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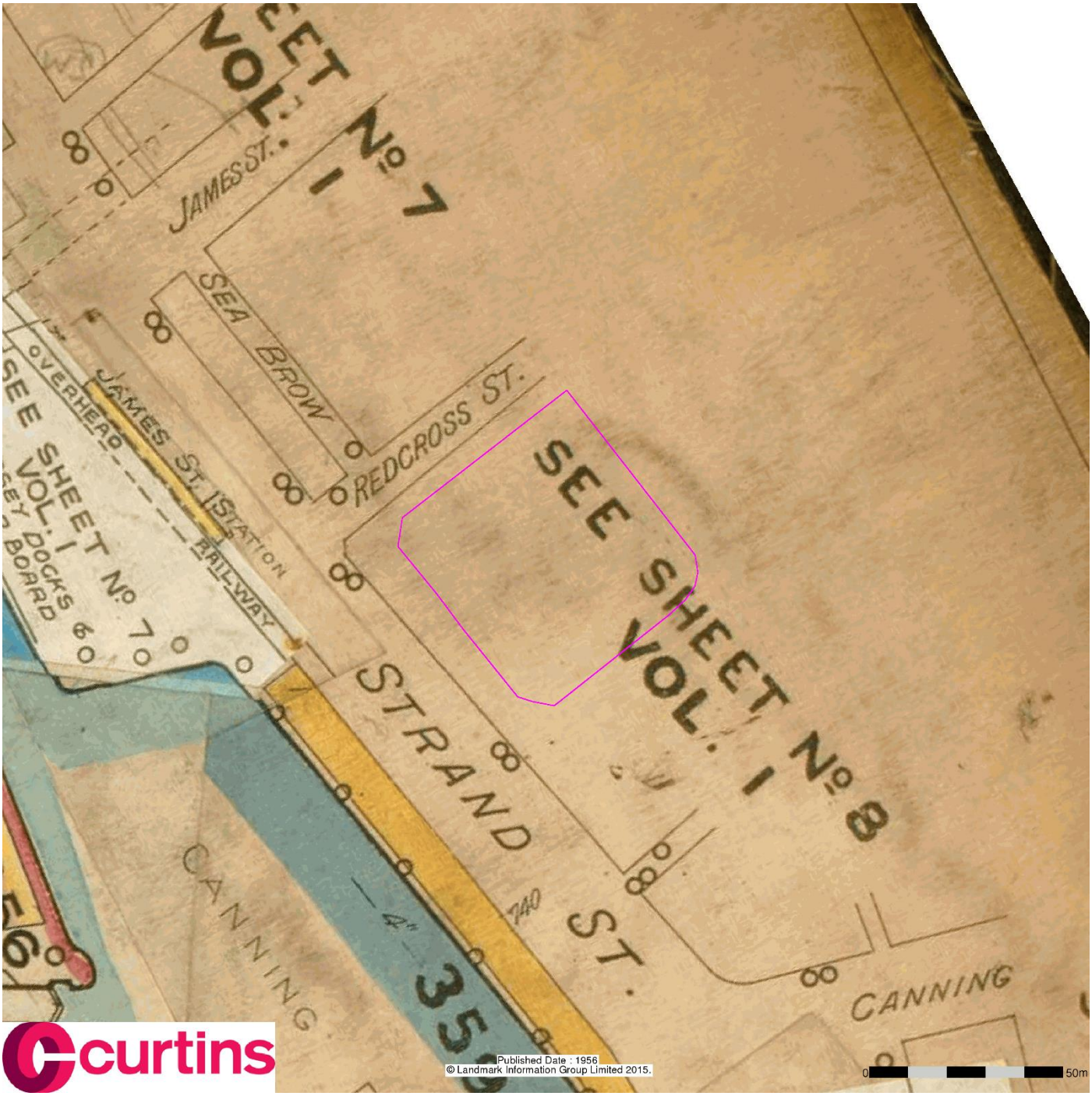
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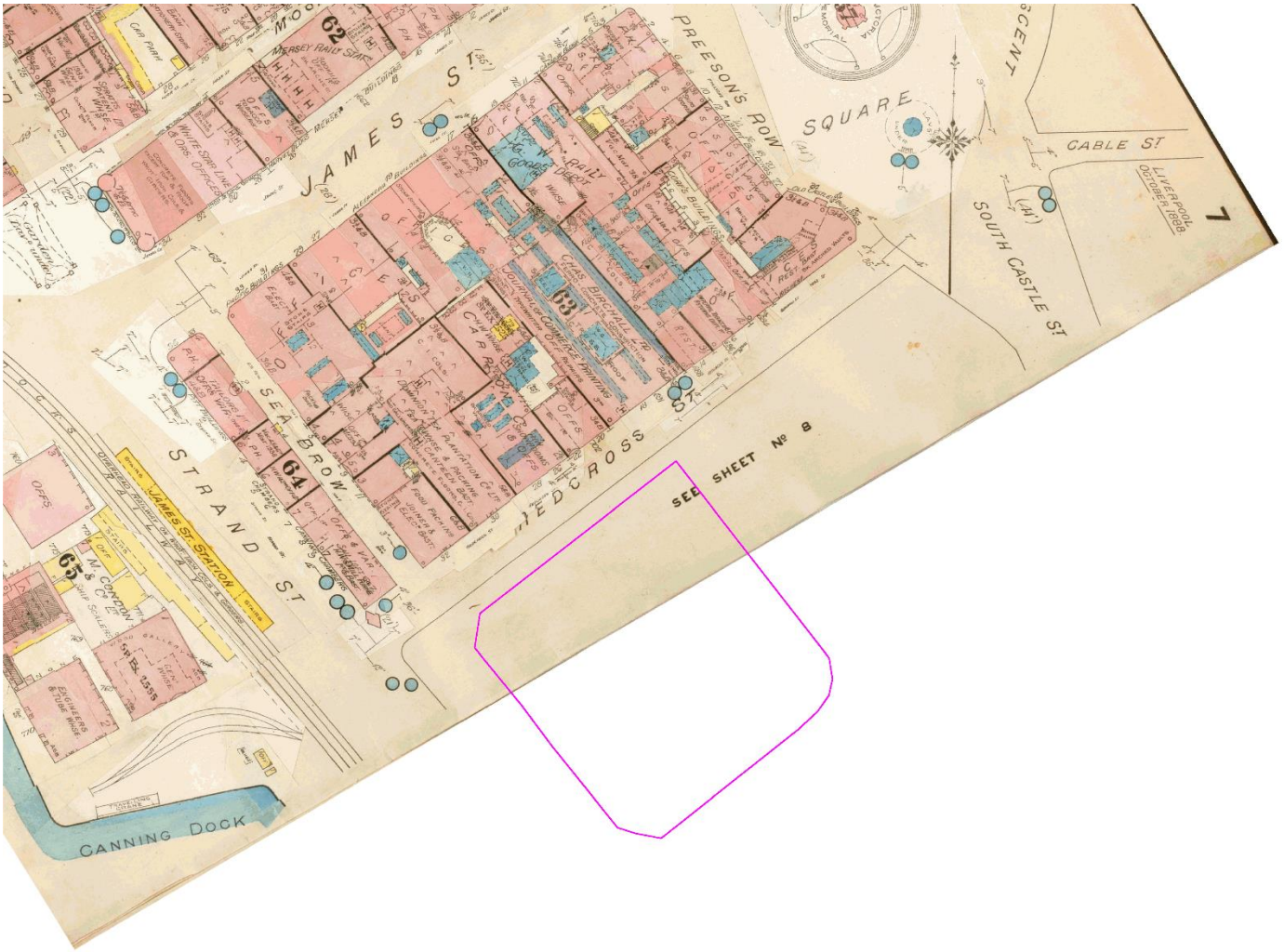

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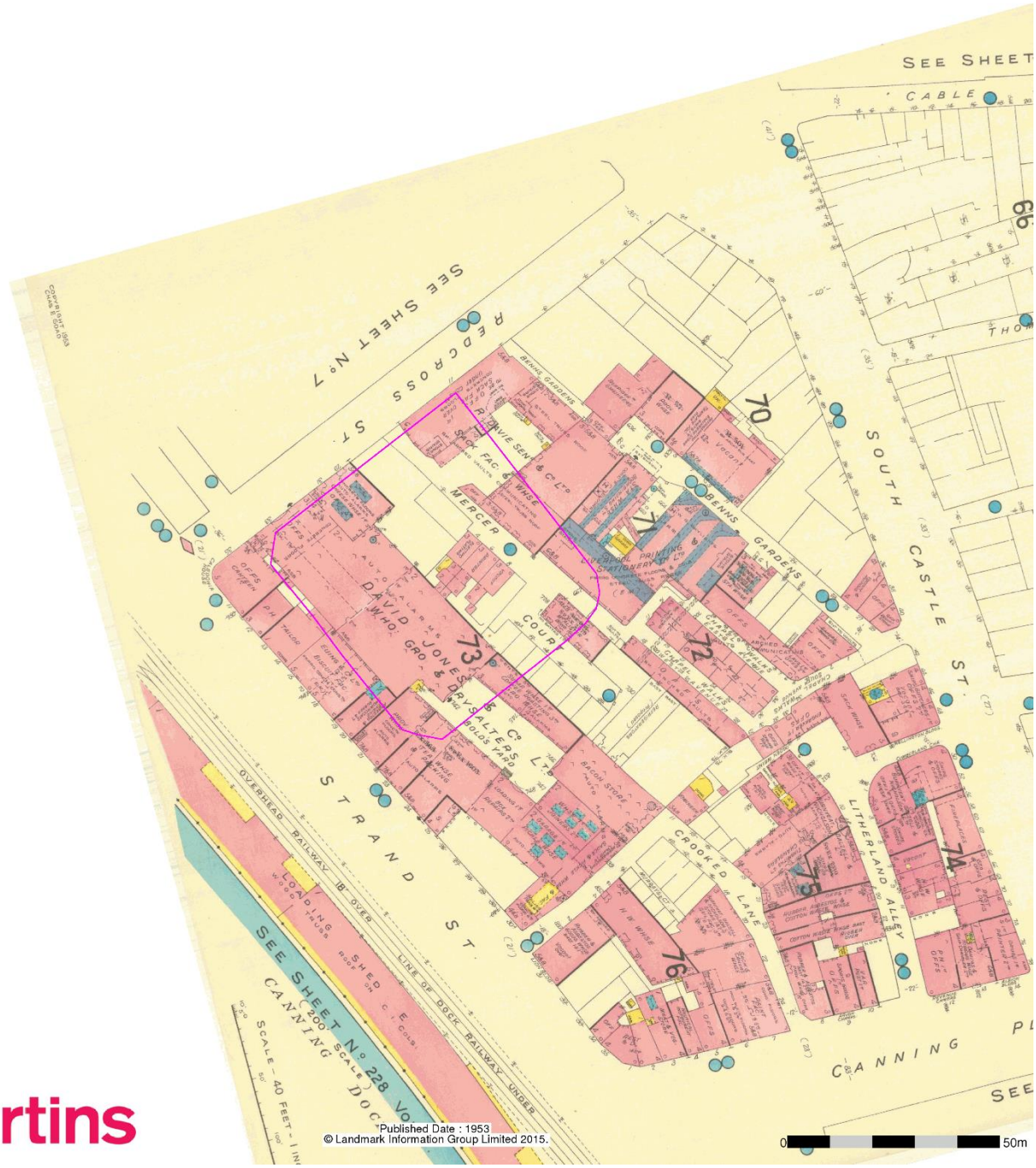
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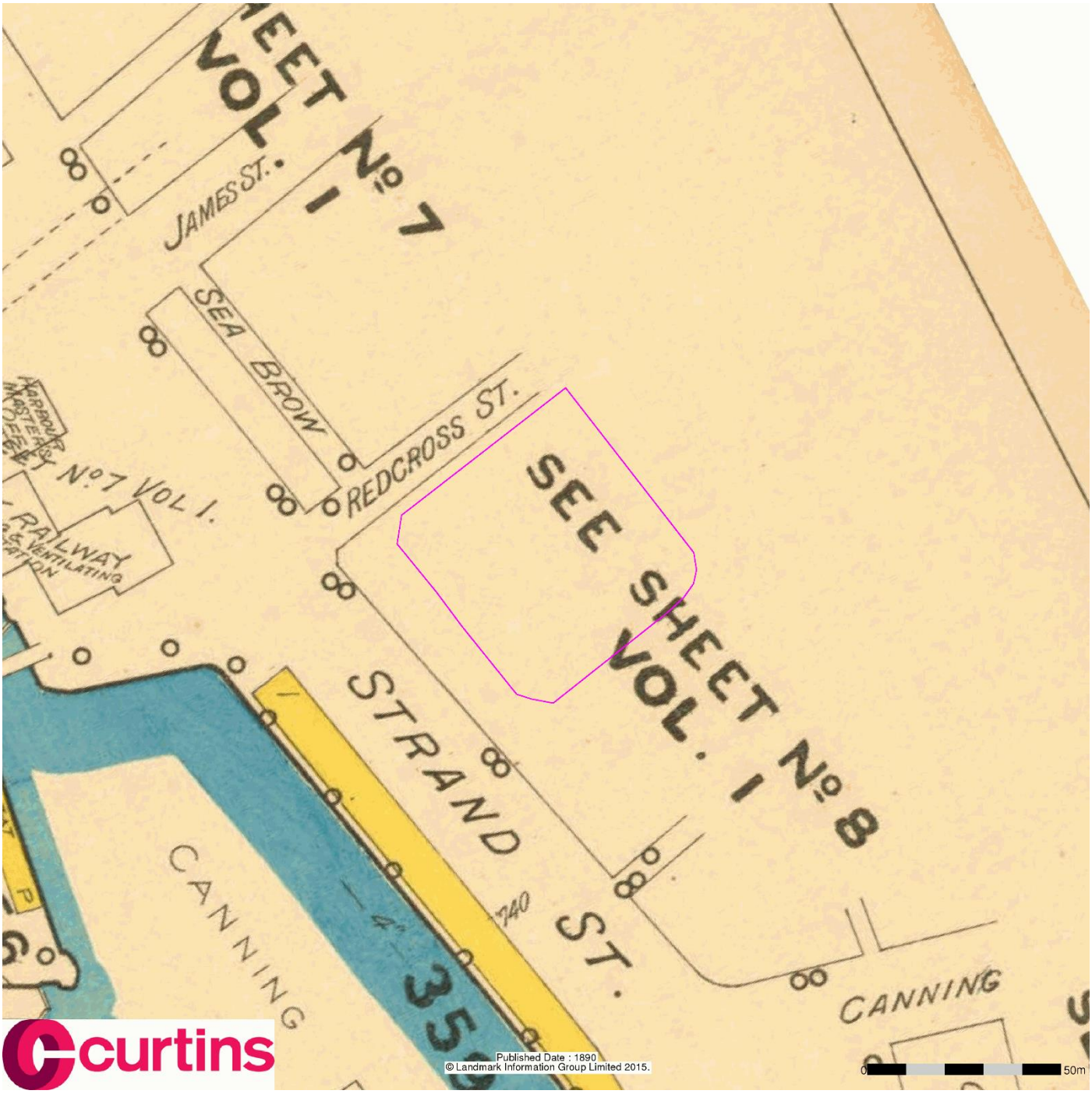
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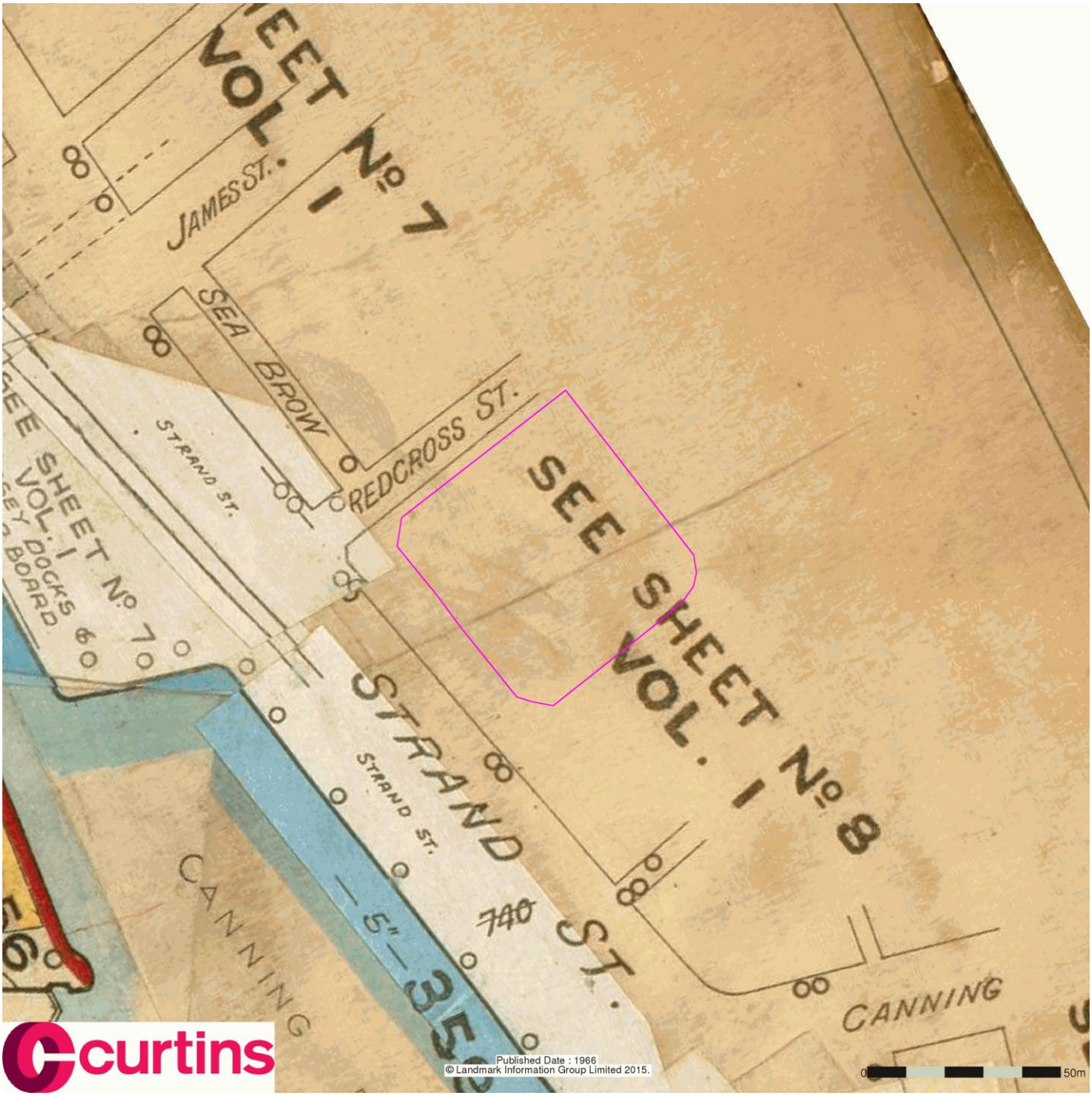
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Published Date : 1888
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curtins

