Appendix C

Dynasafe BACTEC Limited (February 2016), Explosive Ordnance Desktop Threat Assessment.

Explosive Ordnance Desktop Threat Assessment

Site: **Prince's Dock, Liverpool**

Client: **Moda Living**

Ref: **6426TA**

Date: **22nd February 2016**

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This Report has been produced in compliance with the Construction Industry Research and Information Association guidelines for the preparation of Detailed Risk Assessments in the management of UXO risks in the construction industry.

Glossary of Terms

AAA	Anti-Aircraft Artillery
ARP	Air-raid Precautions
BDO	Bomb Disposal Officer
EOD	Explosive Ordnance Disposal (current term for "bomb" disposal)
HE	High Explosive
HG	Home Guard
IB	Incendiary Bomb
kg	Kilogram
LCC	London County Council
LM	Land Mine
LSA	Land Service Ammunition (includes grenades, mortars, etc.)
Luftwaffe	German Air Force
m bgl	Metres Below Ground Level
MoD	Ministry of Defence
OB	Oil Bomb
PM	Parachute Mine
RAF	Royal Air Force
SI	Site Investigation
SAA	Small Arms Ammunition (small calibre cartridges used in rifles & machine guns)
UXB	Unexploded Bomb
UXO	Unexploded Ordnance
V-1	"Doodlebug" the first cruise type missile, used against London from June 1944. Also known as 'Flying Bomb'.
V-2	The first ballistic missile, used against London from September 1944
WWI	First World War (1914 -1918)
WWII	Second World War (1939 – 1945)

Executive Summary

The Site: The site, centred on the approximate OS Grid Reference: 333699, 390854, is located in Liverpool, approximately 600m north-west of Moorfields Railway Station. It is bound to the north by hard-standing, to the east by Bath Street, to the west by William Jessop Way and to the south by a hard surfaced car park.

The site is a rectangular parcel of land predominantly occupied by hard standing. A disused section of railway is present along the eastern site boundary, while a strip of vegetation is visible along the western boundary.

Proposed Works: It is understood that the construction of a high rise residential building is proposed. The associated intrusive works will include boreholes to a maximum depth of 25m bgl, and trial pits to 4.5m bgl.

Risk Assessment Methodology: In accordance with CIRIA guidelines this assessment has carried out research, analysed the evidence and considered the risks that the site has been contaminated with unexploded ordnance; that such items remained on site; that they could be encountered during any intrusive works and the consequences that could result. Appropriate risk mitigation measures have been proposed.

Explosive Ordnance Risk Assessment: BACTEC considers there to be a **Medium to High** risk from unexploded ordnance (UXO)on site. This is based on the following:

- Liverpool was the second most heavily bombed city in the UK during WWII with the docks representing the primary Luftwaffe target area. Consequently the site occupied an area of very high bombing density, as confirmed by official statistics and mapping.
- A comparison of the historical sources records an incendiary bomb strike either on or immediately adjacent to the site and Prince's Dock appears to have sustained bomb strikes during at least five separate air raids.
- During this conflict the site was occupied by a section of the dock basin, a dockside goods shed and adjacent open ground (likely hard-standing) crossed by railway lines.
- The site was situated immediately west of Bath Street during the war and it is known that large fires destroyed dockside warehousing on the west side of Bath Street. Therefore as the 1945 aerial photograph doesn't show any damage to this area, it is considered highly likely that these warehouses were destroyed during 1940-41 and re-built prior to 1945.
- Note that following the destruction of London's Dock systems, Liverpool's docks became even more vitally important to the war effort and therefore any damage sustained would have been prioritised for repair.
- Therefore it is quite possible that the study area sustained substantial fire damage. Following this, the site will have been abandoned for a time until the ruins could be cleared and as nearly all German air raids on Liverpool occurred at night, it is conceivable that a subsequent UXB could have fallen here unnoticed and become immediately obscured from view within the wreckage. Note that the entry hole of an SC50 UXB (the most commonly deployed German HE bomb) could have been as little as 20cm in diameter.
- In addition, such a scenario could have resulted in the weapon coming to rest beneath the adjacent quayside / railway lines due to the J-Curve Effect.
- Furthermore, had a UXB fallen within the dock basin occupying the western third of the site, it will have been immediately obscured from view beneath the water line and subsequently could have become buried under debris / sediment in the post-war period.

