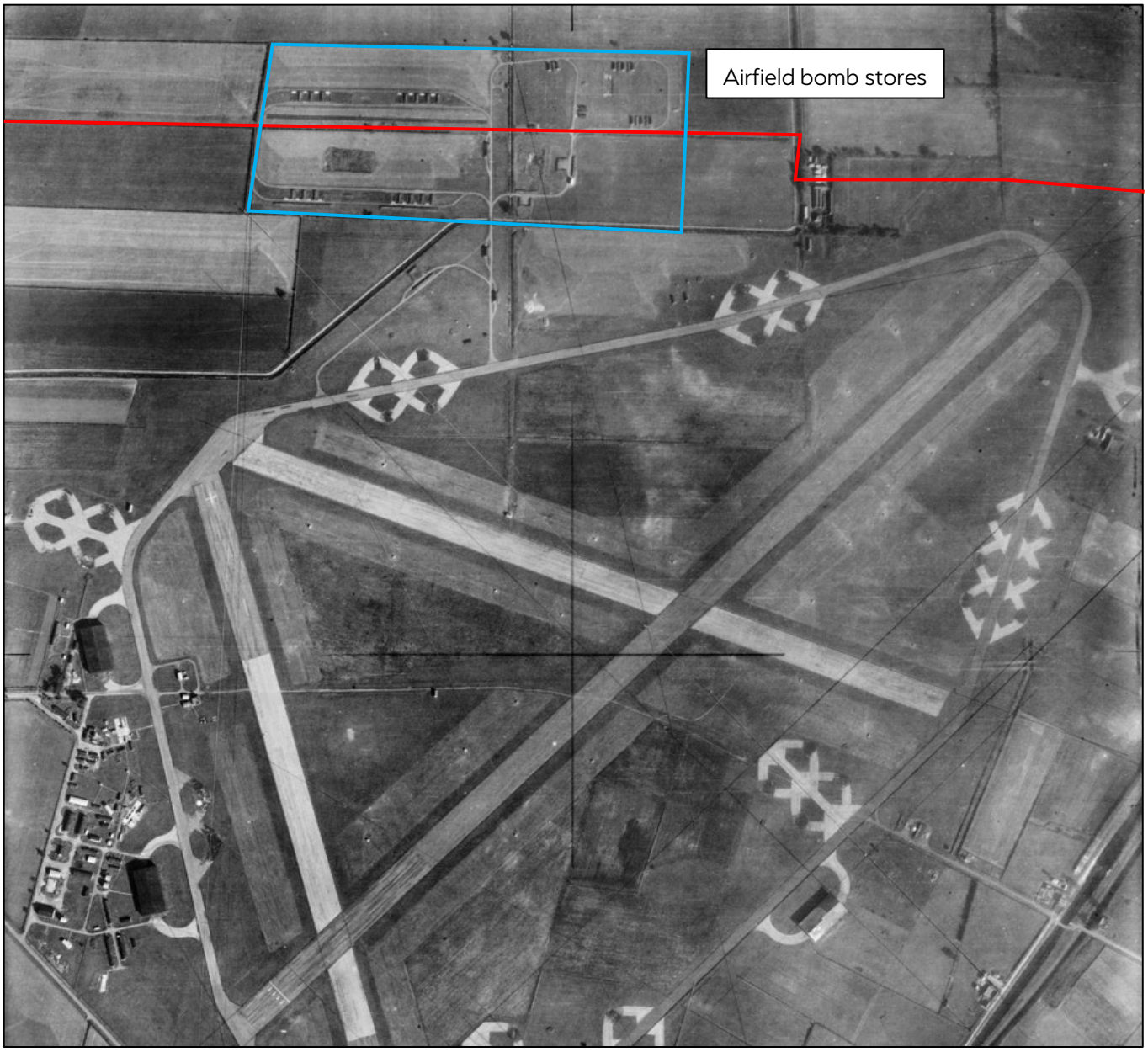

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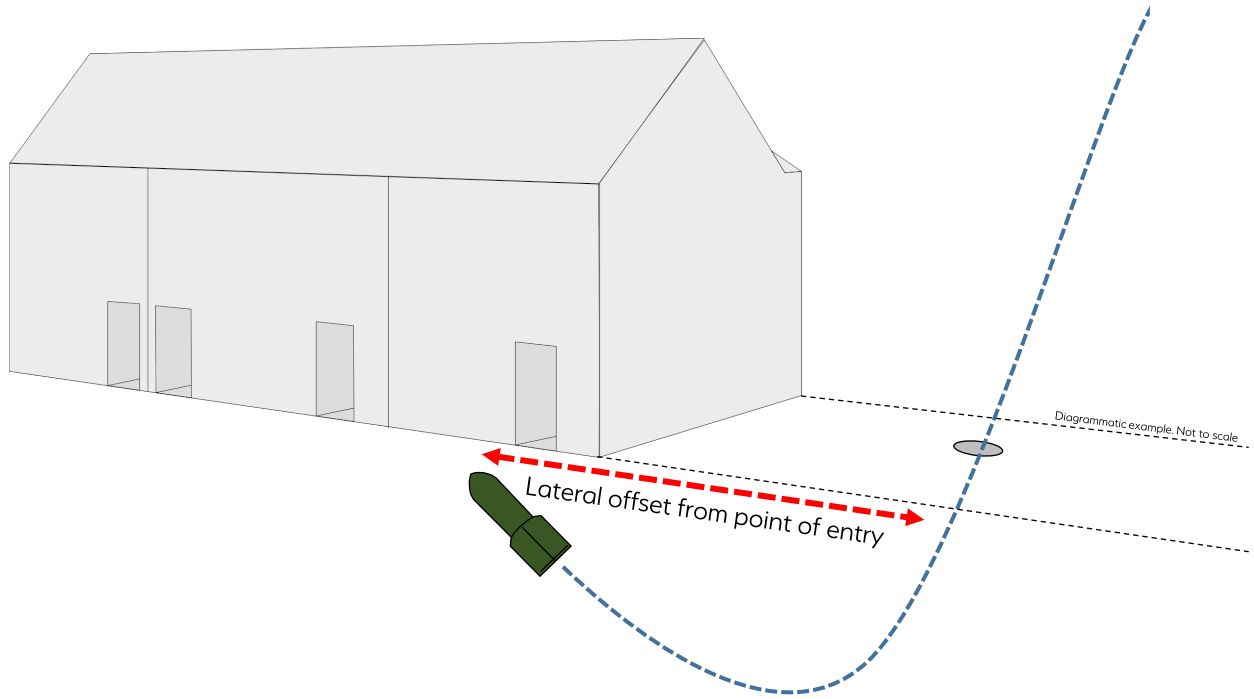
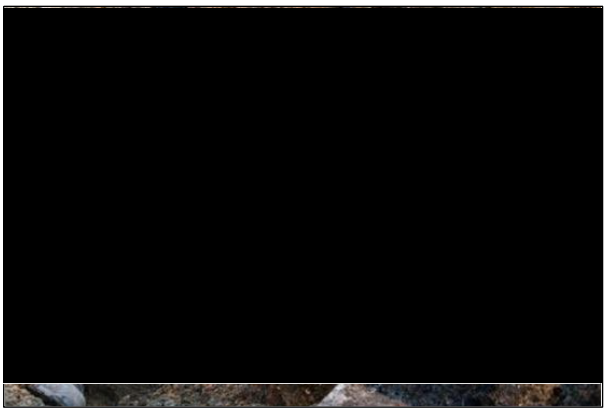
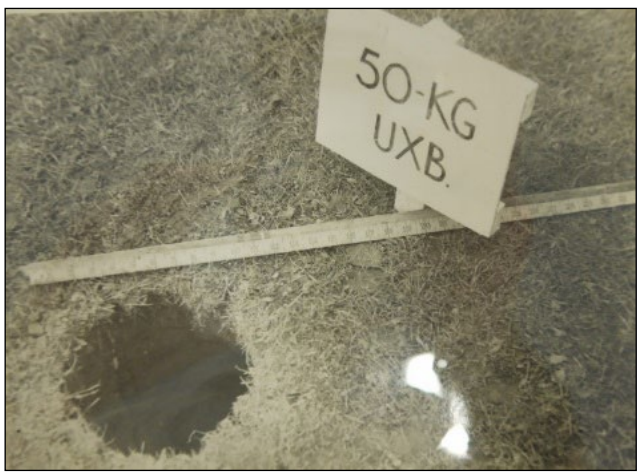
Example of UXO Entry Hole / The 'J-curve' Effect Principle







Top: J-curve Effect - Due to angle of entry, unexploded bombs would often end their trajectory at a lateral offset from point of entry, often ending up beneath adjacent extant structures/sites.

The photograph **above** shows a 250kg unexploded bomb found in Bermondsey in 2015, pointing upwards, demonstrating 'J-curve'.

One of the most common scenarios for UXO going unnoticed was when a UXB fell into a 'bomb site' (such as the area shown **Top Left**), the entry hole of the bomb obscured by any debris and rubble present. Note that the entry hole of a 50kg UXB could be as little as 20cm in diameter (**Left**).

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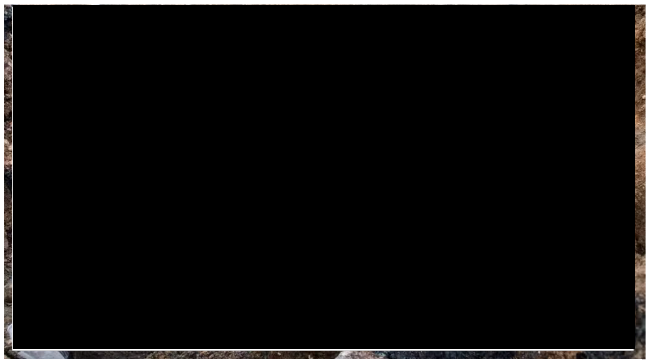
Project:	Tween Bridge Solar, Doncaster
Ref:	DA18705a-00
Source:	Various sources

BBC NEWS

Bermondsey bomb: World War Two device safely removed



An unexploded World War Two bomb found in south London has been driven away safely under police and Army escort.

The 500lb (250kg) device was found on a building site in Grange Walk, Bermondsey on Monday.

Two primary schools were closed and hundreds of homes were evacuated as a precaution.

A cordon and 656ft (200m) exclusion zone was lifted at about 18:15 GMT as the bomb was removed to a quarry in Kent to be detonated, police said.

The Metropolitan Police force said the device was a 'SA' 250kg WWII German air-dropped bomb, known to the Army's Royal Logistic Corps bomb disposal experts.

250kg German HE Bomb, March 2015

BBC NEWS

WW2 bomb found near London City Airport blown up

An unexploded World War Two bomb found near London City Airport has been detonated.

The 500kg device was discovered at the King George V Dock on Sunday during planned work at the airport.

It was closed and all flights were cancelled on Monday after an exclusion zone was put in place.

The detonation, which took take place off Shoeburyness, Essex, was postponed on Tuesday because of high winds and dangerous conditions for divers.

The 1.5m-long German bomb - which was found in a bed of silt, 15m underwater - was carefully removed from the Thames and placed in a secure location a mile away from the coast of Essex.