1ST LINE DEFENCE
UXO SOLUTIONS

Detailed Unexploded Ordnance (UXO) Risk Assessment

Project Name	The Strand, Liverpool		
Client	Curtins		
Site Address	Strand House, 21 Strand St, Liverpool, L1 8LT		
Report Reference	DA3469-00	Revision	00
Date	18th May 2016		
Originator	AT		

1ST LINE DEFENCE
UXO SOLUTIONS

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

Executive Summary

Site Location

The site is situated within the Centre of the City of Liverpool.

Currently the site is occupied by a four storey office building with incorporating car parking at ground level; surface car parking is at the rear of the site. Canning Dock and Canning Graving docks are to the south west.

The site boundaries are the Strand to the south west, Red Cross Street to the north west and existing building development to the north east and south east.

The site is centred on the approximate OS grid reference: SJ 3422290109.

Proposed Works

It is understood that the site is to be redeveloped for multi storey development, with a part basement level of car parking located to the rear half of the site.

A site investigation comprising shallow and deep boreholes will be undertaken. Piled foundation solution is anticipated.

Geology and Bomb Penetration Depth

The British Geological Survey (BGS) map shows the site to be underlain by the Chester Pebble Beds Formation - Sandstone, Pebbly (gravelly) of the Triassic Period. It has not been possible to determine maximum bomb penetration capabilities due to the lack of site specific geotechnical information. A site specific assessment of bomb penetration depth can be made on site by a UXO Specialist if required.

UXO Risk Assessment

1st Line Defence believes that there is a **Medium Risk** from UXO across the site. This assessment is based on the following factors:

- During WWII the County Borough of Liverpool was subjected to a High Density bombing campaign, with 91.5 items falling per 1,000 acres. The bombing of Liverpool was focused on the City Centre and the docks.
- The site was within the city centre of Liverpool, which was bombed severely. Multiple incidents of HE damage can be seen close to the site area on a small scale map obtained from the Liverpool Record Office.
- Very limited information regarding the bombing of the City of Liverpool has survived to date. No detailed bomb plot or damage maps, or complete set of incident records appear to have survived the war. It is possible that the serious damage Liverpool sustained over a short period of time in May 1941 meant that accurate record keeping was not achieved. It has therefore not been possible to determine exactly where bombs fell within the city, and other data such as post-war mapping and photography therefore become an essential tool in looking at changes resulting from damage and assessing whether ground conditions present would have been conducive to the observation of UXB entry holes.
- Several areas within the centre of the site appear to have been cleared post-war. Within the north-east of the site two structures appear to have been reduced to ruins. It is considered likely that these changes were the direct result of bomb damage, and that an amount of rubble and debris would have been present across these areas. Evidence of UXO could easily be overlooked within areas of debris resulting from bombing – note that the entry hole of a 50kg bomb could be as little as 20cm in diameter.
- While areas of the site did survive the war, the risk from 'J-Curve', where a bomb can end up laterally offset from its point of entry (see section 10.4) means that no one area can be considered at 'low' risk. A 'buffer zone' has been placed around these cleared/damaged areas to account for this possibility of 'J-Curve'.
- There has been some re-development on the site post WWII. The extent of the developments and depth of foundations can partly mitigate the UXO risk as any present items of UXO may have been uncovered during the works.
- Any developments involving deep intrusive works will have mitigated the risk of deep-buried unexploded bombs at the locations of piling and foundations. Any smaller developments may have partially mitigated the risk of encountering shallow buried UXO especially 1kg incendiaries and anti-aircraft projectiles.

Recommended Risk Mitigation Measures
The following risk mitigation measures are recommended to support the proposed works at The Strand, Liverpool site: **All works** • Site Specific Unexploded Ordnance Awareness Briefings to all personnel conducting intrusive works **Shallow intrusive works (trial pits, open excavations, shallow foundations etc.)** • Unexploded Ordnance (UXO) Specialist Presence on Site to support shallow intrusive works **Deep intrusive works (boreholes and piles)** • Intrusive Magnetometer Survey of all Borehole and pile locations down to a maximum bomb penetration depth

In making this assessment and recommending the above risk mitigation measures, the proposed 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.

Glossary

Abbreviation	Definition
AA	Anti-Aircraft
AAA	Anti-Aircraft Ammunition
AFS	Auxiliary Fire Service
AP	Anti-Personnel
ARP	Air Raid Precautions
AWAS	Air Warfare Analysis Section
EOC	Explosive Ordnance Clearance
EOD	Explosive Ordnance Disposal
FP	Fire Pot
GM	G Mine (Parachute mine)
HAA	Heavy Anti Air
HE	High Explosive
IB	Incendiary Bomb
LAA	Light Anti Air
LCC	London County Council
LRRB	Long Range Rocket Bomb (V2)
LSA	Land Service Ammunition
MOL	Molotov (Incendiary Bomb)
OB	Oil Bomb
PAC	Pilotless Aircraft (V1)
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
SD1000	1000kg high explosive bomb
SD2	2kg incendiary
U/C	Unclassified bomb
UP	Unrotated Projectile (rocket)
USAAF	United States Army Air Force
UX	Unexploded
UXAA	Unexploded Anti Air
UXB	Unexploded Bomb
UXO	Unexploded Ordnance
V1	Vengeance Weapon 1
V2	Vengeance Weapon 2
WAAF	Women's Auxiliary Air Force
X	Exploded

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

Site: The Strand, Liverpool
Client: Curtins

1. Introduction

1.1. Background

1st Line Defence has been commissioned by The Strand, Liverpool to produce a Detailed Unexploded Ordnance (UXO) Risk Assessment for the proposed works at Curtins.

UXO in the UK can originate from three principal sources:

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

In certain parts of the UK buried UXO can present a significant risk to construction works and development projects. Whilst UXO may certainly present a safety risk even the simple discovery of a suspected device during on-going works can cause considerable disruption to production and cause unwanted delays and expense.

This report will examine in detail all the factors that could potentially contribute to a risk from UXO at the site in question. For the majority of sites in the UK the likelihood of encountering UXO of any sort is minimal and generally no further action will be required beyond an initial desktop risk assessment. However, if a potential risk is identified, the report will make recommendations for the most appropriate and work-specific measures available in order to reduce the risk to as low as reasonably practicable. Full analysis and evidence will be provided to allow to client to fully understand the basis for the assessed risk level and any recommendations.

The report directly follows the guidelines set out in the document CIRIA C681 'Unexploded Ordnance (UXO) A Guide for the Construction Industry'.

2. UK Regulatory Environment

2.1. General

There is no formal requirement for undertaking an assessment of UXO risk for construction projects in the UK, nor any specific legislation covering 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.) do undertake a comprehensive and robust assessment or potential risks to employees and that mitigation measures are put in place to address any identified hazards.

2.2. CDM Regulations 2015

This legislation defines the responsibilities of all parties (primarily the Client, the CDM Co-ordinator, the Designer and the Principal Contractor) involved with works. Under CDM2015, the client has the 'legal responsibility for the way that a construction project is managed and run and they are accountable for the health and safety of those working on or affected by the project'.

Although UXO is not specifically addressed, the regulations effectively place obligations on all these 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.

2.3. The 1974 Health and Safety at Work Act

All employers have a responsibility under the Health and Safety at Work Act of 1974 (and the Management of Health and Safety at Work Regulations of 1999) to ensure, so far as is reasonably practicable, the health and safety of their employees and that of other persons who are affected by their work activity (including the general public).

2.4. Additional Legislation

Other relevant legislation includes the Safety at Work Regulations 1999 and The Corporate Manslaughter and Corporate Homicide Act 2007.

3. Role of Commercial UXO Contractors and The Authorities

3.1. Commercial UXO Contractors

The role of an experienced UXO specialist such as 1st Line Defence is to provide expert knowledge and guidance to the client on the most appropriate and cost effective approach to UXO risk management on a site.

The undertaking of Preliminary and Detailed UXO Risk Assessments is the first step in this risk management process. The extensive amount of specialist experience, weapons knowledge, datasets and historical information available to 1st Line Defence in particular, allows a robust, detailed and realistic assessment of the potential risk, and the recommendation of suitable mitigation measures if deemed necessary.

In addition to undertaking specialist Risk Assessments, a commercial UXO contractor will be able to provide pre-construction site survey and clearance/avoidance, as well as a reactive response to any suspect finds.

The presence on site of a qualified UXO Specialist with ordnance recognition skills will avoid unnecessary call-outs to the authorities and allow for arrangement to be made for the removal and disposal of low risk items. If high risk ordnance is discovered, actions will be co-ordinated with the authorities with the objective of causing the minimum possible disruption to site operations whilst putting immediate, safe and appropriate measures in place.

For more information on the role of commercial UXO specialists, see CIRIA C681.

3.2. The Authorities

The Police have the responsibility for co-ordinating the emergency services in the case of an ordnance-related incident on a construction site. They will make an initial assessment and if they judge necessary, impose a safety cordon and/or evacuation and call the military authorities Joint Services Explosive Ordnance Disposal (JSEOD) to arrange for investigation and/or disposal. In the absence of an UXO Specialist on site many Police Officers will use the precautionary principle, impose cordon/evacuation and await advice from the JSEOD. The discovery of UXO will invariably cause work to cease on the site and may require the evacuation of the site and neighbouring properties.

The priority JSEOD will give to the police request will depend on their judgement of the nature of the UXO risk, the location, people and assets at risk and the availability of resources. They may respond immediately or as resources are freed up. It can take 1-2 days and often longer for the authorities to respond and deal with a UXB.

Depending on the on-site risk assessment the item of ordnance may be removed from site or destroyed by controlled explosion. In the latter case additional cordons and/or evacuations may be necessary and the process will take longer.

It should be noted that following the discovery of an item of UXO, the military authorities will only carry out further investigations or clearances in very high profile or high risk situations. If there are regular UXO finds on a site the JSEOD may not treat each occurrence as an emergency and will recommend the construction company puts in place alternative procedures i.e. the appointment of a commercial contractor to manage the situation.

4. The Report

4.1. Report Objectives

The aim of this report is to undertake a fair, proportionate and comprehensive assessment of the potential risk from UXO at The Strand, Liverpool Every reasonable effort will be made to ensure that all available and pertinent historical information and records are accessed and checked. Full analysis and evidence will be provided where possible to allow the Client to fully understand the basis for the risk assessment.

Site specific risk mitigation measures will be recommended if deemed necessary, to reduce the risk from explosive ordnance during the envisaged works to as low as reasonably practicable.

4.2. Risk Assessment Process

1st Line Defence undertakes a five-step process for assessing the risk posed by UXO:

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

In order to address the above, 1st Line Defence has considered in detail, site specific and non-site specific factors including:

- Evidence of German bombing, delivery of UXBs, records of abandoned bombs and maximum bomb penetration depth assessment.
- Site history, occupancy and conditions during WWII.
- The potential legacy of Allied military activity.
- Details of the specific UXO threat and any known UXO clearance work.
- The extent of any post-war redevelopment.
- The extent and nature of any proposed works.

4.3. Sources of Information

In order to produce a robust and thorough assessment of UXO risk, detailed historical research has been carried out by specialist researchers. Military records and archive material held in the public domain have been accessed. Information from the following sources has been consulted for this report:

- The National Archives, Kew and Liverpool Record Office.
- Landmark Maps.
- Historic England National Monuments Record.
- Relevant information supplied by Curtins.
- Available material from 33 Engineer Regiment (EOD) Archive.
- 1st Line Defence's extensive historical archives, library and UXO geo-datasets.
- Open sources such as published book and internet resources.

Research involved a visit to The National Archives, Kew.

5. Reporting Conditions

5.1. General Considerations

It is important to note that this desktop assessment is based largely upon research of historical evidence. Although every effort has been made to locate all significant and pertinent information, 1st Line Defence cannot be held accountable for any changes to the assessed level of risk 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 at the time of the report's production.

It is often problematic and sometimes impossible to verify the completeness and accuracy of WWII-era records – see 'Background to Bombing Records'. As a consequence, conclusions as to the exact location, quantity and nature a UXO risk can rarely be definitive. To counter this, it is essential that as many different sources and types of information as possible are consulted and analysed before a conclusion is reached. 1st Line Defence cannot be held responsible for inaccuracies or gaps in the available historical information.