No evidence has been located to suggest that the site formerly had any military occupation or usage that could have led to contamination with British / Allied items of UXO.

The risk from deep buried German HE UXBs will have only been mitigated at the specific locations of any post-war pile foundations and within the volume of any basement level bulk excavations. As such works do not appear to have been carried out on site post-war, this risk remains unmitigated down to the maximum bomb penetration depth.

Furthermore, the partial in-filling of the dock basin post-war could conceivably have resulted in the burial of both smaller and larger items of UXO within the western portion of the site.

Bomb Penetration Assessment: It has been assessed that a 500kg bomb would have had a maximum bomb penetration depth of between **6-8m** below WWII ground level, or shortly after impact with the Mudstone layer, whichever is sooner. Penetration depth could potentially have been greater if the UXB was larger (though only 4% of German bombs used in WWII over Britain were of that size). Note that UXBs may be found at any depth between just below the WWII ground level and the maximum penetration depth. This assessment has been made using generic geological information.

Risk Mitigation Measures: BACTEC believes the following risk mitigation measures should be deployed to support the proposed works at the Prince's Dock site:

- Explosive Ordnance Safety and Awareness Briefings to all personnel conducting intrusive works.
- The Provision of Unexploded Ordnance Site Safety Instructions.

- Explosive Ordnance Disposal (EOD) Engineer presence on site to support shallow intrusive works (where the above is considered inappropriate).
- Intrusive Magnetometer Survey of all borehole / pile locations down to the maximum bomb penetration depth.

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Explosive Ordnance Threat Assessment

In Respect of

Prince's Dock, Liverpool

1. Introduction

1.1. Background

Moda Living has commissioned Dynasafe BACTEC Limited to conduct an Explosive Ordnance Threat Assessment for the proposed redevelopment works at the Prince's Dock site, Liverpool.

Unexploded Ordnance (UXO) presents a significant threat to construction projects in parts of the UK as a result of enemy actions during the two 20th Century World Wars and historic British and Allied military activity.

One of the legacies of these conflicts is buried unexploded air-dropped bombs or anti-aircraft projectiles resulting from the failure of a proportion of the weapons to function as designed. It is commonly accepted that the failure rate of these munitions was approximately 10% and, depending on their shape, weight, velocity and ground conditions many penetrated the ground and came to rest at depth.

Intensive efforts were made during and after the war to locate and render safe all UXO but, unsurprisingly, not all were found and dealt with. This is evidenced by the regular, on-going discoveries of unexploded ordnance during construction-related intrusive ground works.

In addition, it is estimated that over 20% of the UK landmass has been used for military training at some point and between 2006 and 2009, over 15,000 items of ordnance (excluding small arms ammunition) were found on UK construction sites (CIRIA).

As a result of a generally increased risk awareness amongst professionals involved in ground engineering works and proactive health and safety measures, the threat to life and limb from unexploded ordnance has been minimised. However even the simple discovery of a suspected device during on-going works can cause considerable disruption to production and cause unwanted delays and expense.

Such risks can be more fully controlled by a better understanding of the site-specific threat and the implementation of appropriate risk mitigation measures.

2. Construction Industry Duties and Responsibilities

2.1. The UK Regulatory Environment

There is no specific legislation covering the management and control of the UXO risk in the UK construction industry but issues regarding health and safety are addressed under a number of regulatory instruments, as outlined below.
In practice the regulations impose a responsibility on the construction industry to ensure that they discharge their obligations to protect those engaged in ground-intrusive operations (such as archaeology, site investigation, drilling, piling or excavations) from any reasonably foreseeable UXO risk.