500kg German HE Bomb, February 2018

BBC NEWS

Exeter WW2 bomb is detonated after homes evacuated

More than 2,600 households and 12 university halls of residence were cleared before the 2,200lb (1,000kg) device **was destroyed** on Saturday.

Police said the blast left a crater about the size of a double-decker bus.

Police have reported large pieces of metal debris hitting buildings and said some properties in the 100m (330ft) exclusion zone had sustained "structural damage".

1000kg German HE bomb, February 2021

BBC NEWS

Great Yarmouth: Huge blast after unplanned WW2 bomb detonation

A World War Two bomb found in Great Yarmouth has detonated while work was being done to defuse it, causing a huge blast that was heard for miles.

Army specialists were attempting to disarm it when there was an unplanned detonation at about 17:00 GMT.

People on social media said they heard a loud bang and felt buildings shake 15 miles (24km) away.

There have been no reports of injuries among the Army, emergency services or the public, Norfolk Police said.

Cordons were put in place when the bomb was first discovered close to two gas pipes on Tuesday, and work began to make it safe.

250kg German HE Bomb, February 2023

BASF has confirmed that an explosive device, most likely a World War II-era bomb, caused the blast that left one person injured Tuesday at a plant construction site in Germany.

The explosion was reported at BASF's Ludwigshafen toluene diisocyanate (TDI) plant, which recently broke ground for a 300,000 metric tons per year TDI production plant and other construction to expand its facilities.

BASF Provides Some Details

Responding to a request from *PaintSquare News* for more information on Wednesday (Feb. 27), BASF's manager of media relations and corporate communications Europe, Ursula von Stetten, wrote in an email, "So here [are] the facts: The detonation took place at 10:00 a.m. One person was injured; the injury is not serious. He will be kept in the hospital for some days.

"Cause of the detonation was an explosive device, presumably a bomb deriving from the Second World War. The device detonated when grounding work was done. No details on [a] delay [are] available. At the moment, the exact circumstances of the incident are [being] evaluated."

1st March 2013

WWII bomb injures 17 at Hattingen construction site

Seventeen people were injured on Friday when a construction crew unwittingly detonated a buried World War II-era bomb in Hattingen.

An excavator apparently drove over a 250-kilogramme (550 pound) American bomb, damaging surrounding buildings. Most of the injured suffered auditory trauma from the blast, and the excavator operator suffered injuries to his hands, police in the German state of North Rhine-Westphalia said.

"The hole was astoundingly small for such a large bomb full of so many explosives," Armin Gebhard, head of the Arnsberg department for military ordnance removal, told The Local. "But of course it damaged all the surrounding buildings too. We are really happy it wasn't worse."

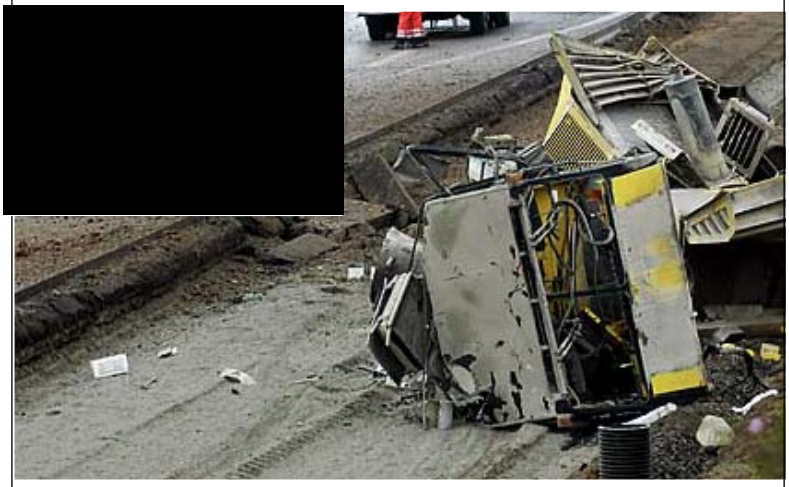
19th September 2013

SPIEGEL ONLINE

Blast Kills One

World War II Bomb Explodes on German Motorway

A highway construction worker in Germany accidentally struck an unexploded World War II bomb, causing an explosion which killed him and wrecked several passing cars.



A World War II bomb has exploded during construction work on a German highway, killing one worker and injuring several motorists who were driving past, police said.

The worker had been cutting through the road surface near the south-western town of Aschaffenburg when his machine struck the bomb and triggered it. Police said they weren't sure yet what type of bomb it was. "The explosion seems to have been too small for it to have been an aircraft bomb," a police spokesman said.

23rd October 2006

BBC NEWS

World War II bomb kills three in Germany

A special commission is investigating the causes of the explosion, while prosecutors are considering whether the team leader should face charges of manslaughter through culpable negligence, the BBC's Oana Lungescu reports from Berlin.

The blast happened an hour before the defusing operation was due to start.

Officials said the three men who died were experienced sappers, or combat engineers, who over 20 years had defused up to 700 bombs.

More than 7,000 people were immediately evacuated when the 500kg bomb was found. Several schools, a kindergarten and local companies remain closed.

2nd June 2010

June 2006

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NEWS

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Unexploded WW1 artillery shell found in Newark

7 December 2020

The bomb was found when a marina worker was dredging the water

An unexploded World War One artillery shell has been found in a river by a marina worker.

James Wilkinson, who works at Newark Marina in Nottinghamshire, was dredging the water at about 11:00 GMT when he uncovered the device.

A specialist bomb disposal unit carried out a controlled explosion to detonate the 18lb and 6in long "highly explosive" device.

Kirby residents react after grenade is detonated on housing estate

12th November 2020

Residents react after wartime grenade 'with pin still in it' is detonated on housing estate

By George King
Digital Audience and Content Editor
@Georgehenryking

Share

1 Comments

Essex Police officers were called to the Taylor Wimpey housing development in Thorpe Road, Kirby Cross, after the 70 plus-year-old hand grenade was discovered.

All Sections YORKSHIRE POST Sign in Subscribe

Army called after unexploded WW2 shell found in village near Ilkley

Police have released photos of an old wartime mortar shell that was found in a rural Yorkshire village.

By Grace Newton
Published 2nd Apr 2020, 12:04 BST
Updated 2nd Apr 2020, 12:06 BST

Army bomb disposal experts from the Royal Logistics Corps were called to Addingham, near Ilkley, yesterday to make the device safe.

Manchester Evening News NEWS IN YOUR AREA MAN UTD MAN CITY WHAT'S ON SPORT MORE

Police warning after discovery of unexploded mortar shell in Glossop moorland

Derbyshire Police described the find as 'very dangerous and unusual'

Bookmark Comments 1

NEWS By Fionnula Hainey UK and world news writer

This unexploded mortar shell was found on moorland above Glossop (Image: Facebook/Glossop Police SNT)

The force said officers were alerted to the large metal shell on Saturday (February 20) by a member of the public.

It was identified by experts as an unexploded mortar shell, which the force described as 'very dangerous and unusual'.

Express & Star

Dozens more mortar shells found during work on Burntwood housing estate

By Luke Bartlett | Burntwood | Published: May 24, 2018 | 1 Comments

A large number of mortar shells have been discovered on a building site in Burntwood forcing businesses to evacuate.

The shells were found by Staffordshire Police on the site near Milestone Way, in Chasetown, and a 200m (656ft) cordon was soon after put in place.

Members of the public are being advised to stay away from the area near Morrisons supermarket while police deal with the shells.

Developers Taylor Wimpey and Barratt Homes were behind the plans to build 150 homes at Milestone Way.

Unexploded WW2 bomb found at Kenfig Pool, Bridgend

23 August 2014

Dean Smith believes the shell was made in Germany

Bomb experts have been called to a south Wales nature reserve after an unexploded World War Two shell was discovered by a walker in Bridgend.

Dean Smith, 38, of Pyle, was walking near Kenfig Pool on Saturday when he saw a fin sticking out of the sand.

He reached down to pick it up, but ending up falling and landed with the 2ft-long (0.6m) bomb on top of him.

The site has been cordoned off by police and the Royal Logistics Corps will carry out a controlled explosion.

SwindonAdvertiser

News Sport Crime What's On Opinion Announcements

News Traffic and Travel Property Politics Health News Business news

Worker on old school site in Swindon finds buried explosives

25th November 2022

At around 9.30am, the digger rubbed against the lid of something which was approximately 600mm below ground - and would have blown up instantly if broken.

AW Bombs are yellow phosphorous hand grenades in half pint clear glass bottles weighing 1.5lbs each, which ignite instantly once their liquid contents react with the outside air.

deadline.

NEWS ENVIRONMENT IN BRIEF TOP STORIES

December 14, 2020 0 1983

Locals on Isle of Wight find 1ft long unexploded WW2 bomb

AN UNEXPLODED World War Two bomb has been discovered by locals on the Isle of Wight.

Bomb disposal experts were deployed to the B3323 in Shorwell, after police arrived and identified the dangerous device.

SuffolkNews

Icklingham mortar bomb is blown up by Army

Published: 16:46, 25 February 2015

Police had to guard an unexploded WW2 4in calibre mortar bomb overnight in a field near Icklingham until Army bomb disposal could blow it up on Tuesday.

The bomb had been found by farmworkers using a digger at about 2.50pm on Monday but by the time the Regiment Royal Logistic Corps' 621 Squadron, 11 Explosive Ordanance Disposal, from Colchester, had examined it it was too dark to carry out a controlled explosion.

Yorkshire

This article is more than **1 year old**

Army detonates WW2 bomb uncovered in Goole, east Yorkshire

Major roads reopen and people return home after device found on housing estate made safe

Miranda Bryant *and agencies*

Sat 24 Jul 2021 18.33 BST

Residents have been allowed to return to their homes and businesses have reopened after a second world war bomb was detonated by the army after being uncovered on a street in east Yorkshire.

Homes had been evacuated, an entire stretch of motorway was closed and a no-fly zone implemented after the unexploded bomb was discovered on a housing development.