5.2. Background to Bombing Records

In September 1940, the Government started to collect and collate information relating to damage sustained during bombing raids. The data became known as the 'Bomb Census'. Initially, only information relating to London, Birmingham and Liverpool was collated, but quickly the bomb census was extended to cover the rest of the UK.

Its purpose was to provide the Government with a complete picture of raid patterns, types of weapon used and damage caused – in particular to strategic services and installations such as railways, factories and public utilities.

Information was gathered locally by police, Air Raid Wardens and military personnel. They noted when, where and what types of bombs had fallen during an air raid, and passed this on to the Ministry of Home Security. Records of strikes were made either through direct observation or by post-raid surveys. However, the immediate priority was to deal with casualties and minimise damage. As a result, it is only to be expected that the records kept were often incomplete and contradictory.

Prior to the official 'Bomb Census', record keeping in the early months of the war was not comprehensive. The quality, detail and nature of record keeping could vary considerably from borough to borough and town to town. Many records were even damaged or destroyed in subsequent attacks. Records of raids that took place on sparsely or uninhabited areas were often based upon third party or hearsay information and are not always reliable. Furthermore, records of attacks on military or strategic targets were often maintained separately from the general records and have not always survived.

6. The Site

6.1. Site Location

The site is situated within the Centre of the City of Liverpool.

The site boundaries are the Strand to the south west, Red Cross Street to the north west and existing building development to the north east and south east.

The site is centred on the approximate OS grid reference: SJ 3422290109.

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

6.2. Site Description

Currently the site is occupied by a four storey office building with incorporating car parking at ground level; surface car parking is at the rear of the site. Canning Dock and Canning Graving docks are to the south west.

A recent aerial photograph, site boundary and plan drawing of the site area are presented in **Annex B** and **Annex C** respectively.

7. Scope of the Proposed Works

7.1. General

It is understood that the site is to be redeveloped for multi storey development, with a part basement level of car parking located to the rear half of the site.

A site investigation comprising shallow and deep boreholes will be undertaken. Piled foundation solution is anticipated.

8. Ground Conditions

8.1. General Geology

The British Geological Survey (BGS) map shows the site to be underlain by the Chester Pebble Beds Formation - Sandstone, Pebbly (gravelly) of the Triassic Period.

8.2. Site Specific Geology

No site specific geotechnical information was available during the production of this report.

9. Site History

9.1. Ordnance Survey Historical Maps

Pre and post-WWII historical maps for the site were obtained by 1st Line Defence from Landmark Maps & the National Library of Scotland. The maps for the years 1927, 1954 & 1991, were obtained from Landmark Maps, while the 1938 map was obtained from the National Library of Scotland. These are presented in **Annex D.**

Pre-WWII		
Date	**Scale**	**Description**
1927	1:2,500	The site is bordered by Redcross Street and The Strand. It appears to be occupied by a range of buildings, with a large building in the centre of the site and many smaller buildings surrounding this. None of the buildings are labelled or named, therefore it is not known what their exact use was at this time.
1938	1:10,560	This map edition is of a small scale and shows the site is entirely occupied by buildings. No significant change can be seen within the site area, although the small scale of this map edition means smaller-scale change is not visible.

Post-WWII		
Date	**Scale**	**Description**
1954	1:1,250	The main building within the site area is now shown to be part of a 'Wholesale Food Depot'. Several smaller buildings, including a public house can be seen on the part of the site bordering The Strand. An area within the north-east section of the site on Mercer Court appears to have been cleared of buildings. The site appears to be located within an industrial area, as several warehouses are outlined east of the site.
1991	1:10,000	This map is of a smaller scale. Despite this, it appears that the site has been cleared for redevelopment.

10. Aerial Bombing Introduction

10.1. General

During WWI and WWII, many towns and cities throughout the UK were subjected to bombing which often resulted in extensive damage to city centres, docks, rail infrastructure and industrial areas. The poor accuracy of WWII targeting technology and techniques often resulted in all areas around a specific target being bombed.

In addition to raids which concentrated on specific targets, indiscriminate bombing of large areas also took place – notably the London 'Blitz', but also affecting many other towns and cities. As discussed in the following sections, a proportion of the bombs dropped on the UK did not detonate as designed and while extensive efforts were made to locate and deal with these UXBs at the time, many still remain buried and can present a potential risk to construction projects.

The main focus of this report with regards to bombing will be weapons dropped during WWII, although WWI bombing will also be considered.

10.2. Generic Types of WWII German Air-delivered Ordnance

The type and characteristics of the ordnance used by the Luftwaffe during WWII allows an informed assessment of the hazards posed by any unexploded items that may remain in situ on a site. A brief summary of these characteristics is given below. Examples of German air delivered ordnance are presented at **Annex E**.

Generic Types of WWII German Air Delivered Ordnance	
High Explosive (HE) Bombs	
Frequency	In terms of weight of ordnance dropped, HE bombs were the most frequent weapon deployed by the Luftwaffe during WWII.
Size/Weight	Most bombs were 50kg, 250kg or 500kg (overall weight, about half of which was high explosive) though larger bombs of up to 2000kg were also used.
Description	High explosive bombs are thick-skinned and typically have sufficient mass and velocity and a suitably streamlined shape to enable them to penetrate the ground if they failed to explode on the surface.
Likelihood of detecting Unexploded	Although efforts were made to identify the presence of unexploded ordnance following a raid, often the damage and destruction caused by bombs which did detonate often made observation of UXB entry holes impossible. The entry hole of an unexploded bomb can be as little as 20cm in diameter and easily overlooked in certain ground conditions (See **Annex F**). Furthermore, ARP documents describe the danger of assuming that damage, actually caused by a large UXB, was due to an exploded 50kg bomb. UXB's therefore present the greatest risk to present–day intrusive works.
Aerial or Parachute Mines	
Frequency	These were much less frequently deployed than HE and Incendiary bombs due to their size, cost and their difficulty technically to deploy.
Size/Weight	Their weight was either 500kg or 1000kg (overall weight, of which about 2/3 was explosive) depending on the type of mine. Their length ranged from 1.73-2.64m.
Description	The Luftmines (LMA-500kg and LMB-1000kg) were magnetic sea mines which were thin walled, cylindrical in shape with a hemispherical nose and were deployed under a green artificial silk parachute about 8m in diameter. They were fitted with magnetic and later with acoustic or magnetic/acoustic firing. When the mine hit the water and sank to more than 8ft, hydrostatic pressure and the dissolution of a soluble plug actuated the magnetic device and the mine

	became operational against shipping. The mine was also armed with a clockwork bomb fuze which caused the bomb to explode when used against land targets, and this was started by the impact of hitting the ground. The Bombenmine (BM 1000, Monika, or G Mine) was also used. This was fitted with a tail made from Bakelite which broke up on impact. It had a photoelectric cell beneath a cover which detonated the bomb if exposed to light to counteract the work of bomb disposal units.
Likelihood of detecting Unexploded	The aerial mines were either 500kg or 1000kg (overall weight, of which about 2/3 was explosive) depending on the type of mine. Their length ranged from 1.73-2.64m. They were much less frequently deployed than H.E. and Incendiary bombs due to their size, cost and the fact that they could not be delivered to point targets. If functioning correctly, parachute mines would generally have had a slow rate of descent (falling at about 40 mph) 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. When operating as designed they caused considerable damage due to the high weight of explosive and their detonation at or near the surface. However 1st Line Defence does not consider there to be a significant risk from unexploded aerial mines on land.
1kg Incendiary Bombs	
Frequency	In terms of number of weapons dropped these small Incendiaries were the most numerous. Millions of these weapons were dropped throughout WWII.
Size/Weight	1kg
Description	These thermite filled devices were jettisoned from air-dropped containers. Some variants had explosive heads and these present a risk of detonation during intrusive works.
Likelihood of detecting Unexploded	They had very limited penetration capability and in urban areas especially would usually have been located in post-raid surveys. If they failed to initiate and fell in water, on soft vegetated ground, or bomb rubble, they could easily have gone unnoticed.
Large Incendiary Bombs	
Frequency	These items of ordnance were not as common as the 1kg Incendiaries however they were still more frequently deployed than the Parachute Mines and Anti-Personnel Bomblets.
Size/Weight	These could weigh up to 350kg.
Description	They had various flammable fill materials (including oil and white phosphorus), and a small explosive charge. They were designed to explode and burn close to the surface. Although they were often the same shape as HE bombs, they were thin-skinned and generally did not penetrate the surface.
Likelihood of detecting Unexploded	If they did penetrate the ground, complete combustion did not always occur and in such cases they could remain a risk to intrusive works.
Anti-personnel (AP) Bomblets	
Frequency	They were not commonly used and generally considered to pose a low risk to most works in the UK.
Size/Weight	The size and weight ranged depending on the type used. The most common was the “Butterfly Bomb” (SD2) which weighed 2kg and contained 225 grams of TNT.
Description	The ‘Butterfly Bomb’ had an 8cm long, thin, cylindrical, cast iron outer shell which hinged open when the bomblet deployed gave it the superficial appearance of a large butterfly. A steel cable 15 cm long was attached via a spindle to an aluminium fuze. The wings at the end were canted at an angle to the airflow, which turned the spindle anti-clockwise as the bomblet fell. After the spindle had revolved approximately 10 times (partially unscrewing itself from the bomb) it released a spring-loaded pin inside the fuze, which fully armed the SD2 bomb. They were generally lethal to anyone within a radius of 10 metres (33 ft) and could inflict serious shrapnel injuries. There were a number of variants, the most common being the SD2 which weighed 2kg

	and contained 225 grams of TNT. They were not commonly used and generally considered to pose a low risk to most works in the UK.
Likelihood of detecting Unexploded	SD2 bomblets were not dropped individually, but were packed into containers holding between 6 and 108 submunitions however, AP bombs 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.

10.3. Failure Rate of German Air-Delivered Ordnance

It has been estimated that 10% of the German HE bombs dropped during WWII failed to explode as designed. This estimate is based on the statistics of wartime recovered UXBs and therefore will not have taken account of the unknown numbers of UXBs that were not recorded at the time. It is therefore quite likely that the average failure rate would have been higher than this.

There are a number of reasons why an air-delivered weapon might fail to function as designed:

- Many German bombs were fitted with a clockwork mechanism which could jam or malfunction.
- Malfunction of the fuze or gain mechanism (manufacturing fault, sabotage by forced labour or faulty installation)
- Failure of the bomber aircraft to arm the bombs due to human error or equipment defect.
- Jettison of the bomb before it was armed or from a very low altitude. Most likely if the bomber was under attack or crashing.

War Office Statistics document that a daily average of 84 bombs which failed to function were dropped on civilian targets in Great Britain between 21st September 1940 and 5th July 1941. 1 in 12 of these probably mostly fitted with time delay fuzes exploded sometime after they fell, the remainder were unintentional failures.

From 1940 to 1945 bomb disposal teams dealt with a total of 50,000 explosive items of 50 kg and over i.e. German bombs, 7,000 AAA shells and 300,000 beach mines. These operations resulted in the deaths of 394 officers and men. However, unexploded ordnance is still regularly encountered across the UK, especially in London; see press articles in **Annex G**.

10.4. V-Weapons

From mid-1944, Hitler's 'V-weapon' campaign began. It used newly developed unmanned cruise missiles and rockets. The V1 known as the Flying Bomb or Doodlebug and the V2, a Long Range Rocket, were launched from bases in Germany and occupied Europe. In total 9,251 V1s and 1,115 V2s 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 Northern England were too far to be considered for V-weapon strikes by the Luftwaffe. No V-weapons were recorded within the County Borough of Liverpool.

The threat from V-weapons in Liverpool is therefore considered negligible and will not be further addressed in this report.

11. UXB Ground Penetration

11.1. General

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 groundcover
- Underlying geology

Geology is perhaps the most important variable. If the ground is soft, there is more potential for deeper penetration – peat and alluvium are easier to penetrate than gravel and sand for example and the bomb is likely to come to rest at deeper depths. Layers of hard strata will significantly retard and may stop the trajectory of a UXB.

11.2. The J Curve Effect

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.

11.3. WWII UXB 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, mostly in the London area. They then came to conclusions as to the likely average and maximum depths of penetration of different sized bombs in different geological strata.

They concluded that the largest common German bomb, 500kg, had a likely 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 1000kg bomb 12.8m. Theoretical calculations suggested that significantly greater penetration depths were probable.

11.4. Site Specific Bomb Penetration Considerations

When considering an assessment of the bomb penetration at the site the following parameters have been used:

- WWII Geology – Chester Pebble Beds Formation.
- Impact Angle and Velocity – 10-15° from Vertical and 270 metres per second.
- Bomb Mass and Configuration – The 500kg SC (General Purpose) 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 due to the lack of site specific geotechnical information. A site specific assessment of bomb penetration depth can be made on site by a UXO Specialist if required.

12. Initiation of Unexploded Ordnance

12.1. General

Unexploded ordnance does not spontaneously explode. All high explosive requires significant energy to create the conditions for detonation to occur. In the case of unexploded German bombs discovered within the construction site environment, there are a number of potential initiation mechanisms.

12.2. UXB Initiation Mechanisms

There are a number of ways in which UXB can be initiated. These are detailed in the table below.

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	This is the most likely scenario resulting in the weapon detonating; 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.

Annex G details UXB incidents where intrusive works have caused UXBs to detonate, resulting in death or injury and damage to plant.

12.3. Effects 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 weakening of support structures
- Environment – introduction of potentially contaminating materials

13. The Risk from German UXBs

13.1. World War I

During WWI the UK was targeted and bombed by Zeppelin Airships and by Gotha and Giant fixed-wing aircraft. The first raid of 1916 was carried out by the German Navy. Liverpool does not appear to have been successfully bombed during WWI. Nine Zeppelins were sent to Liverpool on the night of 31st January – 1st February, but a combination of poor weather, difficult navigation and mechanical problems scattered the aircraft across the English Midlands and several towns were bombed. A total of 61 people were reported killed and 101 injured by the raid. See **Annex H** for a WWI Bomb Plot Map of the UK.

WWI bombs were generally smaller than those used in WWII and were dropped from a lower altitude, resulting 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 Liverpool

The Luftwaffe's objective for the attacks on Liverpool was to paralyse the commercial life of the city by bombing the docks, warehouses, wharves, railway lines, factories and power stations.

The outbreak of WWII placed Liverpool in a position of immense strategic importance. After London, it was the UK's largest port, as well as being the major port facing westwards, towards the Atlantic Ocean. It was a busy centre for coastal traffic, as well as handling a third of the UK's imports and exports. During the war, this proportion rose dramatically, due to the vulnerability of London and ports on the east coast to air raids and naval forces. In addition to food, fuel, raw materials, weapons and troops entered the country through the Liverpool Docks. Because of the huge dock system within Liverpool & its surrounding towns of Bootle, Wallasey and Birkenhead, Liverpool's docks represented the number one target for enemy bombers outside London. Fatalities in the city were twice as high as any other British port.

The worst raids on Liverpool came in the 'May Blitz' on 1941, when the city was bombed for eight nights in a row. In this time, the heaviest consecutive nights of bombing on Liverpool during the war, 1,453 people were killed within the city. Between May 1st and 8th, 1941, over seven consecutive nights, German planes dropped 870 tonnes of high explosive bombs and over 112,000 incendiary bombs. While serious damage was caused to the docks and the city of Liverpool, the docks were never closed and shipping was never seriously disrupted.

Records of bombing incidents in the civilian areas of Liverpool were collected by the Air Raid Precautions wardens and collated by the Civil Defence Office. Some other organisations, such as the London Port Authority and railways, 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 city 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 for Liverpool are presented in the following sections.

13.3. Second World War Bombing Statistics

The following tables summarise the quantity of German bombs (excluding 1kg incendiaries and anti-personnel bombs) falling on the County Borough of Liverpool between 1940 and 1945.