2.2. The Health and Safety at Work Act, 1974

The Act places a duty of care on an employer to put in place safe systems of work to address, as far as is reasonably practicable, all risks (to employees and the general public) that are reasonably foreseeable.

2.3. Construction (Design and Management) 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.

Although UXO issues are not specifically addressed the regulations effectively place obligations on all these parties to:

- Ensure that any potential UXO risk is properly assessed
- Put in place appropriate risk mitigation measures if necessary
- Keep all parties affected by the risk fully informed
- Prepare a suitably robust emergency response plan

2.4. Other Legislation

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

3. The Role of the Authorities and Commercial Contractors

3.1. The Authorities

The Police have the responsibilities for co-ordinating the emergency services in the case of an ordnance-related incident on a construction site. They will make an initial assessment (i.e. is there a risk that the find is ordnance or not?) and if they judge necessary impose a safety cordon and/or evacuation and call the military authorities (JSEODOC - Joint Services Explosive Ordnance Disposal Operations centre) to arrange for investigation and/or disposal. In the absence of an EOD specialist on site many Police Officers will use the precautionary principle, impose cordon(s)/evacuation and await advice from the JSEODOC.

The priority given to the request by JSEODOC will depend on their judgement of the nature of the threat (ordnance, location, people and assets at risk) and the availability of resources. They may respond immediately or as resources are freed up. Depending on the on-site risk assessment the item of ordnance may be removed or demolished (by controlled explosion) in-situ. In the latter case additional cordons and/or evacuations may be necessary.

Note that the military authorities will only carry out further investigations or clearances in very high profile or high risk situations. If there are regular ordnance finds on a site the JSEODOC may not treat each occurrence as an emergency and will encourage the construction company to put in place alternative procedures (i.e. the appointment of a commercial contractor) to manage the situation and relieve pressure from the JSEODOC disposal teams.

3.2. Commercial Contractors

In addition to pre-construction site surveys and clearances a commercial contractor is able to provide a reactive service on construction sites. The presence of a qualified EOD Engineer with ordnance recognition skills will avoid unnecessary call-outs to the authorities and the Contractor will be able to arrange for the removal and disposal of low risk ordnance. 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.

4. This Report

4.1. Aims and Objectives

The aim of this report is to examine the possibility of encountering any explosive ordnance during any intrusive works at the Prince's Dock site. Risk mitigation measures will be recommended, if deemed necessary, to reduce the threat from explosive ordnance during the envisaged works. The report follows the CIRIA Guidelines.

4.2. Risk Assessment Methodology

The following issues will be addressed in the report:

- The risk that the site was contaminated with unexploded ordnance.
- The risk that unexploded ordnance remains on site.
- The risk that ordnance may be encountered during any intrusive works.
- The risk that ordnance may be initiated.
- The consequences of initiating or encountering ordnance.

Risk mitigation measures, appropriate to the assessed level of risk and site conditions, will be recommended if required.

4.3. Approach

In preparing this Explosive Ordnance Threat Assessment Report, BACTEC has considered general and, as far as possible, site specific factors including:

- Evidence of German bombing and delivery of UXBs.
- Site history, occupancy and conditions during WWII.
- The legacy of Allied military activity.
- Details of any known EOD clearance activity.
- The extent of any post war redevelopment.
- Scope of the current proposed works.

4.4. Sources of Information

Dynasafe BACTEC has carried out detailed historical research for this Explosive Ordnance Threat Assessment including accessing military records and archived material held in the public domain and in the MoD.

Material from the following sources has been consulted:

- The National Archives.
- Liverpool Record Office.
- Historic England.
- Landmark Maps.
- Relevant information supplied by Moda Living.
- Available material from 33 Engineer Regiment (EOD) Archive.
- Dynasafe BACTEC's extensive archives built up over many years of research and hands-on Explosive Ordnance Disposal activities in the UK.
- Open sources such as published books, local historical records and the internet.