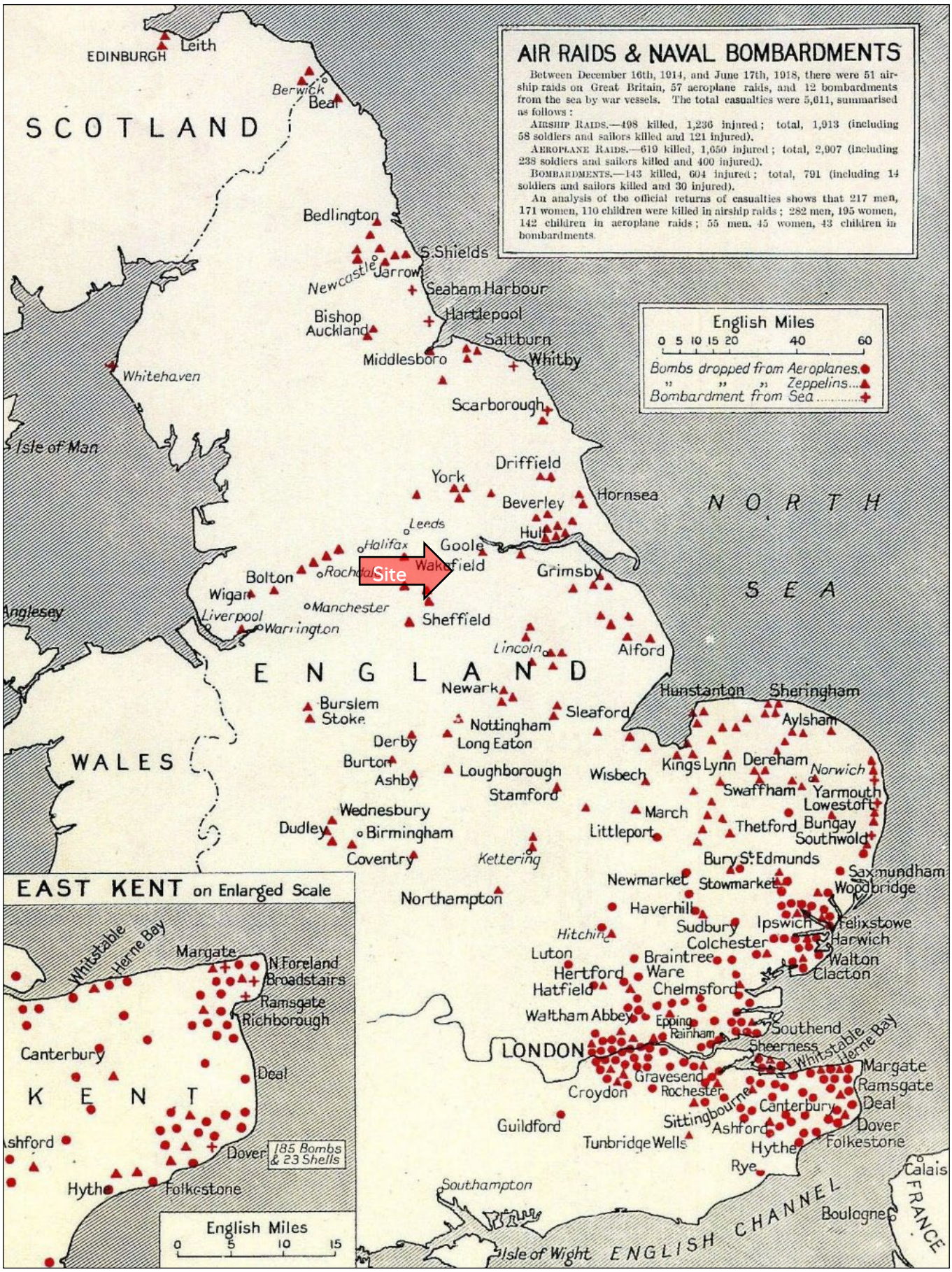
The army were called in to detonate the 500lb (227kg) device in Goole after it was found on Thursday. Eight homes were evacuated and the M62 closed in both directions between junctions 35 and 37.

Humberside police said they responded to reports of an "unexploded WW2 bomb [that] had been found at a new housing development on Rawcliffe Road, Goole" at 11.45am on Thursday.

[redacted] the site manager of the Beal Homes development, said workers called him on Thursday to say they had discovered what they thought was a metal pipe.

A worker went down to look at it, and "as he uncovered it he realised it was a bomb and got out pretty quickly", Sharpe told the BBC.

He said the bomb was believed to have been dropped by a Lancaster bomber in a crash landing.



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Email: info@1stlinedefence.co.uk
Tel: +44 (0)1992 245 020

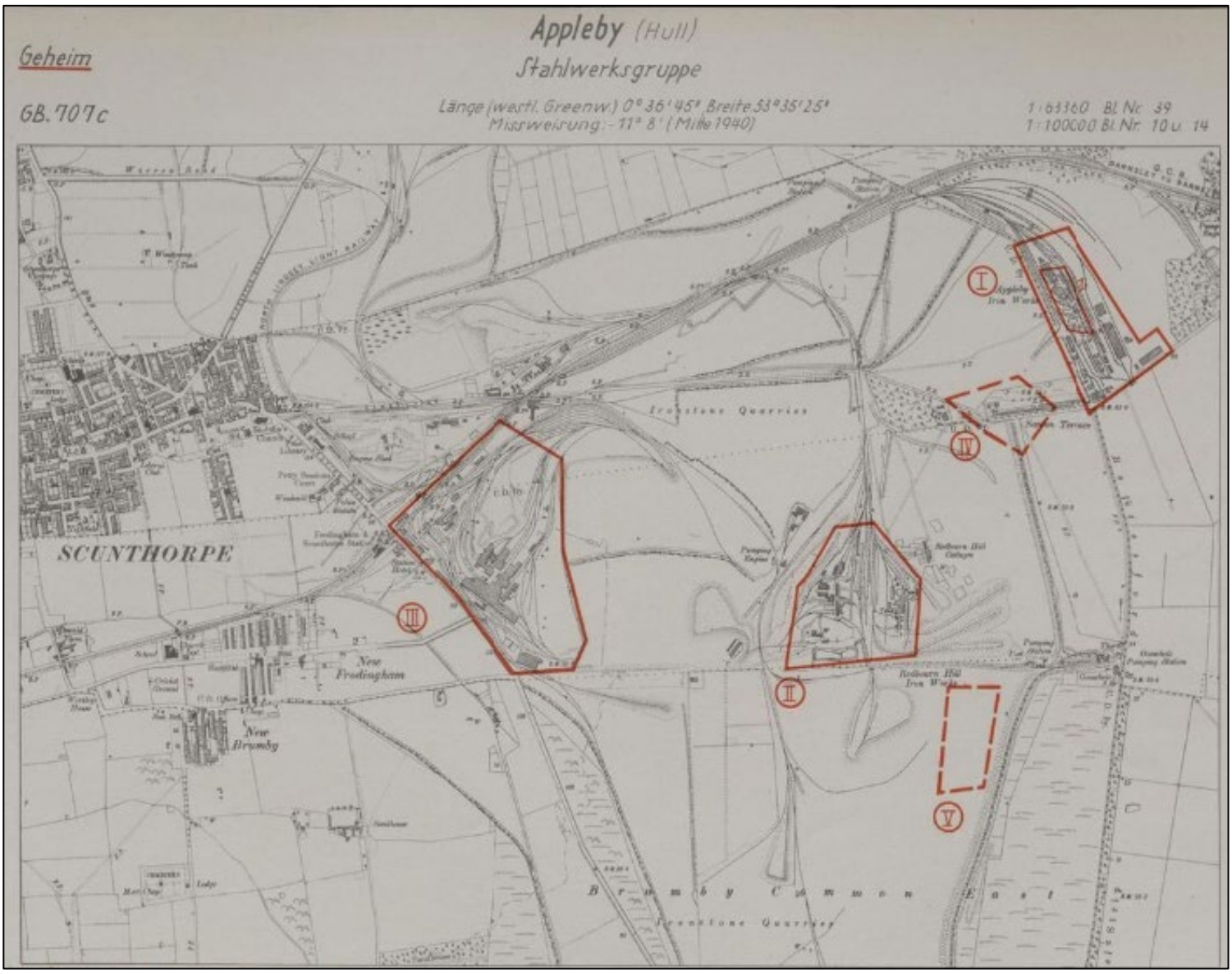
Client: RWE Renewable UK Solar and Storage Ltd

Project: Tween Bridge Solar, Doncaster

Ref: DA18705a-00

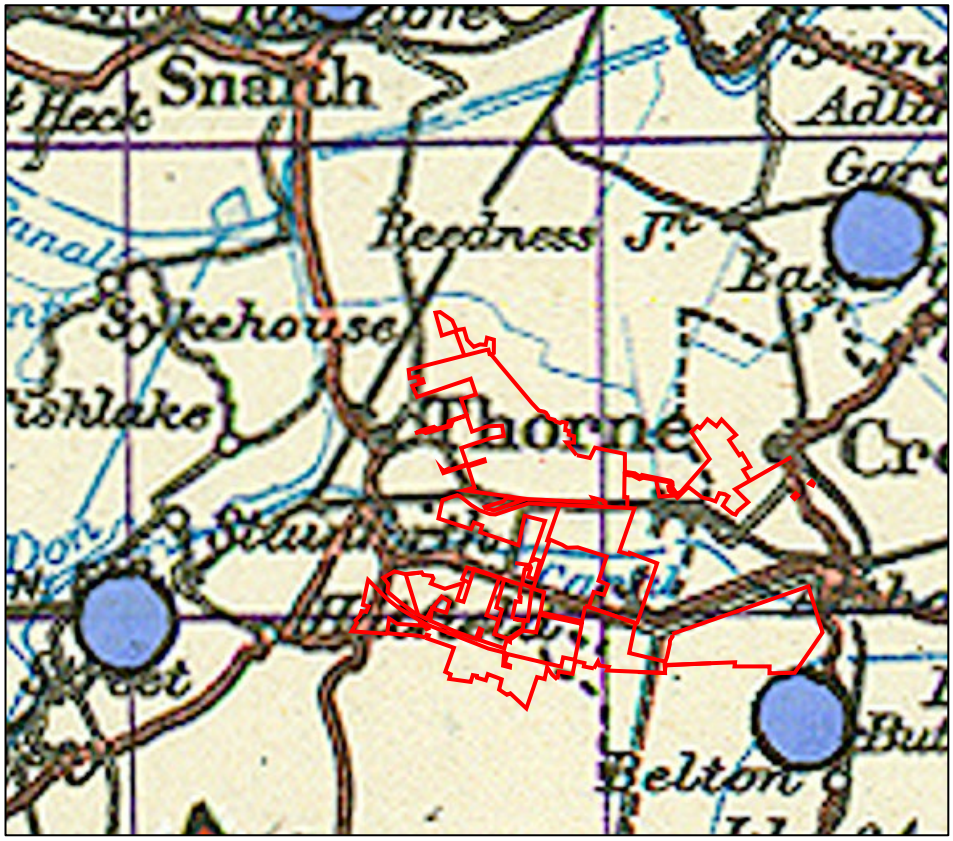
Source: J. Morris, German Air Raids on Britain

N



Scunthorpe – Steel Works

The site is approximately 12.8km west of Scunthorpe steel works.