Record of German Ordnance Dropped on the County Borough of Liverpool		
Area Acreage		**27,321**
Weapons	High Explosive Bombs (all types)	2,332
	Parachute Mines	117
	Oil Bombs	50
	Phosphorus Bombs	0
	Fire Pot	0
	Pilotless Aircraft (V1)	0
	Long Range Rockets (V2)	0
Total		**2,499**
Number of Items per 1000 acres		**91.5**

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 incendiaries are not particularly significant in the threat they pose, they nevertheless are items of ordnance that were designed to cause damage and inflict injury and should not be overlooked in assessing the general risk to personnel and equipment. The anti-personnel bombs were used in much smaller quantities and are rarely found today but are potentially more dangerous.

13.4. Liverpool Bomb Plot Map

This bomb plot map was obtained from the Liverpool Record Office. It is believed to be an enlarged photograph of a pin-board map from the period. The map covers the entire county borough of Liverpool, and it is thus hard to exactly pinpoint bomb strikes when zoomed in. The section showing the area of the site is presented in **Annex I**.

Liverpool Bomb Plot Map – Annex I	
Date Range	**Comments**
Consolidated bomb plot map: presumed 1940 - 1945	The site has been placed as accurately as is possible on this map, although the small scale of the map makes it difficult to tell where exactly the site lies. What is obvious is that the site was within the city centre of Liverpool, which was bombed severely, as multiple incidents of HE damage can be seen close to the site area.

13.5. Liverpool Echo Bomb Layers

These layers come from the website of the Liverpool Echo. Their source is not given, but they appear to cover the 'May Blitz' on Liverpool in 1941, when the majority of the bombing and damage Liverpool sustained was caused. These layers were downloaded and overlaid onto Google Earth. The site and surrounding bombing are shown in **Annex J**.

Liverpool Echo Bomb Layers – Annex J	
Date Range	**Comments**
1st – 8th May 1941	According to these layers, the site does not appear to have been struck by bombs during the May Blitz. It should be noted that these strikes are plotted approximately rather than accurately. The closest strikes to the site area are described below. Red Pin - 2/3 May 1941 - Large fires and heavy damage on Strand Street and James Street. Blast damage to India Buildings, Cunard Buildings, Tunnel Building. Green Pin - 3/4 May 1941 - Area bounded by Between Lord Street, Canning Place and Paradise Street devastated.

13.6. Bomb Damage Photography

Two images of damage close to the site area were obtained from the Liverpool Museums website. These two images show heavy damage on Strand Street and James Street. While the damage shown is not within the site area, these two images give an idea of the severe damage sustained by Liverpool City Centre during the May Blitz. These two images are shown in **Annex K**.

13.7. Liverpool Bomb Damage Tracings

Several tracings of bomb damage were obtained from the National Archives for the city of Liverpool. These tracings show buildings that were hit by bombing, and were likely traced from historical OS maps of the time. As they were traced, they do not show buildings that were not damaged, and it is not possible to place the site area in these tracings. The tracings were looked through, and no tracings concerning the site area were found. Examples of tracings showing the bombing the city centre of Liverpool sustained can be seen in **Annex L**. It should be noted that these tracings do not provide a comprehensive account of the bombing of the City of Liverpool.

13.8. WWII-Era Aerial Photographs

A low resolution image of a WWII-era aerial photograph which covers the site area was obtained from the 'Liverpool Blitz 70' website. This image, from the 11th of June 1941 shows the centre of Liverpool only a month after the severe 'May Blitz' on the city. While it is not possible to see clearly any exact damage within the site, it is clear that by the time the image was taken it had escaped the destruction seen to the east of the site area, between Lord Street and Canning Place. This image can be seen in **Annex M**.

High resolution scans of WWII-era aerial photography for the site area were obtained from the National Monuments Record (Historic England). Imagery dated 1st April 1946 is presented in **Annex N**.

There are now obvious signs of bomb damage within the site. Two large areas of cleared land can be seen within the north and south of the site. Only a few properties have survived in the middle area between the two. Within the north-east of the site, two former warehouses appear to have been seriously damaged. The food depot within the west of the site and the industry within the east of the site do appear to have survived the war.

A larger area of the city of Liverpool is shown in **Annex N**. It is obvious from this image the damage that the city centre of Liverpool sustained during the bombing campaign. A large area east of the site has been almost been completely cleared, and few structures have survived. South of the site, the large custom house lies in ruins, appearing to be completely burnt out.

13.9. 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 were encountered, Bomb Disposal Officer Teams would normally have been requested to attempt to locate, render safe and dispose of the bomb. Occasionally evidence of 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.

13.10. Bomb Disposal Tasks

The information service from the Explosive Ordnance Disposal (EOD) Archive Information Office at 33 Engineer Regiment (EOD) is currently facing considerable delay. 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 Curtins will be advised.

13.11. Evaluation of Bombing Records

Item	Conclusion
Density of Bombing *It is important to consider the bombing density when assessing the possibility that UXBs remain in an area. High levels of bombing density could allow for error in record keeping due to extreme damage caused to the area.*	The site was situated within the County Borough of Liverpool during WWII. This borough sustained a heavy bomb density of 91.5 items per 1,000 acres. A bomb map, obtained from Liverpool Record Office, suggests that the site and the surrounding area were subject to a large amount of serious HE damage. However, this bomb map is very large, and it is not possible to know for sure exactly where bombs landed. The record set for Liverpool is known to be incomplete, and no complete set of incident records or bomb census mapping is known to be available from either local or national archives.
Ground Cover *The type & amount of ground cover existing during WWII would have a substantial influence on any visual indication that may indicate UXO being present.*	It is likely that unexploded bombs falling on areas of the site that were occupied by buildings that were undamaged throughout the war would have been noticed and acted upon. UXB's falling on areas that were heavily damaged may have gone unnoticed. The entry hole of a 50kg UXB can be as little as 20cm in diameter and easily obscured by rubble and debris.
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 are also likely to have been subject to post-raid checks for evidence of UXO.*	Pre-war, the site was occupied by industrial buildings and attached yard areas. All the while these areas were undamaged, it can be presumed that they would have been accessed frequently throughout the war. However, areas within the site that were damaged and cleared, or areas that were left as ruins would not have been accessed frequently or subject to specific post-raid checks.
Damage *If buildings or structures on a site suffered 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.*	Areas within the site appear to have been seriously damaged during the war. Two areas within the centre of the site have been cleared of buildings, while two structures within the north-east of the site has been reduced to rubble.
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 within the site vicinity.
Bombing Decoy sites	1st Line Defence could find no evidence of bombing decoy sites within the site vicinity.
Bomb Disposal Tasks	1st Line Defence could find no evidence of Bomb Disposal Tasks within the site boundary and immediate area.

14. The Risk from Allied Military Ordnance

14.1. General

In addition to the risk from aerial delivered UXO, this report also assesses the potential risk from Allied military ordnance. Contamination from items of Land Service (LSA) and Small Arms Ammunition (SAA) may result, for example, from historic occupation of an area or its use for military training. Inner city sites can be at risk from buried unexploded Anti-Aircraft projectiles fired during WWII.

14.2. Defending London from Aerial Attack

Both passive and active defences were deployed against enemy bombers attacking targets in the Greater London region.

Passive Defences	Active Defences
These included defence tactics such as: • To hinder the identification of targets, by using lighting blackouts at night and camouflaging strategic installations. • To mislead bomber pilots into attacking decoy sites located away from the city with the use of dummy buildings or lighting to replicate that of the city under attack. • To force attacking aircraft to higher altitudes with the use of barrage balloons.	These relied on a coordinated combination of a number of installations in order to actively engage and oppose attacking aircraft. Some of these installations were: • Fighter aircraft to act as interceptors. • Anti-aircraft gun batteries. • The use of rockets and missiles (later during WWII).

14.3. Anti-Aircraft Artillery (AAA) and Projectiles

At the start of WWII two types of Anti-Aircraft Artillery (AAA) guns were deployed: Heavy Anti-Aircraft Artillery (HAA), using large calibre weapons such as the 3.7" QF (Quick Firing) gun and Light Anti-Aircraft Artillery (LAA) using smaller calibre weapons such as 40mm Bofors gun.

During the early war period there was a severe shortage of AAA available and older WWI 3" and modified naval 4.5" guns were deployed alongside those available 3.7" weapons. The maximum ceiling height of fire at that time was around 11,000m for the 3.7" gun and less for other weapons. As the war progressed improved variants of the 3.7" gun were introduced and, from 1942, large 5.25 inch weapons began to be brought into service. These had significantly improved ceiling heights of fire reaching over 18,000m.

The LAA batteries were intended to engage fast low flying aircraft and were typically deployed around airfields or strategic installations. These batteries were mobile and could be moved to new positions with relative ease when required. The most numerous of these were the 40mm Bofors gun which could fire up to 120 x 40mm HE shells per minute to over 1800m.

The HAA projectiles were high explosive shells, usually fitted with a time delay or barometric pressure fuze to make them explode at a pre-determined height. If they failed to explode or strike an aircraft, they would eventually fall back to earth. Details of the most commonly deployed WWII AAA projectiles are shown below:

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

Although the larger unexploded projectiles could enter the ground they did not have great penetration ability and are therefore likely to be found close to WWII ground level. These shells are frequently mistakenly identified as small German air-delivered bombs, but are differentiated by the copper driving band found in front of the base. With a high explosive fill and fragmentation hazard these items of UXO present a significant risk if encountered. The smaller 40mm projectiles are similar in appearance and effect to small arms ammunition and, although still dangerous, present a lower hazard because of a lower explosive content. They are still dangerous because they were fitted with an impact initiated fuze which was also a spin-decay self-destruct mechanism.

Numerous unexploded AAA shells were recovered during and following WWII and are still occasionally encountered on sites today. The closest recorded HAA battery to the site was situated approximately 3.25kn east in the vicinity of Five Ways. Illustrations of Anti-Aircraft artillery, projectiles and rockets are presented at **Annex O**.

14.4. Evaluation of Allied Military Ordnance Risk

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

Item	Conclusion
Military Camps	1st Line Defence could find no evidence of a Military Camp within the site.
Anti-Aircraft Defences	1st Line Defence could find no evidence of Anti-Aircraft Defences in the site proximity.
Home Guard Activity	Evidence of Home Guard training areas and activities is difficult to obtain. 1st Line Defence has no evidence of any Home Guard activities on the site.
Defensive Positions	There is no evidence of any defensive structures in the vicinity of the site.
Training or firing ranges	No evidence of these could be found.
Defensive Minefields	No evidence of these could be found.
Ordnance Manufacture	No evidence of ordnance manufacture could be found.
Military Related Airfields	The site was not situated within the vicinity of a military airfield.
Explosive Ordnance Clearance Tasks	1st Line Defence holds no records of EOD operations on the site.

15. Ordnance Clearance and Post-WWII Ground Works

15.1. General

The extent to which any ordnance clearance activities have taken place on site or extensive ground works have occurred is relevant since on the one hand they may indicate previous ordnance contamination but also may have reduced the risk that ordnance remains undiscovered.

15.2. UXO Clearance

1st Line Defence has no evidence that any official ordnance clearance operations have taken place on site. Note however that we have not received confirmation of this fact from 33 EOD Regiment.

15.3. Post war Redevelopment

There has been some re-development on the site post WWII. The extent of the developments and depth of foundations can partly mitigate the UXO risk as any present items of UXO may have been uncovered during the works.

Any developments involving deep intrusive works will have mitigated the risk of deep-buried unexploded bombs at the locations of piling and foundations. Any smaller developments may have partially mitigated the risk of encountering shallow buried UXO especially 1kg incendiaries and anti-aircraft projectiles.

16. 1st Line Defence Risk Assessment

16.1. Risk Assessment Stages

Taking into account the quality of the historical evidence, the assessment of the overall risk to the proposed works 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.

UXO Risk Assessment	
Quality of the Historical Record	The research has located and evaluated pre- and post-WWII Ordnance Survey maps, a Bomb Plot Map and Bomb Layers for the City of Liverpool, in-house data and post WWII era aerial photographs for the site. The record set for Liverpool is known to be incomplete, and no complete set of incident records or bomb census mapping is known to be available from either local or national archives.
The Risk that the Site was Contaminated with UXO	After considering the following facts, 1st Line Defence has assessed that there is a **Medium Risk** that items of unexploded German air-delivered ordnance could have fallen unnoticed and unrecorded within the site boundary. • During WWII the County Borough of Liverpool was subjected to a High Density bombing campaign, with 91.5 items falling per 1,000 acres. The bombing of Liverpool was focused on the City Centre and the docks. • The site was within the city centre of Liverpool, which was bombed severely. Multiple incidents of HE damage can be seen close to the site area on a small scale map obtained from the Liverpool Record Office. • Very limited information regarding the bombing of the City of Liverpool has survived to date. No detailed bomb plot or damage maps, or complete set of incident records appear to have survived the war. It is possible that the serious damage Liverpool sustained over a short period of time in May 1941 meant that accurate record keeping was not achieved. It has therefore not been possible to determine exactly where bombs fell within the city, and other data such as post-war mapping and photography therefore become an essential tool in looking at changes resulting from damage and assessing whether ground conditions present would have been conducive to the observation of UXB entry holes. • Several areas within the centre of the site appear to have been cleared post-war. Within the north-east of the site two structures appear to have been reduced to ruins. It is considered likely that these changes were the direct result of bomb damage, and that an amount of rubble and debris would have been present across these areas. Evidence of UXO could easily be overlooked within areas of debris resulting from bombing – note that the entry hole of a 50kg bomb could be as little as 20cm in diameter. • While areas of the site did survive the war, the risk from 'J-Curve', where a bomb can end up laterally offset from its point of entry (see section 10.4) means that no one area can be considered at 'low' risk. A 'buffer zone' has been placed around these cleared/damaged areas to account for this possibility of 'J-Curve'.

The Risk that UXO Remains on Site	There has been some re-development on the site post WWII. The extent of the developments and depth of foundations can partly mitigate the UXO risk as any present items of UXO may have been uncovered during the works. Any developments involving deep intrusive works will have mitigated the risk of deep-buried unexploded bombs at the locations of piling and foundations. Any smaller developments may have partially mitigated the risk of encountering shallow buried UXO especially 1kg incendiaries and anti-aircraft projectiles.
The Risk that UXO may be Encountered during the Works	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. Since an air-dropped bomb may come to rest at any depth between just below ground level and its maximum penetration depth, there is also a chance that such an item could be encountered during shallow excavations (for services or site investigations) into the original WWII ground level.
The Risk that UXO may be Initiated	The risk that UXO could be initiated if encountered will depend on its condition, how it is found and the energy with which it is struck. Certain construction activities such as piling and percussive drilling pose a greater risk of initiating UXO than, say, machine excavation where the force of impact is generally lower and the item more likely to be observed. If a UXB is struck by piling or percussive drilling equipment, the force of the impact can be sufficient to detonate the main high explosive charge irrespective of the condition of the fuze or other components. Violent vibration might also impart enough energy to a chemical detonator for it to function, and there is a potential risk that clockwork fuzes could restart. If piling works are planned at The Strand, Liverpool there is a potential risk that a UXB, if present, could be initiated. The risk of initiation is assessed to be lower for any shallow intrusive works planned.
The Consequences of Encountering or Initiating Ordnance	The repercussions of the inadvertent detonation of UXO during intrusive ground works 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. If appropriate risk mitigation measures are put in place, the chances of initiating an item of UXO during ground works is comparatively low. The primary consequence of encounter of UXO will therefore be economic. This would be particularly notable in the case of a high-profile site and sites 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 loss of production. Generally, the first action of the police in most cases will be to isolate the locale whilst awaiting military assistance, even if this turns out to have been unnecessary.