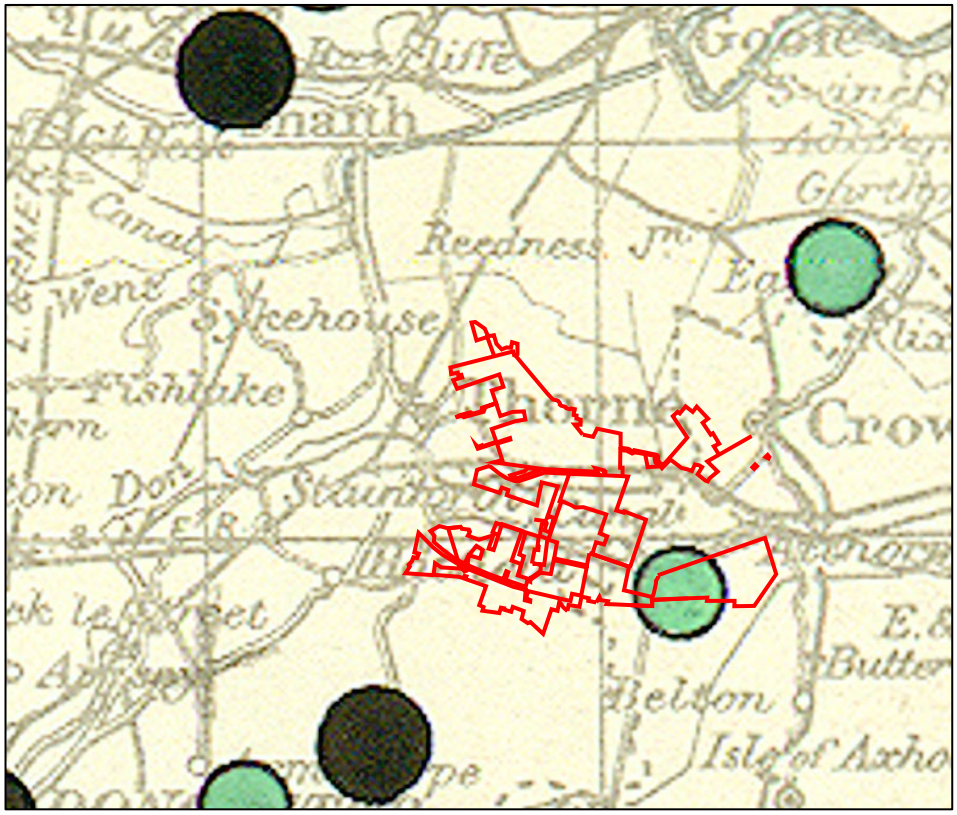
Copy of "DEFENCE MEASURES" MAP,
Original made and held by
Colonel Turner's Dept. Air Ministry.
C/o. G.P.O. Shepperton, Mddx.

KEY

- Q Site
- SF (with or without QL)
- QF (with or without QL)
- Cover Plan Site
- K Site (with or without Q)
- Dummy Buildings

K.P.I.D. MAP No: 1018

TOP SECRET



TOP SECRET

DEFENCE MEASURES MAP

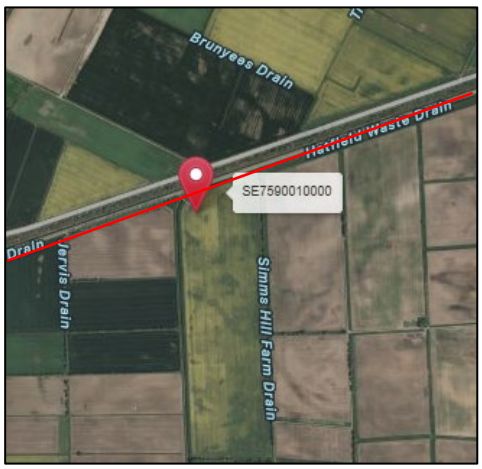
KEY

- Site Decoyed.
- Starfish.
- QF, QL, etc.

Compiled by K.P.I.D from lists
Supplied by Colonel Turner's Dept.
Air Ministry, Shepperton Mddx.

K.P.I.D. MAP No: 1042.

H.M.S. 16/1/46. PART I.



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Tel: +44 (0)1992 245 020

Client: RWE Renewable UK Solar and Storage Ltd

Project: Tween Bridge Solar, Doncaster

Ref: DA18705a-00

Source: The National Archives, Kew

Approximate site boundary

N

Risk Zone	Activity	Recommended Risk Mitigation Measure
Low	All Works	• UXO Risk Management Plan • Site Specific UXO Awareness Briefings to all personnel conducting intrusive works.
Medium	Open Excavations (trial pits, service pits, bulk excavations, strip foundations etc.)	• UXO Specialist On-site Support
Medium-High		

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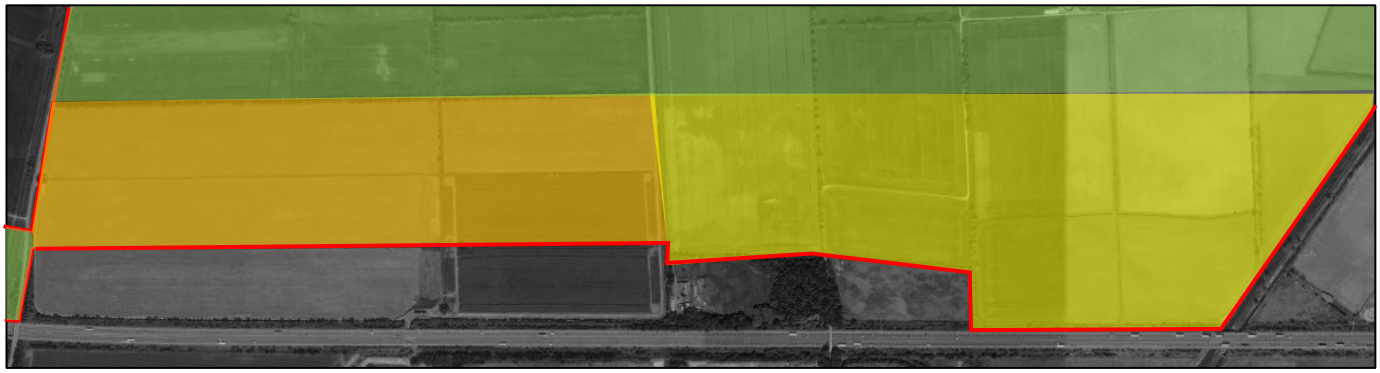
Project: Tween Bridge Solar, Doncaster

Ref: DA18705a-00

Source: 1st Line Defence

Approximate site boundary

N



Risk Zone	Activity	Recommended Risk Mitigation Measure
Low	All Works	• UXO Risk Management Plan • Site Specific UXO Awareness Briefings to all personnel conducting intrusive works.
Medium Medium-High	Open Excavations (trial pits, service pits, bulk excavations, strip foundations etc.)	• UXO Specialist On-site Support

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Ref: DA18705a-00

Source: 1st Line Defence

Approximate site boundary

N

In 2021, 1st Line Defence undertook non-intrusive UXO magnetometer surveys at locations several hundred metres distant from a former RAF bomb store at Full Sutton. During the first phase, over 30 practice bombs were recovered, along with an ammunition box, a bomb nose plug and dozens of bomb tail pistols. Dozens of additional practice bombs were found during the second phase of support.

Below are photographs of some of the UXO finds, including practice bombs.

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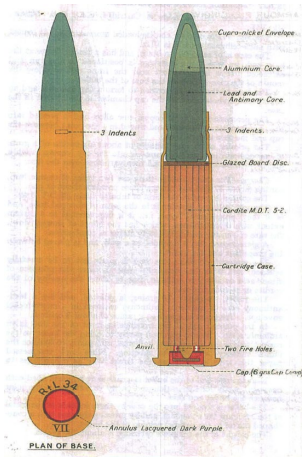
British 303. Round

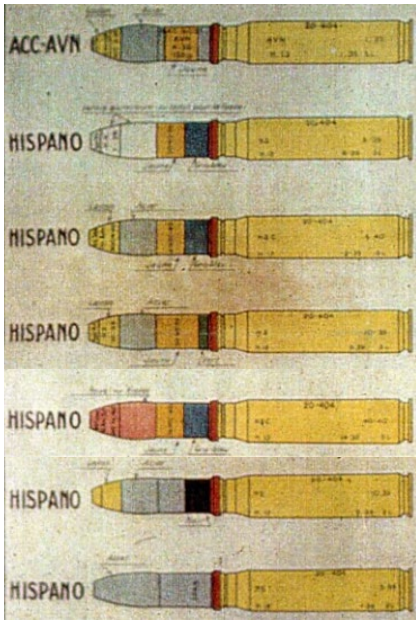
Bullet Diameter	7.92mm
Case length	56.44mm
Overall length	78.11mm
Type	Rifle Ammunition
Use	303 rounds were used in machine guns on aircraft, as well as in aircraft defence, and SAA.
Remarks	First produced in 1889 and still in use today, the .303inch cartridge has progressed through ten 'marks' which eventually extended to a total of around 26 variations.

Bullet Type	Colour of tip	Colour of Annulus
Armour Piercing	Green	Green
Ball	None	Purple
Incendiary	Blue	Blue
Observing	Black	Black
Proof	None	Yellow
Tracer Short Range	White	Red
Tracer Dark Ignition	Grey	Red
Tracer Long Range	Red	Red



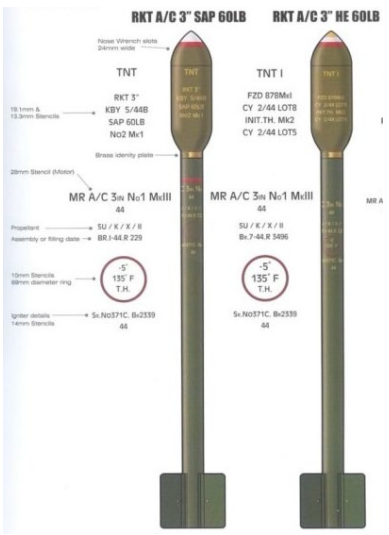
Hispano Suiza HS.404

Weight	HE - 0.13kg (13lbs), complete Round 0.2kg (0.57lbs) Armour Piercing – 0.17kg (0.37lbs) complete round0.29kg (0.64lbs)
Explosive Weight	HE & HEI - 0.014kg. Armour Piercing and shot rounds may not have been filled with an explosive element.
Fuze Type	No.253 MK.1A Direct Action (Percussion) Fuse
Dimensions	20mm x 110m
Use	The Hispano Suiza HS.404 was widely used by both fighter and bomber aircraft throughout WWII
Remarks	Although relatively small, if encountered en masse unexploded HE canon round may present a risk to people and plant.



RP-3 60lbs Rocket

Weight	37kg (80lbs)
Explosive Weight	25kg (25kg)
Fuze Type	No. 899 MK 1
Dimensions	55.88cm x 11.43cm (22" x 4.5")
Use	A rocket typically deployed from the air at ground targets such as tanks, trains, and shipping.
Remarks	The RP-3 was a high explosive rocket designed to destroy armoured vehicles. If detonated an RP-3 may present a serious risk to both workers and equipment.



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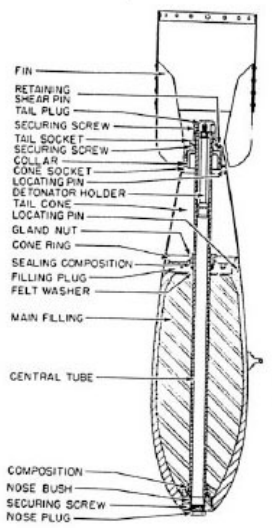
Project: Tween Bridge Solar, Doncaster

Ref: DA18705a-00 **Source:** Various sources

250lb General Purpose Bomb

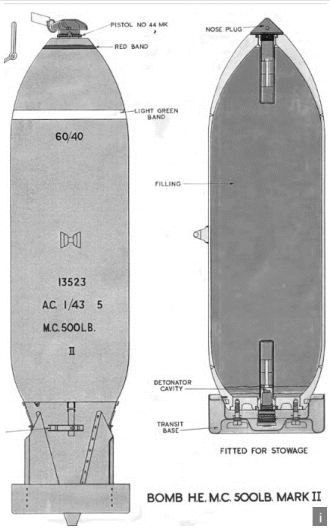
Weight	247lbs
Explosive Weight	123lbs
Fuze Type	Nose fuses included the AM-M103, M118, and M119. Tail fuses included AM-M102A2 or the M114A1
Dimensions	28" x 10.3" (137.66cm x 71.12com)
Use	The 250lbs bomb was used to target railways, small buildings, ammunition dumps, planes, and hangers. Bombs were typically mounted under the wings.
Remarks	Allied ordnance was typically 'lustreless' or 'olive drab'. Bombs were typically marked with a yellow band across the nose or the tail.



Above - A Westland Whirlwind being armed with 250lbs underwing. Below - 250s in N. Africa.

500lb General Purpose Bomb

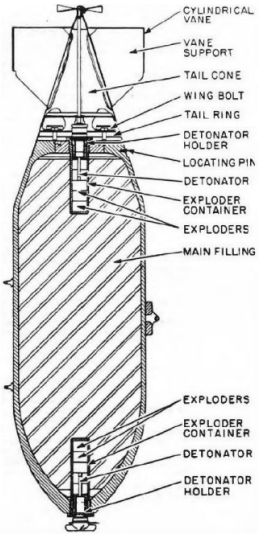
Weight	509lbs
Explosive Weight	262lbs
Fuze Type	Nose fuses included the AM-M103, M118, and M119. Tail fuses included AM-M102A2 or the M114A1
Dimensions	35.7" by 13" (90.67cm x 33.02cm)
Use	The 500lbs general purpose bomb was the most commonly deployed item, of Allied aerially delivered ordnance. 1,729,611 500lbs were deployed by the allies.
Remarks	Allied ordnance was typically 'lustreless' or 'olive drab'. Bombs were typically marked with a yellow band across the nose or the tail.



A Hawker Tempest being equipped with 500lbs general purpose bombs circa 1943 – 1945.

1000lb Medium capacity bomb

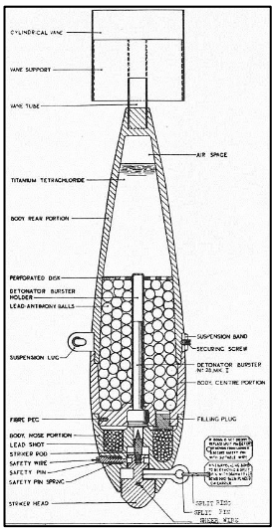
Weight	1,021lbs (464.09kg)
Explosive Weight	480lbs (approx. 47% of bomb weight)
Fuze Type	Nose fuses included the AM-M103, M118, and M119. Tail fuses included AM-M102A2 or the M114A1.
Dimensions	1010x678mm.
Use	The bomb was usually fitted under the wings of fighter aircraft and used for the tactical bombing of strategic targets. From 1944 the bomb was rationed for the purpose of supporting land operations.
Remarks	The bomb is made of case steel with an amatol 50/50 or 60/40 amtex filling.



Above, a 1000lbs.
Below, a 1000lbs being fitted to a P-40 Warhawk.

8.5 lb Practice Bomb

Bomb Weight	85 lb (approx. 3.9 kg)
Explosive Weight	1 lb (approx. 0.45 g)
Fuze Type	Explosive fuze and bursting charge.
Bomb Length	15.9 in (405 mm)
Body Diameter	Max. 2.95 in (75 mm)
Use	Dropped by Allied forces in order to practice bombing accuracy. Practice bombs used a small bursting charge to release smoke to mark their position.
Remarks	Had a moulded plastic shell. The Mk I had smoke filling and the Mk III had a flash filling, a mixture of gunpowder and magnesium turnings.



10 lb Practice Bomb

Bomb Weight	10 lb (approx. 4.5 kg)
Explosive Weight	1 lb (approx. 0.4 g)
Fuze Type	Explosive fuze and bursting charge.
Bomb Length	18 in (460 mm)
Body Diameter	Max. 3 in (76 mm)
Use	Dropped by Allied forces in order to practice bombing accuracy. Practice bombs used a small bursting charge to release smoke to mark their position.
Remarks	The Mk I had smoke filling and the Mk III had a flash filling, a mixture of gunpowder and magnesium turnings.

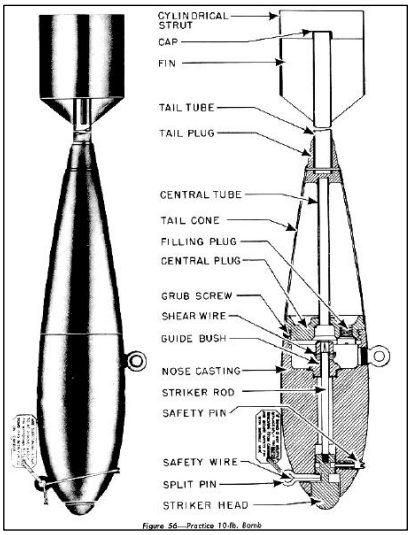


Figure 56—Practice 10-lb. Bomb

11.5 lb Practice Bomb

Bomb Weight	11.5 lb (approx. 5.0 kg to 5.3 kg)
Explosive Weight	1 lb (approx. 0.45 g)
Fuze Type	Explosive fuze and bursting charge.
Bomb Length	460 mm (18 in)
Body Diameter	Max. 3 in (76 mm)
Use	Dropped by Allied forces in order to practice bombing accuracy. Practice bombs used a small bursting charge to release smoke to mark their position.
Remarks	Available with smoke or flash filling. Mk II was made of Bakelite. Most often had a white shell.

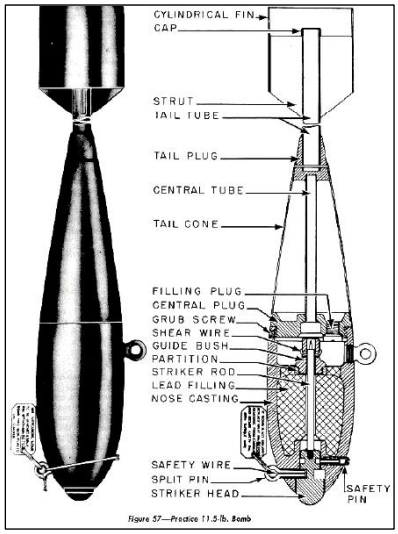


Figure 57—Practice 11.5-lb. Bomb

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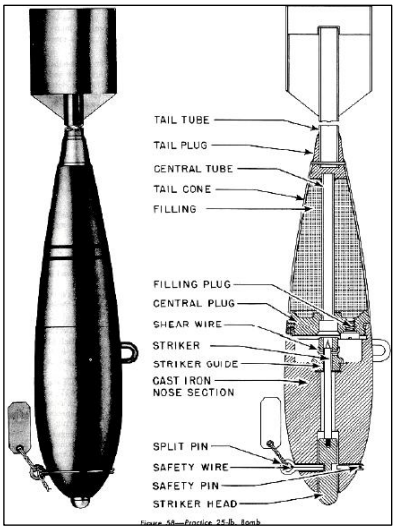
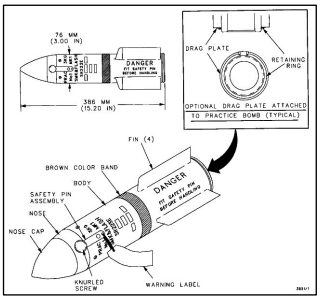
25 lb Practice Bomb

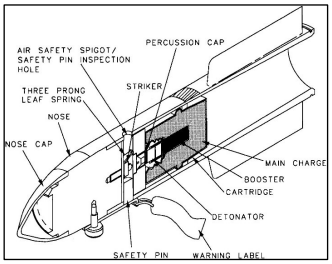
Bomb Weight	25 lb (11 – 11.5 kg)
Explosive Weight	1 lb (approx. 0.45 g)
Fuze Type	Explosive fuze and bursting charge.
Bomb Length	22 in (550 – 560 mm)
Body Diameter	4 in (100 mm)
Use	Dropped by Allied forces in order to practice bombing accuracy. Practice bombs used a small bursting charge to release smoke to mark their position.
Remarks	Mks I and IV had a smoke filling and Mks III and V had a flash filling for use at night. The 25 lb Practice Bomb was usually white with a cast iron nose.



3 kg Practice Bomb

Bomb Weight	3 kg (approx. 6.6 lb)
Explosive Weight	Contains a smoke or flash filling.
Fuze Type	Varied
Bomb Length	386 mm (15.2 in)
Body Diameter	76 mm (3 in)
Use	Dropped by Allied forces in order to practice bombing accuracy. The 3kg Practice Bomb used a traditional detonator.
Remarks	Coloured banding around the casing denotes the filing of the bomb. The image to the left is a low explosive example.





Buried and Decayed Practice Bombs

Examples of buried 3kg Practice Bombs.

Practice bombs found after a landslide in Mappleton Beach.

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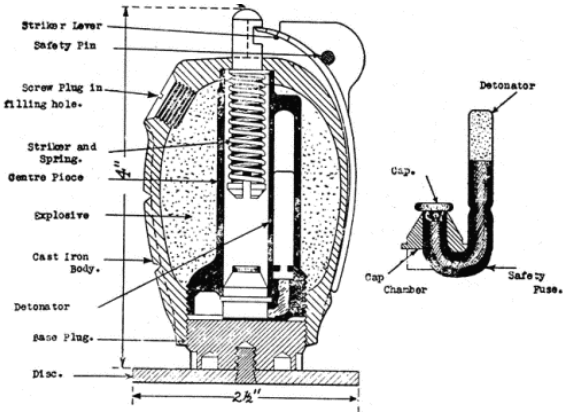
Client: RWE Renewable UK Solar and Storage Ltd

Project: Tween Bridge Solar, Doncaster

Ref: DA18705a-00 **Source:** Various sources

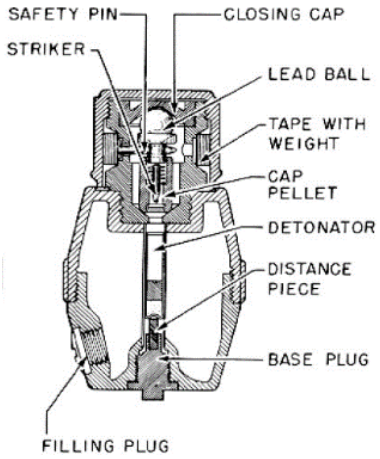
No. 36 'Mills' Grenade

Weight	Approx. 765g filled (1lb 11.25oz)
Explosive Weight	71g (2oz) filling.
Fuze Type	4-7 second delay hand-throwing fuze. No. 6 Detonator
Dimensions	95 x 61mm (4 x 2.4in)
Use	Fragmentation explosive at approx. 30m range 100m range of damage.
Remarks	First introduced in 1915, its classic grooved, cast-iron 'pineapple' design was designed to provide uniform fragmentation. The detonator is inserted before use after removing the base plug.