16.2. Assessed Risk Level

Taking into consideration the findings of this study, 1st Line Defence considers there to be a **Medium Risk** from unexploded ordnance on the site of proposed works.

Medium Risk

The site was occupied by industrial structures and yards during the war. According to RAF aerial photography and post-war historic OS mapping, parts of the site area appear to have been cleared post war, and some buildings within the site area have been reduced to ruins. It is thought that this is due to bomb damage. Given the small size of the site and the risk of 'J-curve', it has not proved possible to negate the risk from UXO within the site area.

Ordnance Type	Risk Level			
	Negligible	Low	Medium	High
German UXB's			✓	
Allied AAA			✓	
German Incendiaries and AP bomblets			✓	
Other Allied Military Ordnance	✓			

17. Proposed Risk Mitigation Methodology

17.1. General

The following risk mitigation measures are recommended to support the proposed works at The Strand, Liverpool.

Type of Work	Recommended Mitigation Measure
All Works	• **Site Specific Unexploded Ordnance Awareness Briefings to all personnel conducting intrusive works.** A specialised briefing is always advisable when there is a possibility of explosive ordnance contamination. It is an essential component of the Health & Safety Plan for the site and conforms to requirements of CDM Regulations 2015. All personnel working on the site should be instructed on the identification of UXO, actions to be taken to alert site management and to keep people and equipment away from the hazard. Posters and information of a general nature on the UXO risk should be held in the site office for reference and as a reminder.
Shallow Intrusive Works/Open Excavations	• **Unexploded Ordnance (UXO) Specialist Presence on Site to support shallow intrusive works:** When on site the role of the UXO Specialist would include; monitoring works using visual recognition and instrumentation and 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 staff that have not received them earlier and advise staff of the need to modify working practices to take account of the ordnance risk, and finally to aid Incident Management which would involve liaison with the local authorities and Police should ordnance be identified and present an explosive hazard.
Borehole/Piles	• **Intrusive Magnetometer Survey of all Borehole and pile locations down to a maximum bomb penetration depth:** 1st Line Defence can deploy a range of intrusive magnetometer techniques to clear ahead of all the pile locations. The appropriate technique is governed by a number of factors, but most importantly the site's ground conditions. The appropriate survey methodology would be confirmed once the enabling works have been completed.

In making this assessment and recommending these risk mitigation measures, the proposed 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 **18th May 2016**

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

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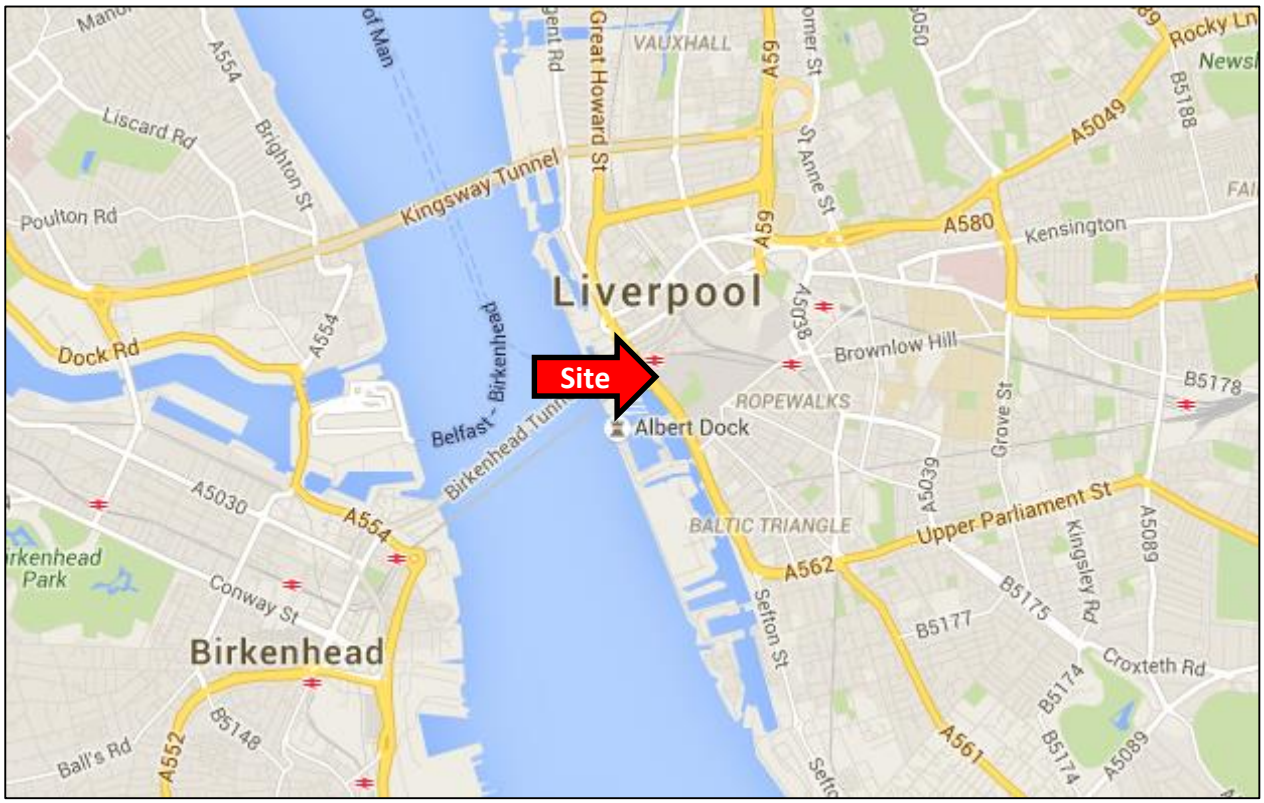
Site Location Maps

Annex: **A**



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Tel: +44 (0)1992 245 020

Client: **Curtins**		**Approximate site boundary**	N
Project: **The Strand, Liverpool**			
Ref: **DA3469-00**	Source: Google Maps		

Recent Aerial Photography

Annex: **B**

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Client: **Curtins**

Project: **The Strand, Liverpool**

Ref: **DA3469-00**

Source: Google Earth ™ Mapping Services

Approximate site boundary

N

Site Plan

Annex: **C**

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Client: **Curtins**

Approximate site boundary

Project: **The Strand, Liverpool**

Ref: **DA3469-00**

Source: Curtins

1927 Historical Map

Annex: **D1**

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Approximate site boundary

N

Project: **The Strand, Liverpool**

Ref: **DA3469-00**

Source: Landmark Maps

1938 Historical Map

Annex: **D2**

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Client: **Curtins**

Approximate site boundary

N

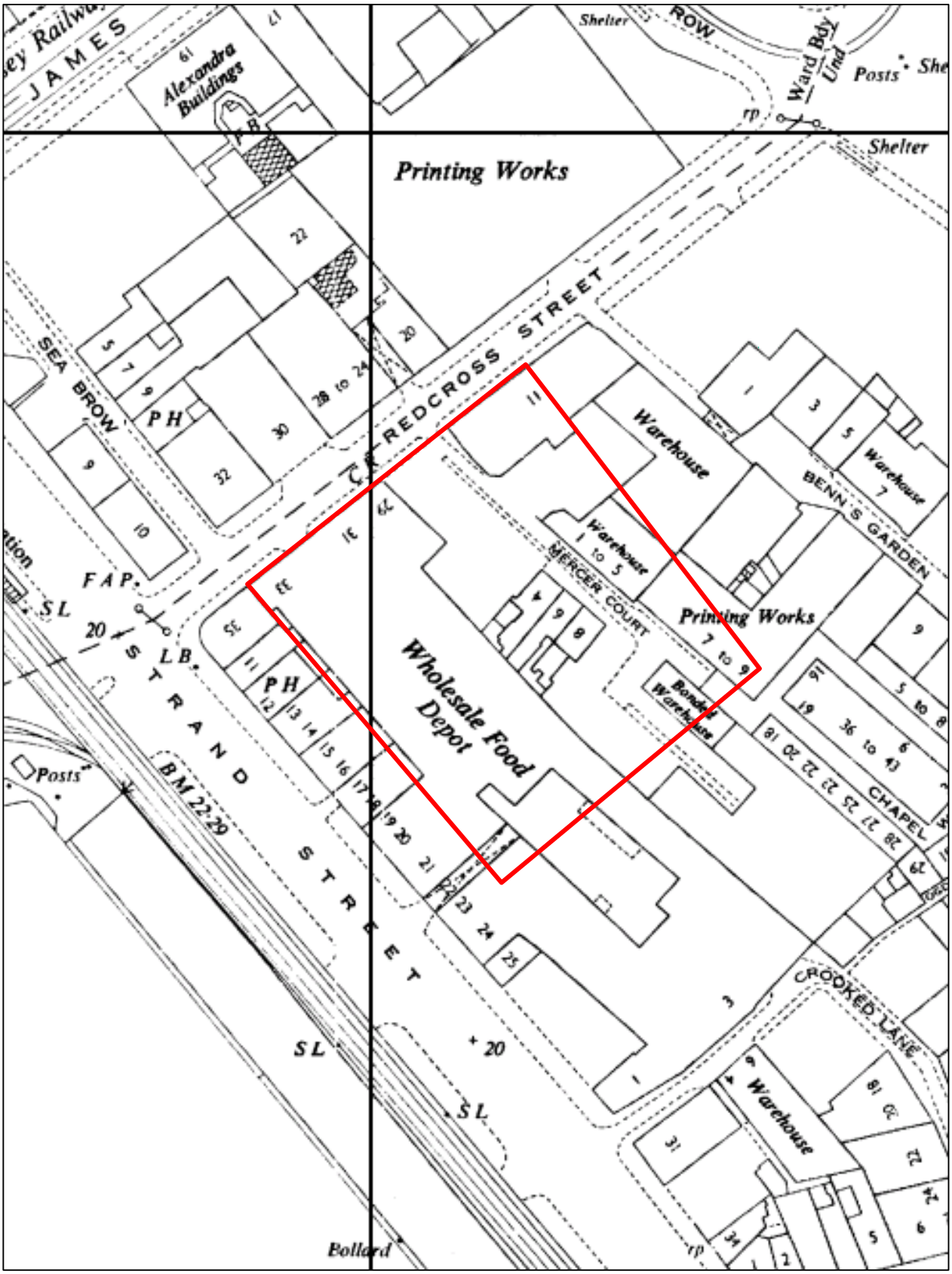
Project: **The Strand, Liverpool**

Ref: **DA3469-00**

Source: National Library of Scotland

1954 Historical Map

Annex: D3



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Client: **Curtins**

Approximate site boundary

N

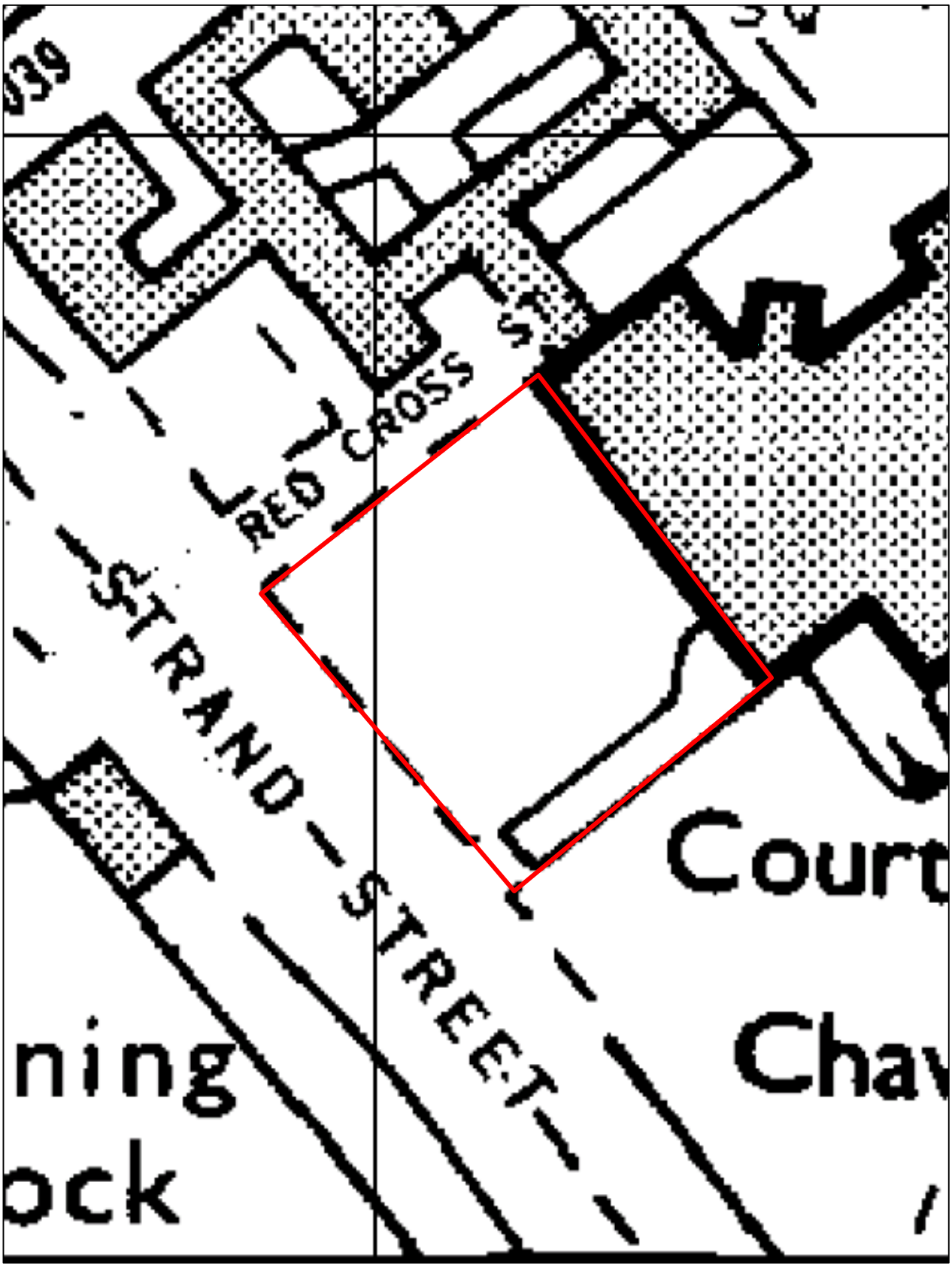
Project: **The Strand, Liverpool**

Ref: **DA3469-00**

Source: Landmark Maps

1991 Historical Map

Annex: D4



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Client: **Curtins**

Approximate site boundary

N

Project: **The Strand, Liverpool**

Ref: **DA3469-00**

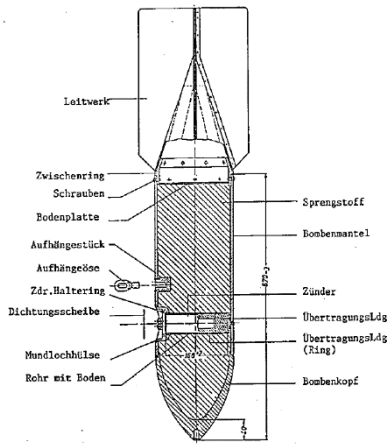
Source: Landmark Maps

Common Types of German HE Air-Delivered Ordnance

Annex: **E1**

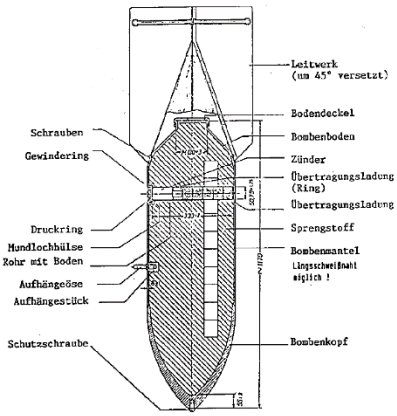
SC 50kg

Bomb Weight	40-54kg (110-119lb)
Explosive Weight	c25kg (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.