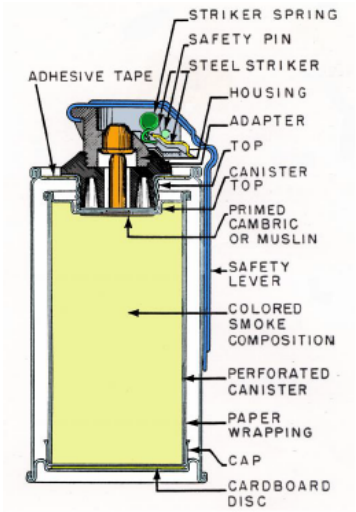
No. 69 Grenade

Weight	Approx. 383g (13.5oz)
Fill Weight	93g (3.25 oz) of either Amatol, Baratol or Lyddite
Fuze Type	'All-ways' fuze. Comprised of a safety cap, a weighted streamer attached to a steel ball bearing and a safety bolt designed to detonate from any point of impact.
Dimensions	115 x 60mm (4.5 x 2 .4 in)
Use	A blast grenade for use as an offensive weapon. Detonator was inserted before use.
Remarks	Introduced December 1940 and made from the plastic Bakelite as opposed to conventional metals. Detection is difficult due to this low metal content.



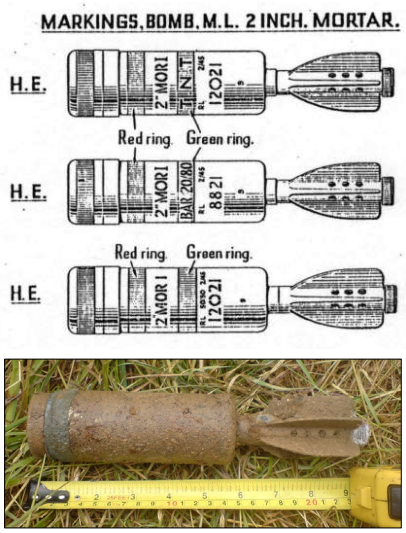
No. 83 Smoke Grenade

Weight	Approx. 680g (1.5lb)
Explosive Weight	Approx. 170-200g. (6-7 oz)
Fuze Type	Originally used a friction system using a match head composition. Later developed to a striker lever ignition system.
Dimensions	Approx. 62 x 140mm (2.44 x 5.5 in)
Use	Use as a target or landing zone marking device and as a screening method for troop / unit movement.
Remarks	This basic design stayed relatively unchanged up to the 1980's. The letters CCC were often etched into the body of the grenade in the colour of the smoke.



2 inch Mortar High Explosive

Weight	Approx. 1.02kg (2.25lb)
Maximum Range	460m (500yards)
Filling	200g RDX/TNT
Dimensions	51 x 290mm (2in x 11.4 in)
Fuze Type	An impact fuze which detonates the fuze booster charge and in turn the high explosive charge.
Use	It had greater range and firepower over hand and rifle grenades, and was used to attack targets behind cover with high explosive rounds.
Identification	HE has a rounded edge to a flat back. Can either be a black body colour with red and yellow band or dark green with yellow band. Brass cap on top. Practice will have hole all the way through the top.



2 inch Mortar Smoke

Weight	Approx. 910g (2lb)
Maximum Range	460m (500yards)
Filling	White phosphorus and smoke fill
Dimensions	51 x 290mm (2in x 11.4 in)
Fuze Type	An impact fuze which initiates a bursting charge. This ruptures the mortar bomb's body and disperses the phosphorus filler.
Identification	Smoke mortars have a recess and emission holes. May still see light green body paint. Look for stained ground around munition.
Use	As a screening device for unit movement or to impair enemy field of vision.

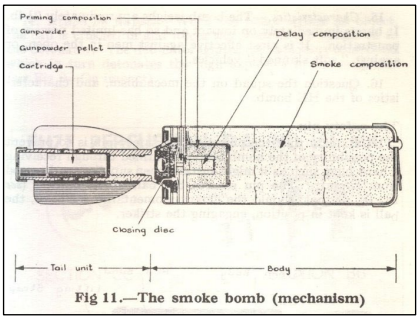
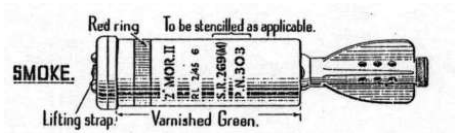
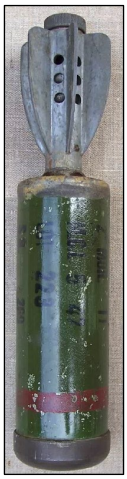


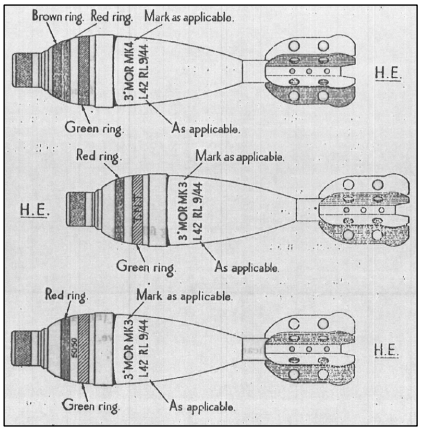
Fig 11.—The smoke bomb (mechanism)

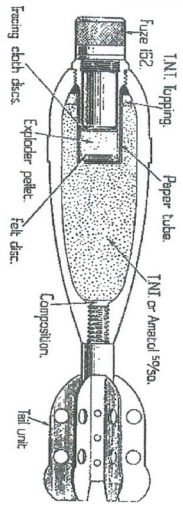




3 inch Mortar High Explosive

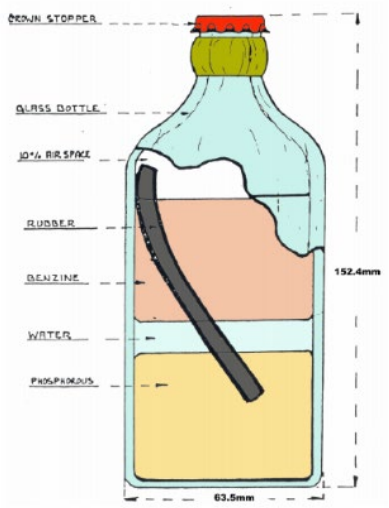
Weight	Approx. 4.5kg (10lb)
Maximum Range	1,460 (Mk1) – 2,560m (Mk2) (1,600 – 2,800yds)
Dimensions	81mm (3in)
Filling	Amatol
Firing Mechanism	Drop, fixed striker
Remarks	Fin-stabilised bomb fired by means of a charge consisting of a primary cartridge in the tail and four secondary cartridges.
Identification	An old style mortar. Often no way of telling if HE or practice, so treat as HE.





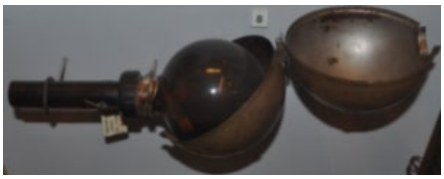
No. 76 Self Igniting Phosphorous (SIP) Grenade

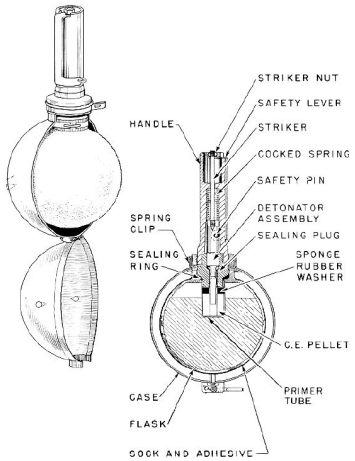
Weight	Approx. 1lb 3oz
Filling	White Phosphorous and Benzene
Design	The filling was contained in a ½ pint sized glass bottle with water and a strip of rubber. Over time the rubber dissolved to create a sticky which would self ignite when the bottle broke.
Use	Originally intended as an anti-tank incendiary weapon deployed by hand. Designed to be produced cheaply without consuming materials needed to produce armaments on the front line.
Remarks	The Home Guard hid caches of these grenades during the war. Not all locations were officially recorded and some caches were lost and encountered post-war. In all cases, the grenades are still found to be dangerous.



No. 74 Grenade ("Sticky Bomb") Mk1

Weight	Approx. 1.1kg (2.25lb)
Filling	Approx. 600g Nobel's No.283 (Nitro-glycerine) (1.33lb)
Design	A glass ball on the end of a Bakelite (plastic) handle. The inside of the ball would contain the explosive filling and the outside a very sticky adhesive coating.
Use	An anti-tank grenade primarily issued to the home guard. It required the user to come in very close proximity of the target and smash the glass explosive container against it.
Remarks	Timer fuze was located in the handle. This would explode after 3-6 secs.





Flame Fougasse Bomb

Weight	Various
Filling	Initially a mixture of 40% petrol and 60% gas. Ammonal provided the propellant charge.
Design	Usually constructed from a 40-gallon drum dug into a roadside and camouflaged.
Use	As an improvised anti-tank bomb. When triggered the Fougasse could project a beam of burning sticky fuel in a fixed direction from up to 3m (10ft) wide and 27m (30yards) long.
Remarks	A highly unorthodox weapon designed by the Petroleum Warfare Department to address a critical lack of weapons in 1940. 50,000 are estimated to have been distributed around the UK.

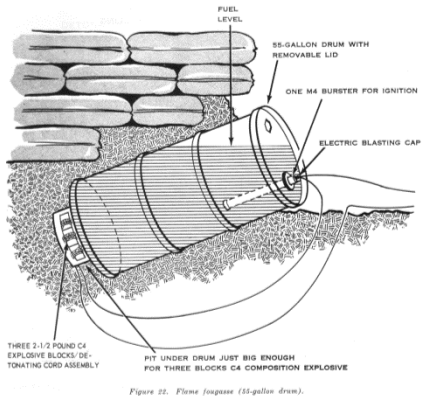
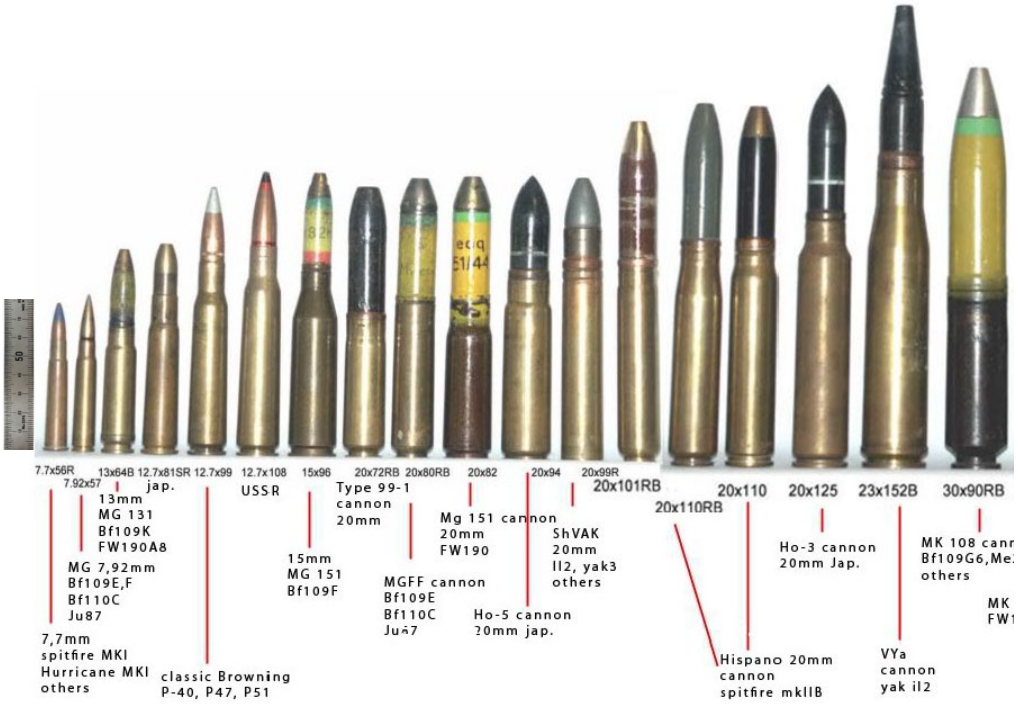
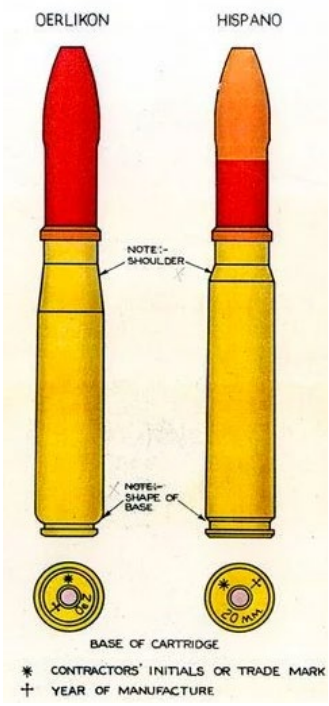


Figure 22. Flame fougasse (55-gallon drum).

Common WWII-era Aircraft Mounted Gun Ammunition

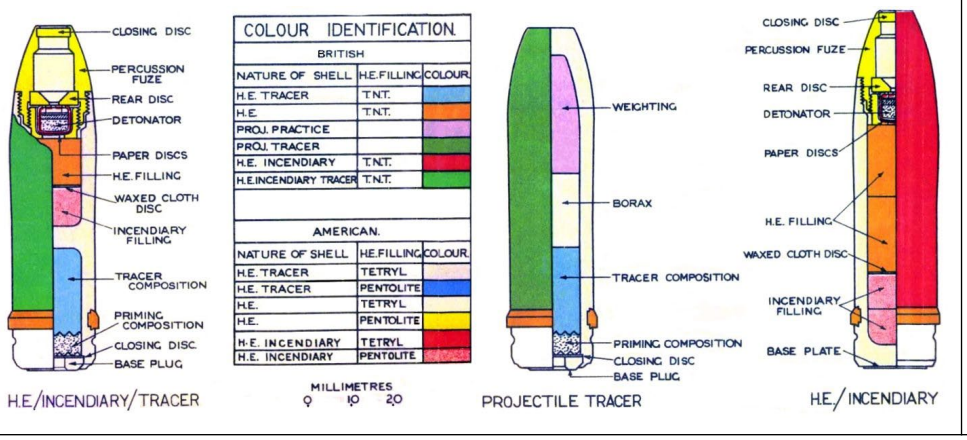


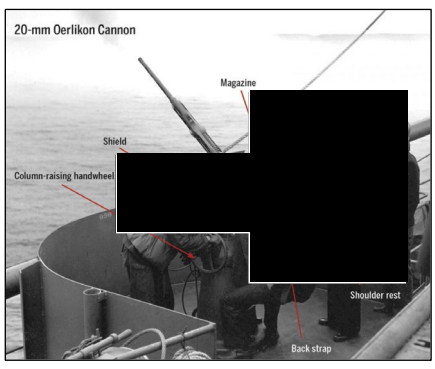


.303 British Rifle Ammunition

Bullet Diameter	7.92mm
Case length	56.44mm
Overall length	78.11mm
Type	Rifle Ammunition
Propellant	Originally black powder. Later Cordite followed by Nitrocellulose
Remarks	First produced in 1889 and still in use today, the .303inch cartridge has progressed through ten 'marks' which eventually extended to a total of around 26 variations.

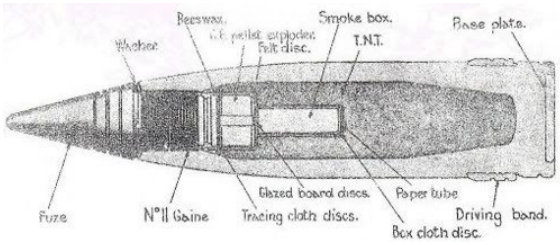
20mm Oerlikon Cannon Rounds





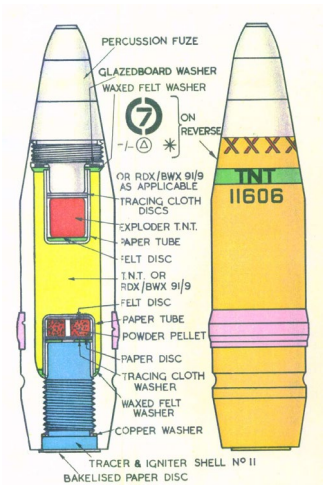
3.7 Inch QF Anti-Aircraft Projectile

Projectile Weight	28lb (12.6 kg)
Explosive Weight	2.52lbs
Fuze Type	Mechanical Time Fuze
Dimensions	3.7in x 14.7in (94mm x 360mm)
Rate of Fire	10 to 20 rounds per minute
Use	The 3.7in AA Mks 1-3 were the standard Heavy Anti-Aircraft guns of the British Army and were commonly used on the Home Front.
Ceiling	30,000ft to 59,000ft



40mm Bofors Projectile

Projectile Weight	1.96lb (0.86kg)
Explosive Weight	300g (0.6lb)
Fuze Type	Impact Fuze
Rate of Fire	120 rounds per minute
Projectile Dimensions	40 x 180mm
Ceiling	23,000ft (7000m)
Remarks	Light quick fire high explosive anti-aircraft projectile. Each projectile fitted with small tracer element. If no target hit, shell would explode when tracer burnt out. Designed to engage aircraft flying below 2,000ft.



3in Unrotated Projectile (UP) Anti-Aircraft Rocket ("Z" Battery)

HE Projectile Weight	3.4kg (7.6lb)
Explosive Weight	0.96kg (2.13lb)
Filling	High Explosive – TNT. Fitted with aerial burst fuzing
Dimensions of projectile	236 x 83mm (9.29 x 3.25in)
Remarks	As a short range rocket-firing anti-aircraft weapon developed for the Royal Navy. It was used extensively by British ships during the early days of World War II. The UP was also used in ground-based single and 128-round launchers known as Z Batteries. Shell consists of a steel cylinder reduced in diameter at the base and threaded externally to screw into the shell ring of the rocket motor.

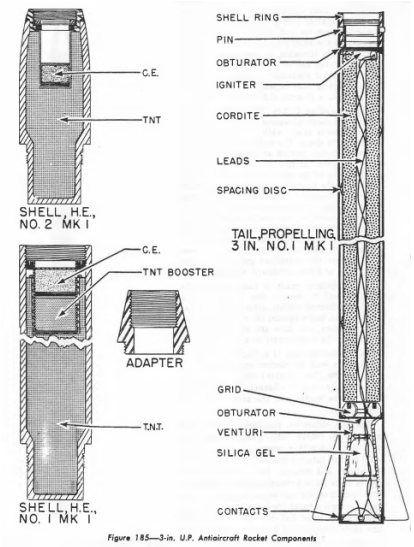


Figure 185.—3-in. U.P. Antiaircraft Rocket Components

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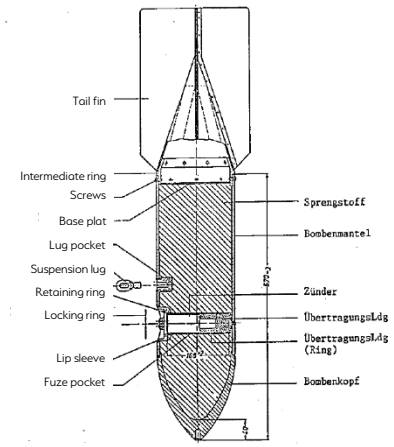
Client: RWE Renewable UK Solar and Storage Ltd

Project: Tween Bridge Solar, Doncaster

Ref: DA18705a-00 **Source:** Various sources

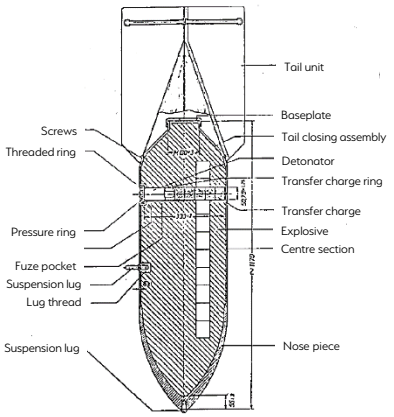
SC 50kg High Explosive Bomb

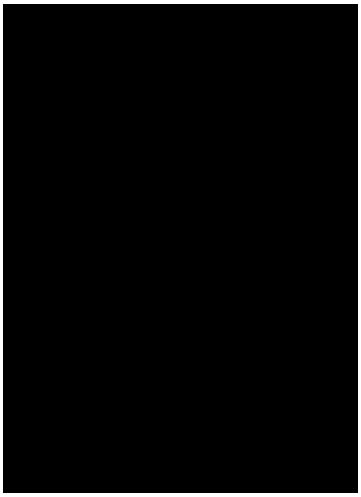
Bomb Weight	40-54kg (88-119lb)
Explosive Weight	25kg (55lb)
Fuze Type	Impact fuze/electro-mechanical time delay fuze
Bomb Dimensions	1,090 x 280mm (42.9 x 11.0in)
Body Diameter	200mm (7.87in)
Use	Against lightly damageable materials, hangars, railway rolling stock, ammunition depots, light bridges and buildings up to three stories.
Remarks	The smallest and most common conventional German bomb. Nearly 70% of bombs dropped on the UK were 50kg.



SC 250kg High Explosive Bomb

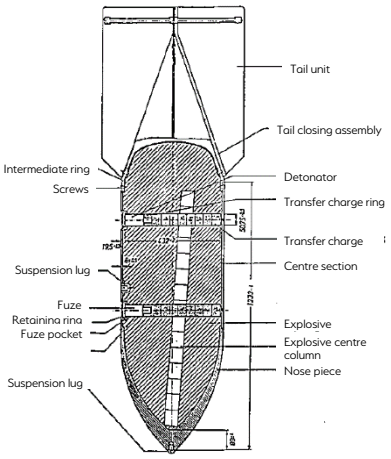
Bomb Weight	245-256kg (540-564lb)
Explosive Weight	125-130kg (276-287lb)
Fuze Type	Electrical impact/mechanical time delay fuze
Bomb Dimensions	1640 x 512mm (64.57 x 20.16in)
Body Diameter	368mm (14.5in)
Use	Against railway installations, embankments, flyovers, underpasses, large buildings and below-ground installations.
Remarks	It could be carried by almost all German bomber aircraft and was used to notable effect by the Junkers Ju-87 Stuka (*Sturzkampfflugzeug*, or dive-bomber).