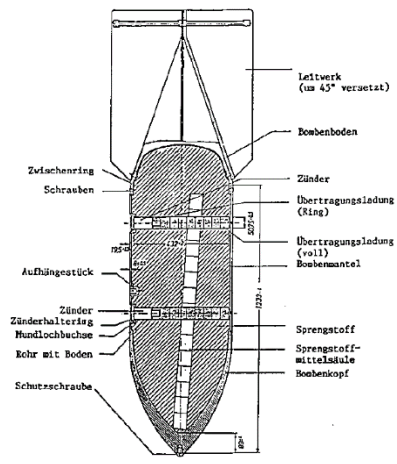
SC 250kg

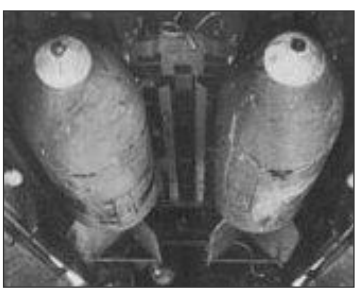
Bomb Weight	245-256kg (540-564lb)
Explosive Weight	125-130kg (276-287lb)
Fuze Type	Electrical impact/mechanical time delay fuze.
Bomb Dimensions	1640 x 512mm (64.57 x 20.16in)
Body Diameter	368mm (14.5in)
Use	Against railway installations, embankments, flyovers, underpasses, large buildings and below-ground 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

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 1-15/16 in. in length and diameter forming





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Project: **The Strand, Liverpool**

Ref: **DA3469-00**

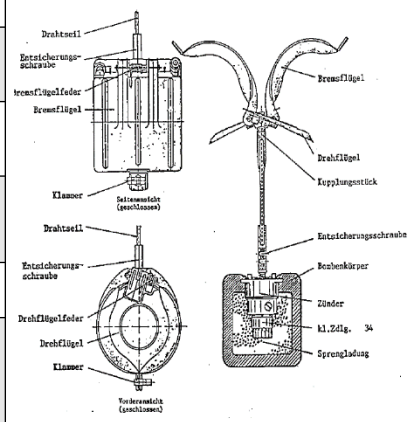
Source: Various sources

Common Types of German HE Air-Delivered Ordnance

Annex: E2

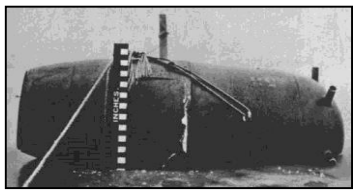
SD2 Butterfly Bomb

Bomb Weight	2kg (4.41lb)
Explosive Weight	7.5oz (225 grams) of TNT surrounded by a layer of bituminous composition.
Fuze Type	41 fuze (time) , 67 fuze (clockwork time delay) or 70 fuze (anti-handling device)
Bomb Dimensions	Length 240 mm Width 140 mm Height 310 mm
Body Diameter	3in (7.62 cm) diameter, 3.1in (7.874) long
Use	It was designed as an anti-personnel/fragmentation weapon. They were delivered by air, being dropped in containers that opened at a predetermined height, thus scattering the bombs.
Remarks	The smallest and most common conventional German bomb. Nearly 70% of bombs dropped on the UK were 50kg.



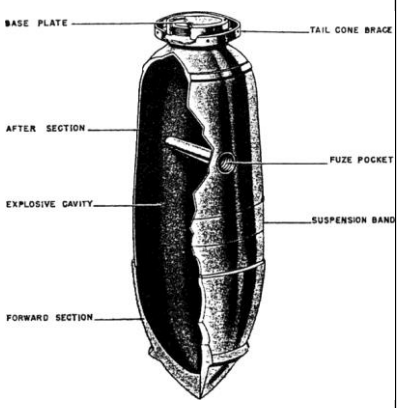
Parachute Mine (Luftmine B / LMB)

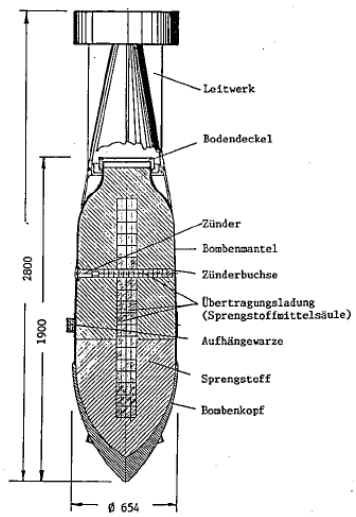
Bomb Weight	987.017kg (2176lb)
Explosive Weight	125-130kg (276-287lb)
Fuze Type	Impact/ Time delay / hydrostatic pressure fuze
Bomb Dimensions	1640 x 512mm (64.57 x 20.16in)
Body Diameter	368mm (14.5in)
Use	Against civilian, military and industrial targets. Designed to detonate above ground level to maximise damage to a wider area.
Remarks	Parachute Mines were normally carried by HE 115 (Naval operations), HE 111 and JU 88 aircraft types. Deployed a parachute when dropped in order to control its descent.



SC 1000kg

Bomb Weight	996-1061kg (1,058-1,146lb)
Explosive Weight	530-620kg (551-573lb)
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 (77 x 25.2in)
Body Diameter	654mm (18.5in)
Use	SC type bombs are 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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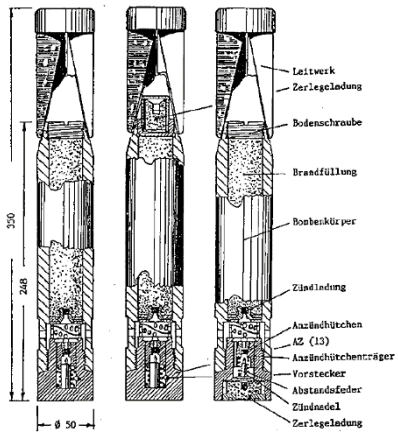
Ref: **DA3469-00**

Source: Various sources

German Incendiary Bombs

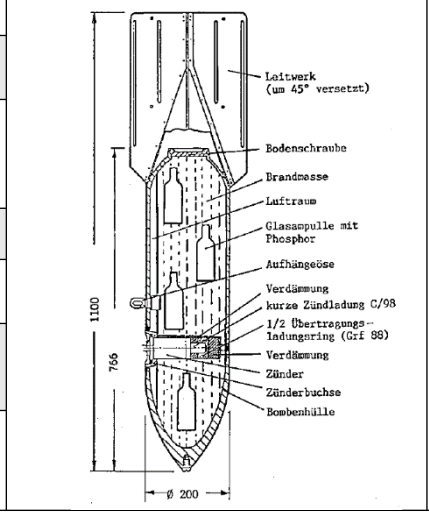
1kg Incendiary Bomb

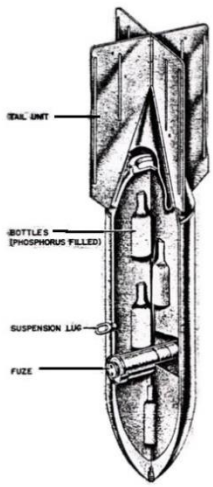
Bomb Weight	1.0 and 1.3kg (2.2 and 2.87lb)
Explosive Weight	680gm (1.3lb) Thermite
Fuze Type	Impact fuze
Bomb Dimensions	350 x 50mm (13.8 x 1.97in)
Body Diameter	50mm (1.97in)
Use	As incendiary – dropped in clusters against towns and industrial complexes
Remarks	Magnesium alloy case. Sometimes fitted 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

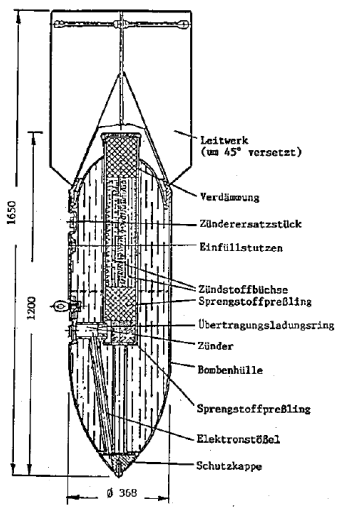
Bomb Weight	c41kg (90.4lb)
Explosive Weight	0.03kg (0.066lb)
Incendiary Filling	12kg (25.5lb) liquid filling with phosphor igniters in glass phials. Benzine 85%; Phosphorus 4%; Pure Rubber 10%
Fuze Type	Electrical impact fuze
Bomb Dimensions	1,100 x 280mm (43.2 x 8in)
Use	Against all targets where an incendiary effect is to be expected
Remarks	Early fill was a phosphorous/carbon disulphide incendiary mixture





Flam C-250 Oil Bomb

Bomb Weight	125kg (276lb)
Explosive Weight	1kg (2.2lb)
Fuze Type	Super-fast electrical impact fuze
Filling	Mixture of 30% petrol and 70% crude oil
Bomb Dimensions	1,650 x 512.2mm (65 x 20.2in)
Body Diameter	368mm (14.5in)
Use	Often used for surprise attacks on living targets, against troop barracks and industrial installations. Thin casing – not designed for ground penetration



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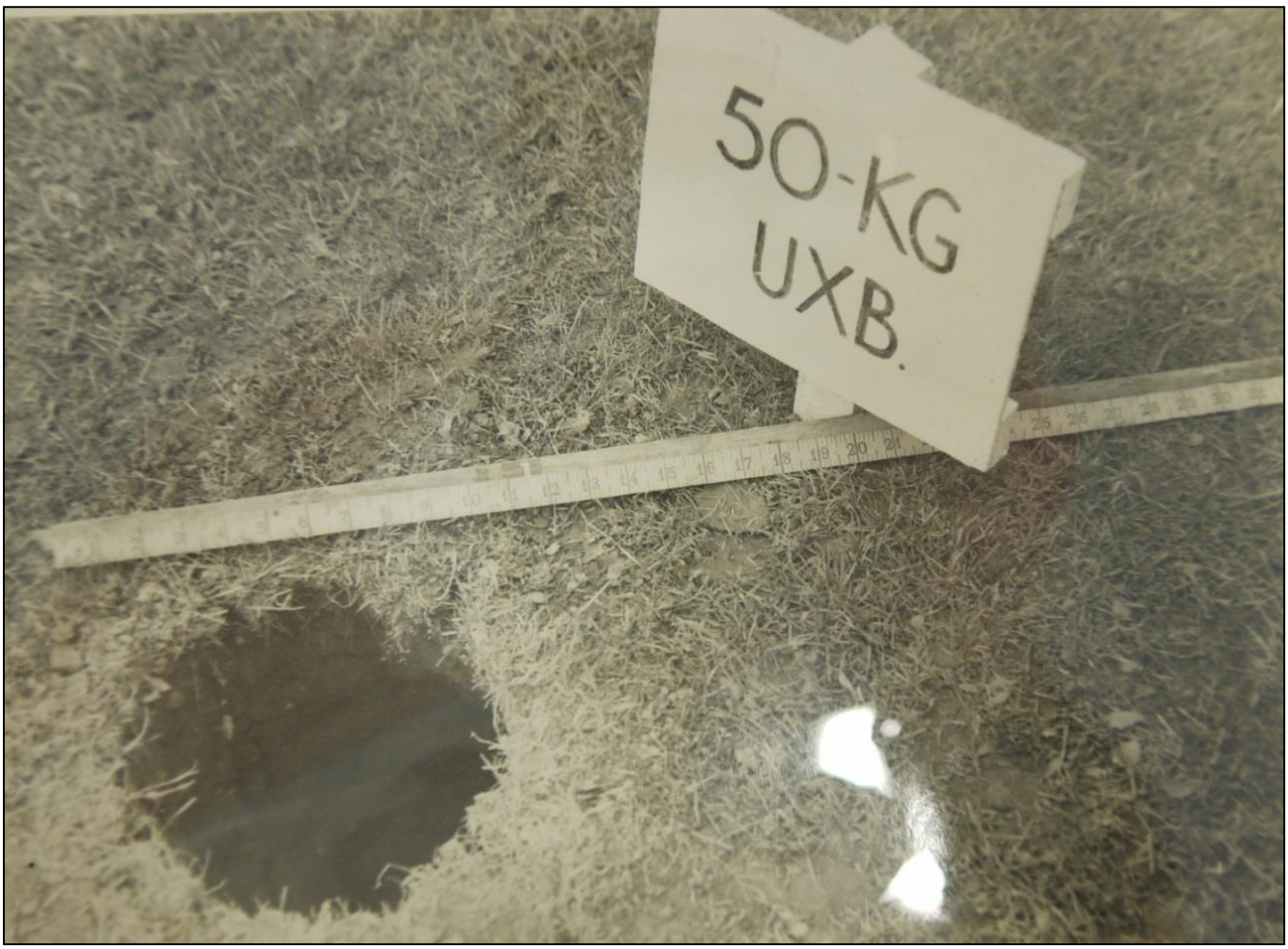
Source: Various sources



German 50kg HE Bomb Entry Hole

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Ref: **DA3469-00**

Source: Archive sources

LIVE BBC NEWS CHANNEL

Page last updated at 14:45 GMT, Friday, 22 May 2009 15:45 UK

E-mail this to a friend Printable version

Building site WWII bomb exploded

A controlled explosion has been carried out on a World War II bomb found on a building site in East Sussex.

The 110lb (50kg) SC50 bomb, thought to have been dropped from a German aircraft in 1940 or 1941, was found at the Hollenden House site in Bexhill.

Children at St Peter and St Paul Primary School next door in Buckhurst Road were sent home early after the discovery on Thursday.

Police said a 160ft (50m) cordon was put round the site during the blast.

Breaking News: UXB in Beckton - controlled explosion ends the drama

Colin Grainger , Editor
Sunday, December 19, 2010
9:32 AM

The World War Two bomb that was found on the 2012 Olympic site in Stratford back in 2009. Picture: Steve Poston

Recommend 0 Tweet 3

+1 Recommend this on Google

Bomb disposal experts carried out a controlled explosion last night on a 250kg World War II shell discovered at Britain's largest sewage works.

Bomb disposal experts carried out a controlled explosion last night on a 250kg World War II shell discovered at Britain's largest sewage works.

The bomb was found at Beckton sewage works off Jenkins Lane after surveyors preparing the site for a £200m expansion detected an unusual magnetic force underground on Saturday morning.

The Thames Water workers immediately alerted police and army ordnance experts, who attended the site and confirmed it was an unexploded German warhead.

A 400-metre exclusion zone was set up before the bomb was destroyed at the works under controlled conditions at 9pm on Saturday.

Second World War bomb which caused commuter chaos has been diffused

By DAILY MAIL REPORTER
Last updated at 4:42 PM on 06th June 2008

Comments (0) Share +1 0 Tweet 0 Like 3

An unexploded Second World War bomb which forced the closure of a number of transport routes in the capital was defused today.

Army experts worked to disarm the 2,000lb UXB faced delays after discovering metal used to make the Second World War device was thicker than expected.

This morning, however, military engineers managed to cut through the casing of the bomb, which measures 5ft by 2ft, enabling them to begin 'steaming' the explosive inside to make it safe.

Effort: Army experts' machines and the unexploded bomb in East London

Commuters faced the prospect of more Tube chaos, however, as lines near the danger area were closed.

The bomb, which is lying on a gas main just 50 yards from the main sewage pump for east London, was unearthed by a mechanical digger on Monday in the banks of the Lea in Bromley-by-Bow near the Olympic site.

Construction workers made the discovery while widening the bank to take barges for the 2012 Games village construction.

It had lain dormant there for more than 60 years.

Holiday beach cordoned off after landslip sends more than a THOUSAND Second World War bombs and rockets tumbling onto the sands

- **Bad weather led to ground movement which exposed the huge arsenal at Mappleton, East Riding**
- **A dog walker stumbled across the deadly find on Saturday and 15 controlled explosions were carried out**
- **Rockets, mortar bombs and 25-pounder bombs were recovered after they were fired into the cliffs by RAF aircraft during the war**
- **Most of the devices were dummy rounds used for bombing practice but contain enough explosives to cause terrible injuries**

By EMILY ALLEN and MARK BRANAGAN

PUBLISHED: 08:11, 23 July 2012 | **UPDATED:** 02:42, 24 July 2012

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Project: **The Strand, Liverpool**

Ref: **DA3469-00**

Source: Various news sources

Examples of Unexpected Detonation of WWII Bombs

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.

1st March 2013

BASF is expanding their its Ludwigshafen location by expanding several plants and building a TDI plant, which was the site of an explosion on Tuesday (Feb. 26). One person was injured in the blast, which BASF believes was caused when excavation work detonated a bomb.

Early reports had speculated that excavation work had detonated a bomb from World War II. While the age of the bomb has not been confirmed, BASF has said that an explosive device was detonated.

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."

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.

Tweet 0 Recommend 1

23rd October 2006

AP

A cutting machine lies wrecked by the side of the A3 motorway next to a small crater left by the explosion.

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.

The A3 Autobahn linking the cities of Frankfurt and Würzburg has been blocked in both directions.

More than 60 years since the end of World War II, construction workers still frequently unearth unexploded bombs and it is not uncommon for whole city districts to be cordoned off and even evacuated while bomb disposal experts defuse them.

Indeed, just last week, some 22,000 people were evacuated from their homes in Hanover when three World War II bombs were discovered.

Allied pilots rained nearly 2 million tons of explosives on Germany during the war. Landmines, hand grenades, mortar bombs and anti-tank devices from the fighting on German soil at the end of the war are also found, and authorities say it will take decades before the country is cleared of duds.

Between 400 and 600 bombs are discovered a year in the state of North Rhine-Westphalia alone, where the heavily industrialized Ruhr region was a major target for Allied bombers.

19th September 2013

WWII bomb injures 17 at Hattingen construction site

Published: 19 Sep 08 16:53 CET

Share +1 0 Tweet 0

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

- Liberals grit teeth ahead of May state election (17 Mar 12)
- Nazi death camp guard Demjanjuk dies (17 Mar 12)
- Stupid stunt causes bomb scare chaos (16 Mar 12)

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."

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2 June 2010 Last updated at 15:37

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World War II bomb kills three in Germany

Three people have been killed and six injured trying to defuse a World War II bomb in central Germany.

2nd June 2010

AFP

All the victims were involved in an operation to defuse the bomb

Workers building a sports stadium had earlier unearthed the bomb in the town of Goettingen.

It was not immediately clear why the bomb, reportedly weighing 500kg (1,100lb), had detonated.

Unexploded WWII bombs dropped by Allied planes are frequently found in Germany, though it is unusual for them to explode unexpectedly.

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.

June 2006

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Client: **Curtins**

Project: **The Strand, Liverpool**

Ref: **DA3469-00**

Source: Various news sources

Bermondsey bomb: World War Two device safely removed

24 March 2015 | London

An unexploded World War Two bomb found in south London has been driven away safety 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.

London Fire Brigade said that between 2009 and 2014 it was called to seven unexploded Second World War bombs and five unexploded hand grenades.

Unexploded World War Two 'shells' found in Liverpool

15 March 2016 | Liverpool

Seven shells have been found over 24 hours in the Pall Mall area

Seven suspected unexploded World War Two shells were discovered in the same area of Liverpool in the space of 24 hours.

Two were unearthed on Monday on a building site in the Pall Mall area, with a third found at about 08:15 GMT.

Four further devices were discovered just under three hours later after a police cordon had been removed.

All seven were initially thought to be bombs but are now believed to be "non-fused ammunition".

A team of Army bomb disposal experts removed the devices and a 200m safety cordon at the junction of Pall Mall and Leeds Road has been lifted.

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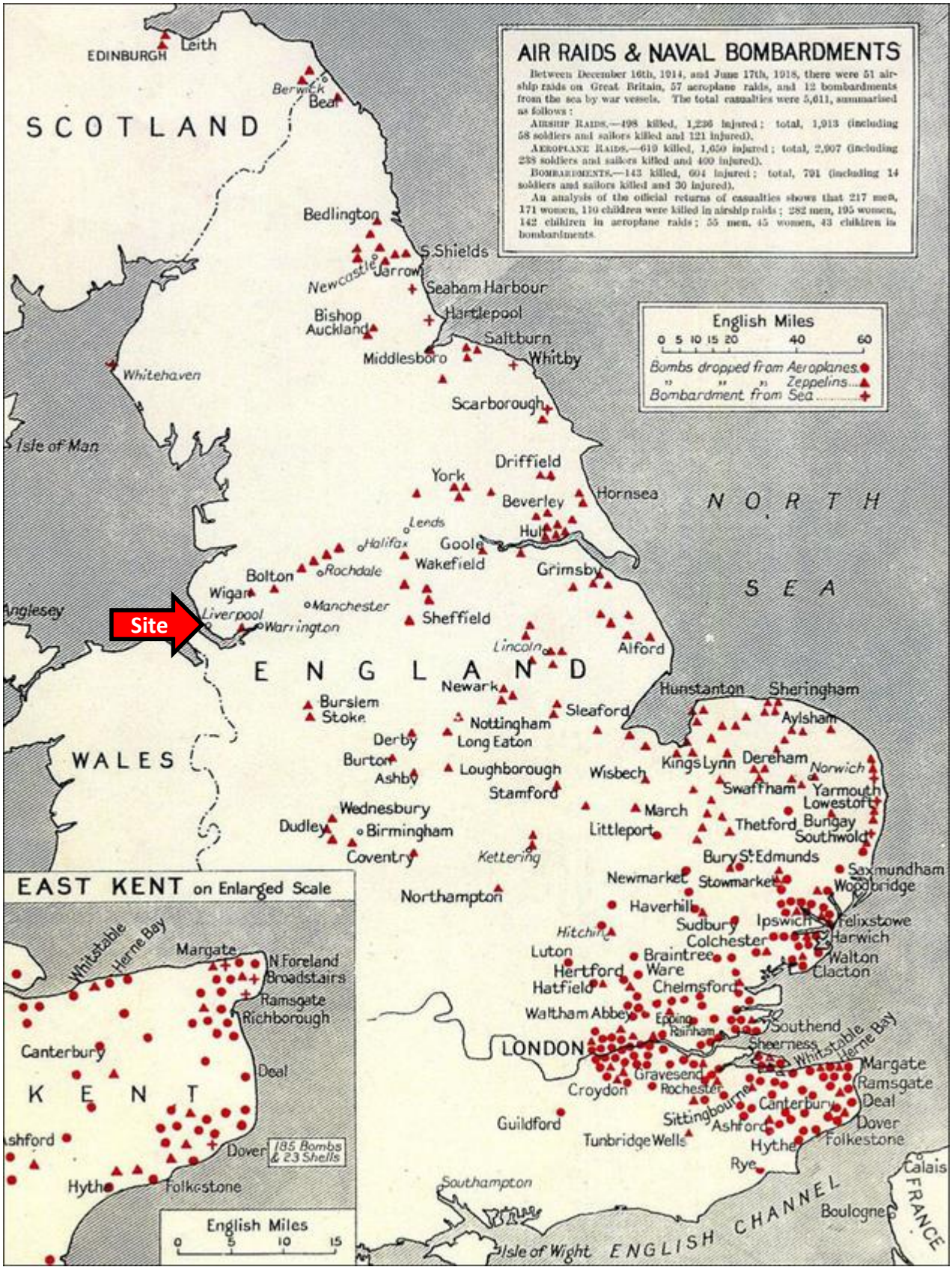
Project: **The Strand, Liverpool**

Ref: **DA3469-00** | Source: BBC News



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Project: **The Strand, Liverpool**

Ref: **DA3469-00**

Source: The National Archives, Kew

N

Liverpool Bomb Map

Annex: I1

Serious H.E. Damage

Serious Fire Damage

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Approximate site boundary

Project: **The Strand, Liverpool**

N

Ref: **DA3469-00**

Source: Liverpool Record Office

Liverpool Bomb Map

Annex: I2

Serious H.E. Damage

Serious Fire Damage

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Client: **Curtins**

Project: **The Strand, Liverpool**

Ref: **DA3469-00**

Source: Liverpool Record Office

N

Liverpool Bomb Layers

Annex: **J**

1/2 May 1941	**Bomb Abbreviation Key**
2/3 May 1941	P - Lights out message
3/4 May 1941	R - Alert
4/5 May 1941	W - Raiders passed
6/7 May 1941	HE - High Explosive bomb(s)
7/8 May 1941	IB - Incendiary bomb(s)
	PM - Parachute mine

http://www.liverpoolecho.co.uk/news/nostalgia/liverpool-blitz-1941-map-bombs-3364817

Red Pin - 2/3 May 1941 - Large fires and heavy damage on Strand Street and James Street. Blast damage to India Buildings, Cunard Buildings, Tunnel Building.

Green Pin - 3/4 May 1941 - Area bounded by Between Lord Street, Canning Place and Paradise Street devastated.

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Approximate site boundary

N

Project: **The Strand, Liverpool**

Ref: **DA3469-00**

Source: Liverpool Echo & Google Earth

Liverpool Bomb Damage Photography

Annex: **K**

Left Image: This image shows heavy damage on the corner of Strand Street and James Street which was bombed on 3 and 4 May 1941. In the centre of the picture an ARP warden can be seen inspecting a fire in a destroyed building while people look on.

Below Image: This image shows damage to a section of the Overhead Railway on Stand Street, near James Street in the city centre. The railway was severely damaged by a high explosive bomb on 3 May 1941 and would be hit twice again later in the month. The railway was extensively repaired and remained in operation until 1956.

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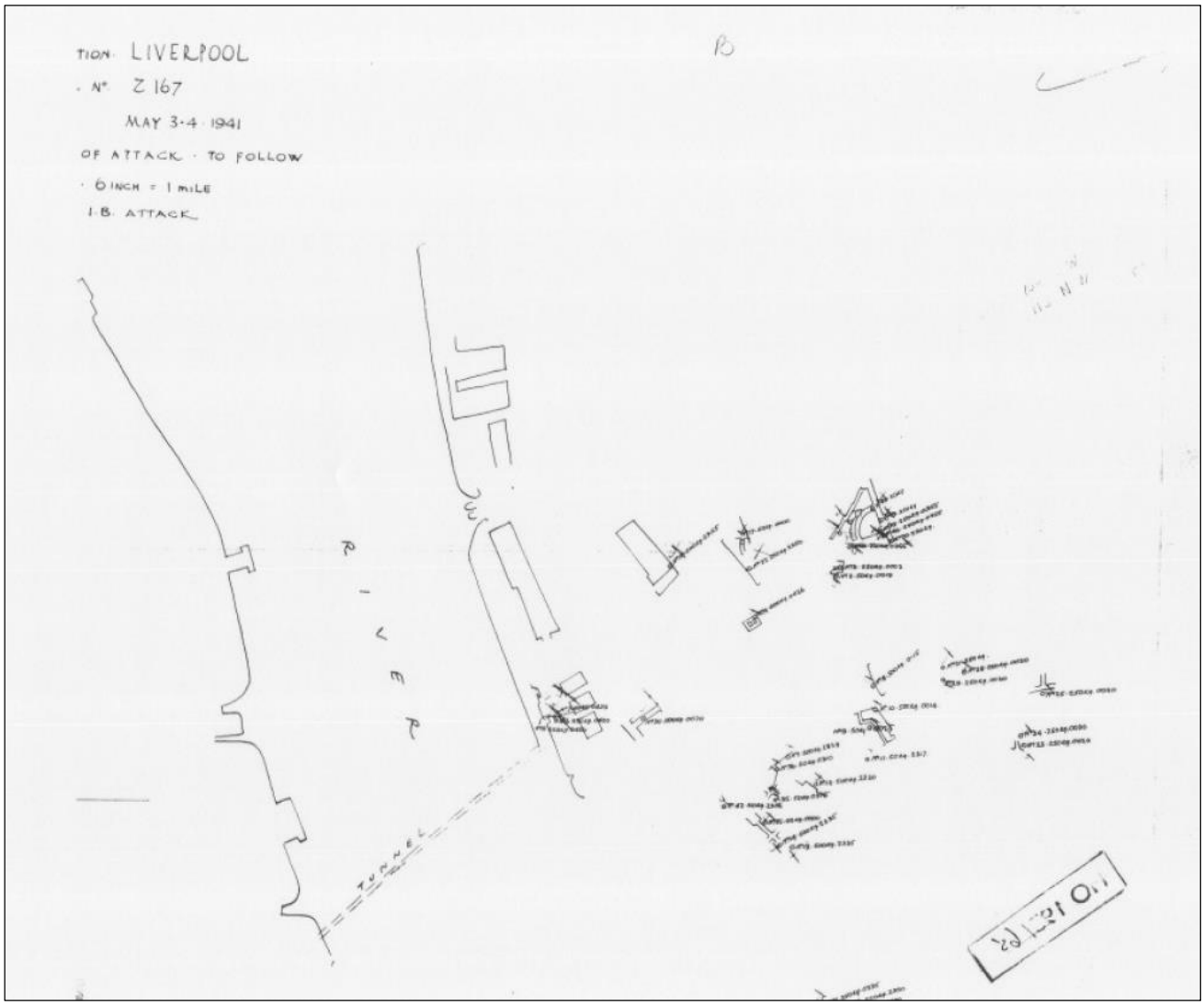
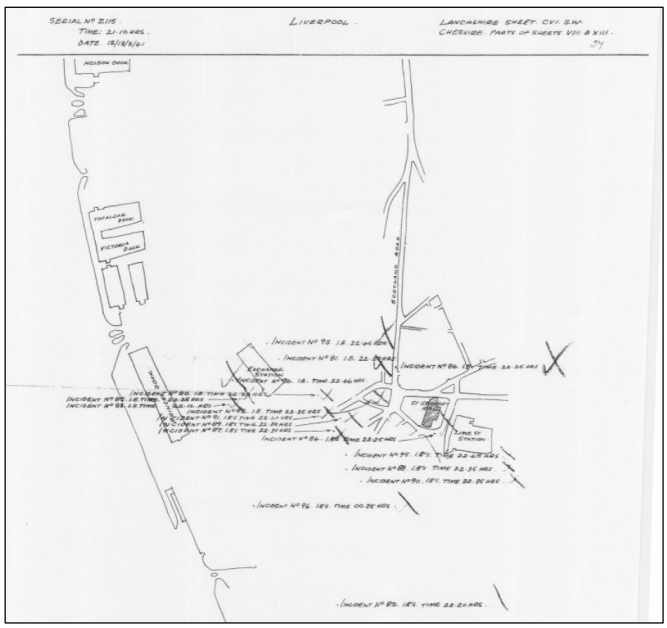
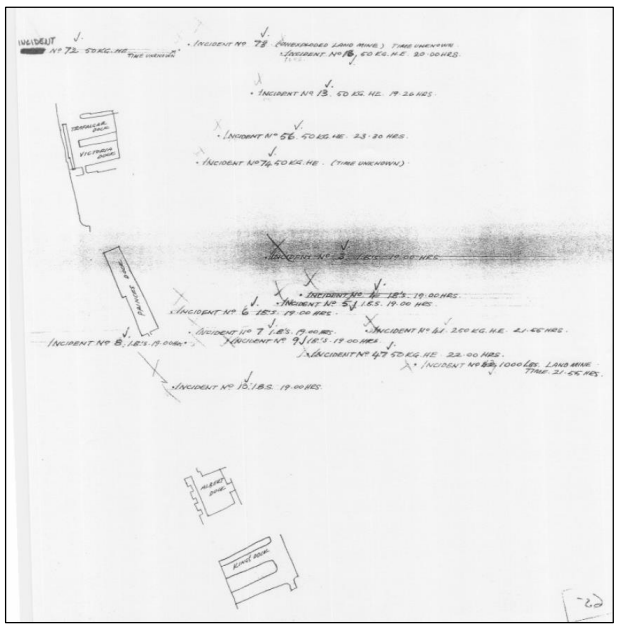
Project: **The Strand, Liverpool**