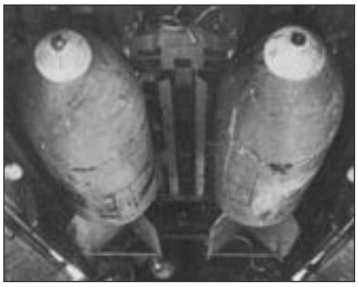




SC 500kg High Explosive Bomb

Bomb Weight	480-520kg (1,058-1,146lb)
Explosive Weight	250-260kg (551-573lb)
Fuze Type	Electrical impact/mechanical time delay fuze
Bomb Dimensions	1957 x 640mm (77 x 25.2in)
Body Diameter	470mm (18.5in)
Use	Against fixed airfield installations, hangars, assembly halls, flyovers, underpasses, high-rise buildings and below-ground installations.
Remarks	40/60 or 50/50 Amatol TNT, Trialene. Bombs recovered with Trialen filling have cylindrical paper-wrapped pellets, 1-15/16in. in length and diameter.





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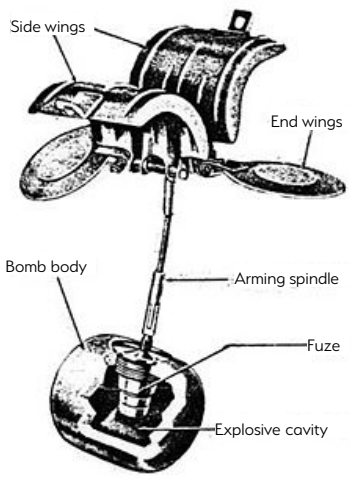
Project: Tween Bridge Solar, Doncaster

Ref: DA18705a-00 **Source:** Various sources

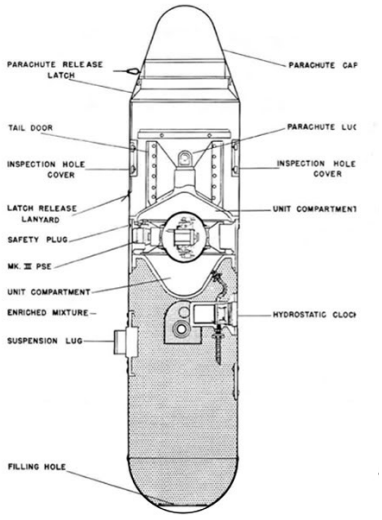
SD2 Anti-Personnel 'Butterfly Bomb'

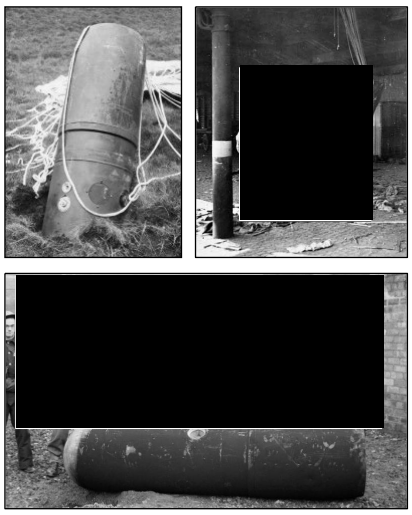
Bomb Weight	Approx. 2kg (4.41lb)
Explosive Weight	Approx. 7.5oz (225 grams) of Amatol surrounded by a layer of bituminous composition.
Fuze Type	41 fuze (time) , 67 fuze (clockwork time delay) or 70 fuze (anti-handling device)
Body Diameter	3in (7.62 cm) diameter, 3.1in (7.874) long
Use	Designed as an anti-personnel/fragmentation weapon. They were delivered by air, being dropped in containers of 23-144 sub-munitions that opened at a predetermined height, thus scattering the bombs.
Remarks	Quite rare. First used against Ipswich in 1940, but were also dropped on Kingston upon Hull, Grimsby and Cleethorpes in June 1943, amongst various other targets in UK. As the bombs fell the outer case flicked open via springs which caused four light metal drogues with a protruding 5 inch steel cable to deploy in the form of a parachute & wind vane, which armed the device as it span.



Parachute Mine (Luftmine B / LMB)

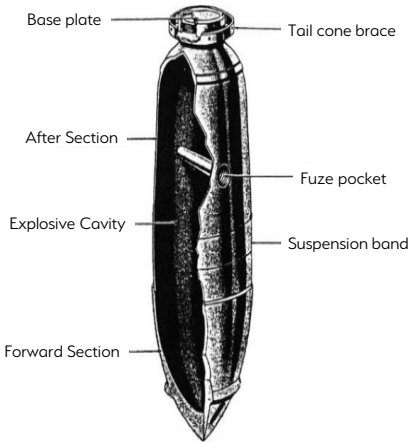
Bomb Weight	Approx. 990kg (2176lb)
Explosive Weight	Approx. 705kg (1,554lb)
Fuze Type	Impact/time delay/hydrostatic pressure fuze
Dimensions	2.64m x 0.64m (3.04m with parachute housing)
Use	Against civilian, military and industrial targets. Used as blast bombs and designed to detonate above ground level to maximise damage to a wider area.
Remarks	Deployed a parachute when dropped in order to control its descent. Had the potential to cause extensive damage within a 100m radius.

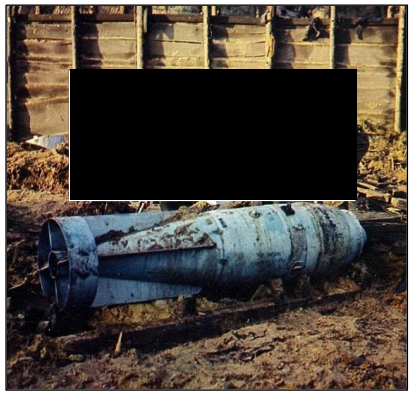




SC 1000kg High Explosive Bomb

Bomb Weight	Approx. 993-1027kg (2,189-2,264lb)
Explosive Weight	Approx. 530-620kg (1168-1367lb)
Fuze Type	Electrical impact/mechanical time delay fuze.
Filling	Mixture of 40% amatol and 60% TNT, but when used as an anti-shipping bomb it was filled with Trialen 105, a mixture of 15% RDX, 70% TNT and 15% aluminium powder.
Bomb Dimensions	2800 x 654mm (110 x 25.8in)
Body Diameter	654mm (18.5in)
Use	SC-type bombs were General Purpose Bombs used primarily for general demolition work. Constructed of parallel walls with comparatively heavy noses, they are usually of three-piece welded construction.





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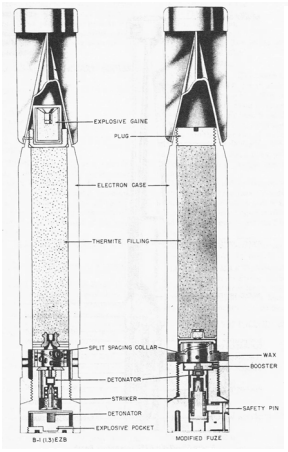
Client: RWE Renewable UK Solar and Storage Ltd

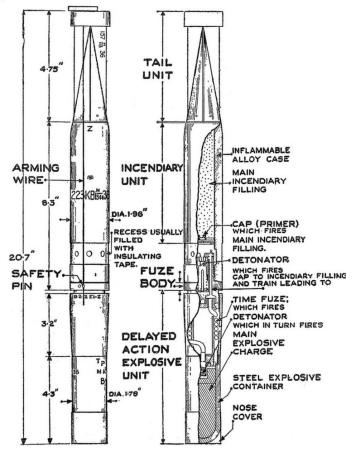
Project: Tween Bridge Solar, Doncaster

Ref: DA18705a-00 **Source:** Various sources

1kg Incendiary Bomb

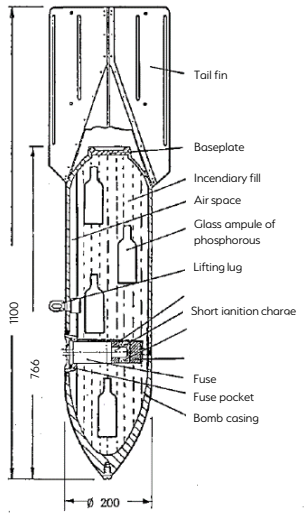
Bomb Weight	Approx. 1.0 - 1.3kg (2.2 and 2.9lb)
Explosive Weight	Approx. 680g (1.5lb) Thermite 8-15gm Explosive Nitropenta
Fuze Type	Impact fuze
Bomb Dimensions	350 x 50mm (13.8 x 1.97in)
Body Diameter	50mm (1.97in)
Use	As incendiary – dropped in clusters on towns and industrial complexes.
Remarks	Magnesium alloy case. Sometimes fitted with high explosive charge. The body is a cylindrical alloy casting threaded internally at the nose to receive the fuze holder and fuze.

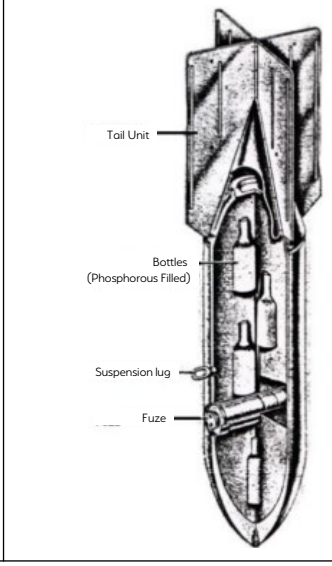




C50 A Incendiary Bomb

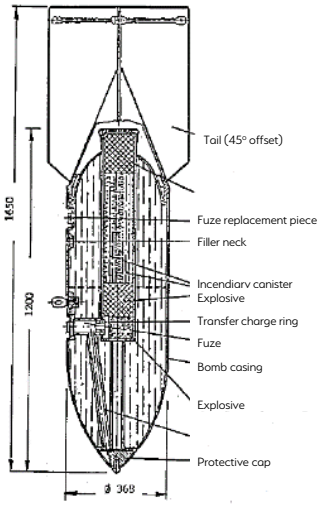
Bomb Weight	Approx. 41kg (90.4lb)
Explosive Weight	Approx. 0.03kg (0.066lb)
Incendiary Filling	12kg (25.5lb) liquid filling with phosphor igniters in glass phials. Benzine 85%; Phosphorus 4%; Pure Rubber 10%
Fuze Type	Electrical impact fuze
Bomb Dimensions	1,100 x 280mm (43.2 x 8in)
Use	Against any targets where an incendiary effect is required.
Remarks	Early fill was a phosphorous/carbon disulphide incendiary mixture.





Flam C-250 Oil Bomb

Bomb Weight	480-520kg (1,058-1,146lb)
Explosive Weight	250-260kg (551-573lb)
Fuze Type	Electrical impact/mechanical time delay fuze
Bomb Dimensions	1957 x 640mm (77 x 25.2in)
Body Diameter	470mm (18.5in)
Use	Against fixed airfield installations, hangars, assembly halls, flyovers, underpasses, high-rise buildings and below-ground installations.
Remarks	40/60 or 50/50 Amatol TNT, Trialene. Bombs recovered with Trialen filling have cylindrical paper-wrapped pellets, 1-15/16in. in length and diameter.



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