Ref: **DA3469-00**

Source: http://www.liverpoolmuseums.org.uk/mol/collections/social-history/blitz/







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Ref: **DA3469-00**

Source: The National Archives

N

RAF Aerial Photography, 11th June 1941

Annex: **M**

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Client: **Curtins**

Approximate site boundary

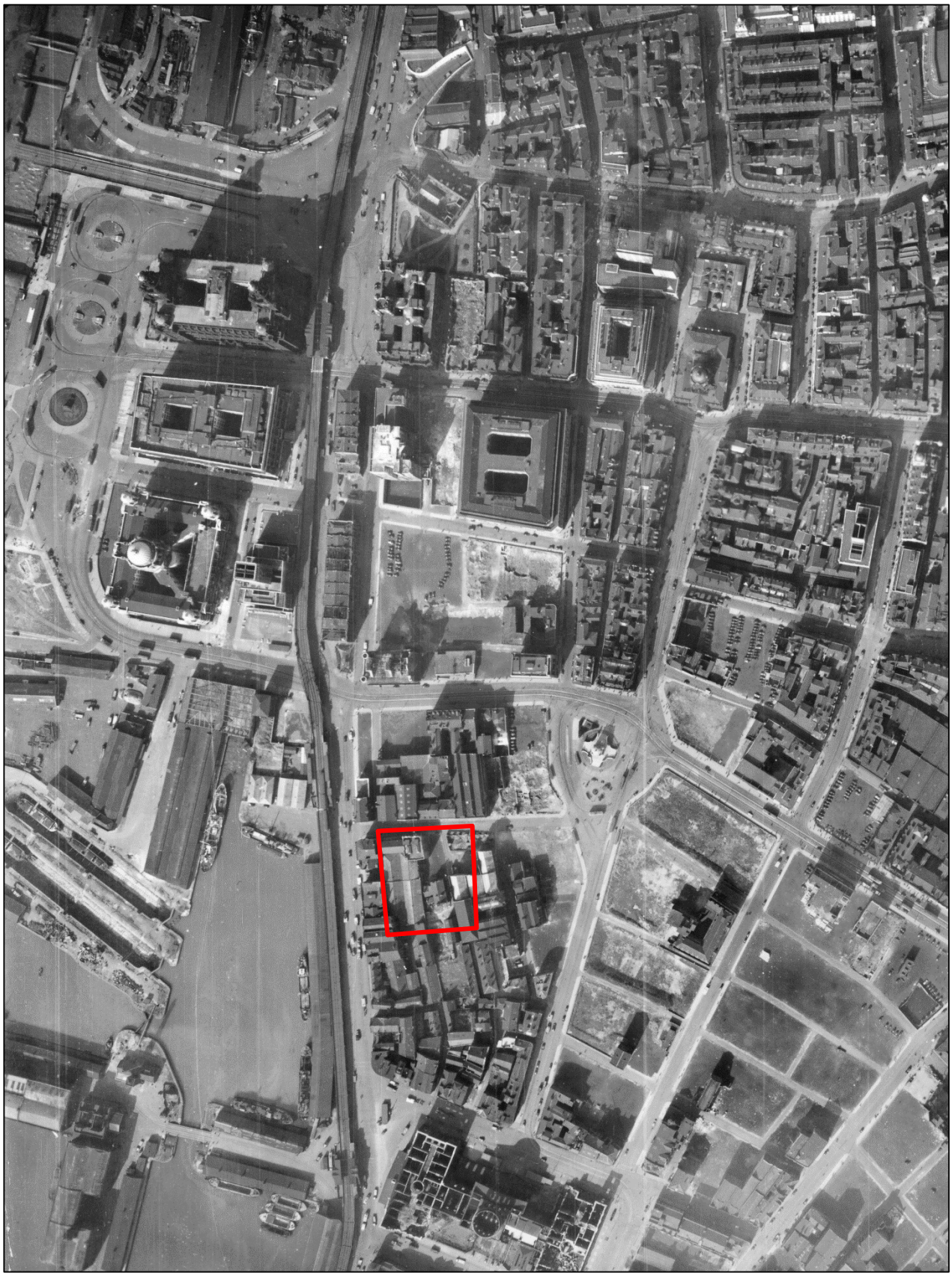
Project: **The Strand, Liverpool**

Ref: **DA3469-00**

Source: http://www.liverpoolblitz70.co.uk/tag/may-blitz/

RAF Aerial Photography 1st April 1946

Annex: **N1**



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Approximate site boundary

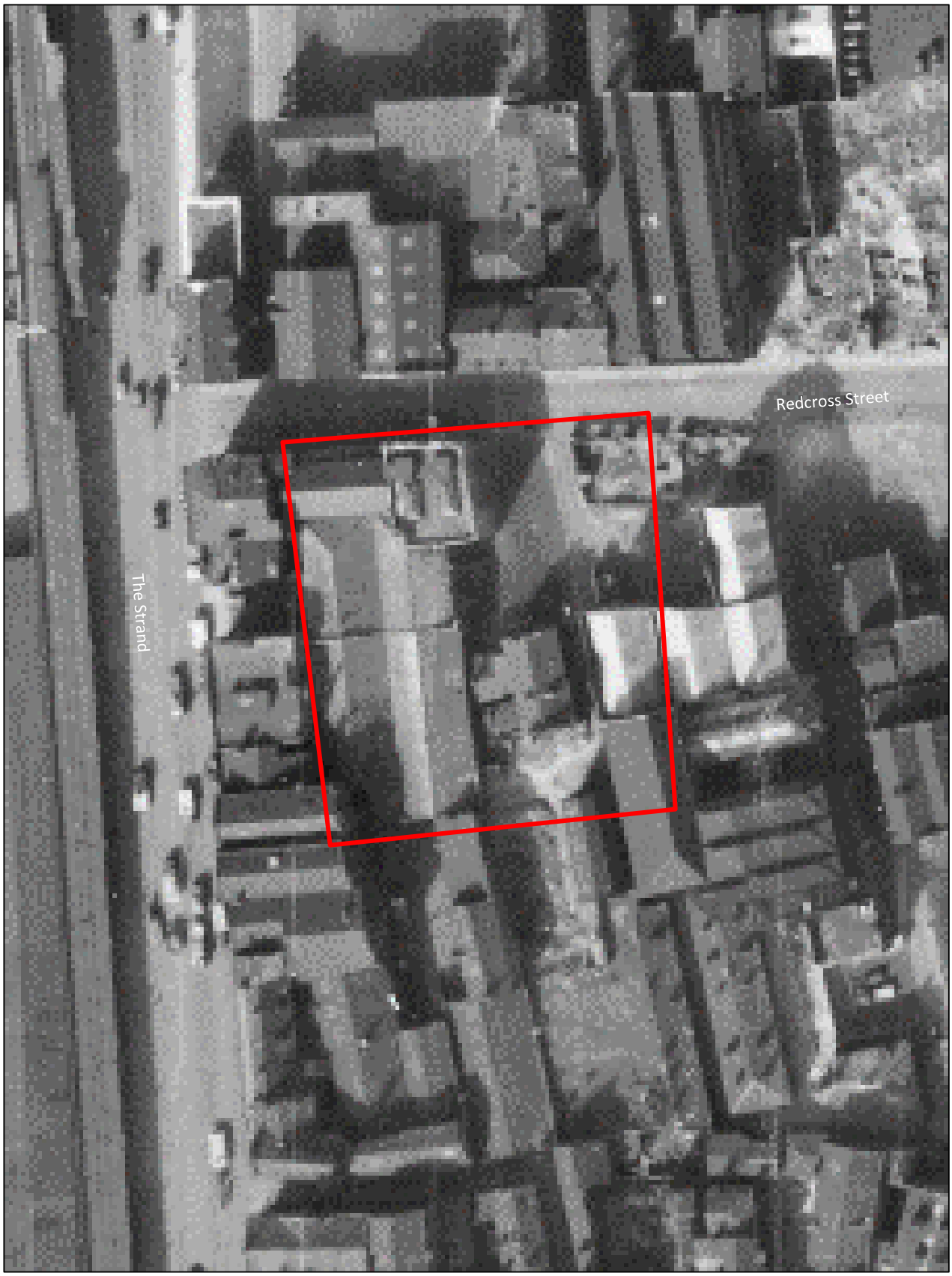
Project: **The Strand, Liverpool**

Ref: **DA3469-00**

Source: National Monuments Record Office (Historic England)

RAF Aerial Photography 1st April 1946

Annex: **N2**



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Approximate site boundary

Project: **The Strand, Liverpool**

Ref: **DA3469-00**

Source: National Monuments Record Office (Historic England)

RAF Aerial Photography 1st April 1946

Annex: **N3**

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Client: **Curtins**

Approximate site boundary

Project: **The Strand, Liverpool**

Ref: **DA3469-00**

Source: National Monuments Record Office (Historic England)

QF 3.7 Inch WWII 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	High Explosive Anti-Aircraft projectile. 4.5in projectiles were also used in this role.
Ceiling	30,000ft to 59,000ft

40mm Bofors Projectile

Projectile Weight	1.96lb (0.86kg)
Explosive Weight	300g (0.6lb)
Fuze Type	Proximity and Mechanical Time Fuze
Rate of Fire	120 rounds per minute
Projectile Dimensions	40mm x 310mm (1.6in x 12.2in)
Ceiling	23,000ft (7000m)

Unrotated Projectile (UP) – Z Battery

Projectile Weight	84lb (24.5kg)
Warhead Weight	4.28lb (1.94kg)
Warhead	Aerial Mine with a No. 700 / 720 fuze
Filling	High Explosive
Dimensions	1930mm x 82.6mm (76 x 3.25in)
Use	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.

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Ref: **DA3469-00**

Source: Various sources

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Appendix A3 – Qualitative Risk Assessment Rationale

The aim of the qualitative risk assessment (QRA) is to establish connecting links between a hazardous source to a potential receptor via an exposure pathway.

The QRA corresponds with the total site area.

Risk assessment is the process of collating known information on a hazard or set of hazards in order to estimate actual or potential risk to receptors. The receptor may be humans, a water resource, a sensitive local ecosystem or future construction materials. Receptors can be connected to the hazardous source by one or several exposure pathways such as direct contact for example. Risks are generally managed by isolating the receptor or intercepting the exposure pathway or by isolating or removing the hazard.

Without the three essential components of a source, pathway and receptor there can be no risk. Therefore the presence of hazard on a site does not necessarily mean there is a risk.

By considering where a viable pathway exists which connects a source with a receptor the risk assessment identifies where potential pollutant linkage (PPL) exists. If there is no pollutant linkage there is no risk and only where a pollutant linkage is established does the risk assessment consider the level of risk.

The risk assessment considers the likelihood of a particular event taking place (accounting for the presence of the hazard and receptor and the integrity of the exposure pathway) in conjunction with the severity of the potential consequence (accounting for the potential severity of the hazard and the sensitivity of the receptor).

In the risk assessment the consequence of the hazard has been classified as severe or medium or mild or minor and the probability (likelihood) of the circumstances actually occurring classified as high likelihood or likely or low likelihood or unlikely.

The consequences and probabilities are subsequently cross-correlated to give a qualitative estimation of the risk using Department of the Environment risk classifications as detailed in the table below and as referenced in CIRIA C552.

		Consequence			
		Severe	**Medium**	**Mild**	**Minor**
Probability (Likelihood)	**High Likelihood**	Very High Risk	High Risk	Moderate Risk	Negligible Risk
	Likely	High Risk	Moderate Risk	Moderate/Low Risk	Negligible Risk
	Low Likelihood	Moderate Risk	Moderate/Low Risk	Low Risk	Negligible Risk
	Unlikely	Moderate/Low Risk	Low Risk	Negligible Risk	Negligible Risk

In accordance with DoE guidance, the following categorisation of **consequence** has been developed.

Classification	Definition	Examples
Severe	Short-term (acute) risk to human health likely to result in "significant harm" as defined by the Environment Protection Act 1990, Part IIA. Short-term risk of pollution of sensitive water resource. Catastrophic damage to buildings/property. A short-term risk to a particular ecosystem or organisation forming part of such ecosystem.	High concentrations of cyanide on the surface of an informal recreation area. Major spillage of contaminants from site into controlled water. Explosion, causing building collapse (can also equate to a short-term human health risk if buildings are occupied).
Medium	Chronic damage to Human Health. Pollution of sensitive water resources. A significant change in a particular ecosystem or organism forming part of such ecosystem.	Concentration of a contaminant from site exceeds the generic or site-specific assessment criteria. Leaching of contaminants from a site to a Principal or Secondary A aquifer. Death of a species within a designated nature reserve. Lesser toxic and asphyxiate effects
Mild	Pollution of non-sensitive water resources. Significant damage to crops, buildings, structures and services. Damage to sensitive buildings/structures/services or the environment.	Pollution of non-classified groundwater (inc. Secondary B aquifers). Damage to building rendering it unsafe to occupy (e.g. foundation damage resulting in instability).
Minor	Harm, although not necessarily significant harm, which may result in a financial loss or expenditure to resolve. Non-permanent health effects to human health (easily prevented by means such as personal protective clothing, etc). Easily repairable effects of damage to buildings, structures and services.	The presence of contaminants at such concentrations that protective equipment is required during site works. The loss of plants in a landscaping scheme. Discoloration of concrete.

In accordance with DoE guidance, the following categorisation of **probability** has been developed.

Classification	Definition
High Likelihood	There is a pollution linkage and an event that either appears very likely in the short term and almost inevitable over the long term or there is evidence at the receptor of harm or pollution.
Likely	There is a pollution linkage and all the elements are present and in the right place, which means that it is probable that an event will occur. Circumstances are such that an event is not inevitable, but possible in the short term and likely over the long term.
Low Likelihood	There is a pollution linkage and circumstances are possible under which an event could occur. However, it is by no means certain that even over a longer period such event would take place, and is less likely in the shorter term.
Unlikely	There is a pollution linkage but circumstances are such that it is improbable that an event would occur even in the very long term.

In accordance with DoE guidance, the following categorisation of **risk** has been developed.

Classification	Definition
Very High Risk	There is a *high probability* that *severe harm* could arise to a designated receptor from an identified hazard at the site without appropriate further action.
High Risk	*Harm* is *likely to arise* to a designated receptor from an identified hazard at the site without appropriate further action.
Moderate Risk	*It is possible* that without appropriate further action *harm could arise* to a designated receptor. It is relatively *unlikely* that any such harm would be *severe*, and if any harm were to occur it is *more likely* that such harm would be *relatively mild.*
Low Risk	*It is possible* that *harm could arise* to a designated receptor from an identified hazard. It is *likely* that, at worst, if any harm was realised any effects would be *mild.*
Negligible Risk	The presence of an identified hazard does not give rise to the potential to cause harm to a designated receptor.

The term 'risk' in this instance refers to the risk that the source, pathway, receptor linkage for a given source of contamination is complete. It does not refer to immediate risk to individuals or features present on the site from potential contaminants and is intended to be used as a tool to assess the necessity of further investigation.

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