4.5. Reliability of Historical Records

4.5.1. General Considerations

This report is based upon research of historical evidence. Whilst every effort has been made to locate all relevant material Dynasafe BACTEC cannot be held responsible for any changes to the assessed level of risk or risk mitigation measures based on documentation or other information that may come to light at a later date.

The accuracy and comprehensiveness of wartime records is frequently difficult or impossible to verify. As a result conclusions as to the exact location, quantity and nature of the ordnance threat can never be definitive but must be based on the accumulation and careful analysis of

all accessible evidence. Dynasafe BACTEC cannot be held responsible for inaccuracies or gaps in the available historical information.

4.5.2. Bombing Records

During WWII considerable efforts were expended in recording enemy air raids. Air Raid Precautions (ARP) wardens were responsible for making records of bomb strikes either through direct observation or by post-raid surveys. However their immediate priority was to deal with casualties and limit damage, so it is to be expected that records are often incomplete and sometimes contradictory. Record keeping in the early days of bombing was not comprehensive and details of bombing in the early part of the war were sometimes destroyed in subsequent attacks. Some reports may cover a single attack, others a period of months or the entire war.

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; records of attacks on military or strategic targets were often maintained separately from the general records and have not always survived.

5. The Site

5.1. Site Location

The site is located in Liverpool, approximately 600m north-west of Moorfields Railway Station. It is bound to the north by hard-standing, to the east by Bath Street, to the west by William Jessop Way and to the south by a hard surfaced car park.

The site is centred on the approximate OS Grid Reference: 333699, 390854.

Site Location Maps are presented in ***Annex A***.

5.2. Site Description

The site is a rectangular parcel of land predominantly occupied by hard standing. A disused section of railway is present along the eastern site boundary, while a strip of vegetation is visible along the western boundary.

A Recent Aerial Photograph of the site is presented in ***Annex B***.

6. Scope of Proposed Works

It is understood that the construction of a high rise residential building is proposed. The associated intrusive works will include boreholes to a maximum depth of 25m bgl, and trial pits to 4.5m bgl.

A Current Site Plan is presented in ***Annex C***.

7. Ground Conditions

Published BGS data for a borehole sunk approximately 80m to the east of the site records the following geological sequence:

- 3.5m of Made Ground (soft fine to coarse sand).
- 7.9m of Made Ground (coarse gravel).
- >0.1m of Made Ground (Grey concrete).

8. Site History

8.1. General

Latest available Pre and earliest available Post-WWII OS maps were obtained from Landmark Maps. These are presented in ***Annex D*** and described below**.**

8.2. Pre-WWII

The 1927 (1:2,500 scale) map shows the central section of the site to be occupied by a large warehouse, while the western portion of the site is shown to extend into the *Princes Dock* basin. The eastern third of the site is exclusively occupied by several parallel railway tracks.

The immediate surrounding area is predominantly commercial / light industrial in nature, being dominated by dock infrastructure.

8.3. Post-WWII

The 1954 (1:2,500 scale) map records some changes within the site boundary. Part of the eastern railway lines have been moved to an Overhead Railway track while the quayside has been extended into the basin, providing for a wider warehouse on site.

Evidence of clearance is apparent approximately 90m east of the site. Note that such observations are usually indicative of serious bomb damage on early post-WWII Liverpool OS maps.

Across the wider area further evidence of serious bomb damage, including clearance, redevelopment and have been highlighted.

9. The Threat from Aerial Bombing

9.1. General Bombing History of Merseyside

9.1.1. First World War

The UK suffered aerial bombardment during WWI, beginning with indiscriminate night raids by Zeppelin airships. However as British defensive measures became more effective and aircraft development progressed, the German military switched to daylight raids by fixed-wing aircraft in June 1917.

Historical sources indicate that Liverpool was targeted by Zeppelins during WWI, however the city escaped bombing due to navigational errors. Therefore the threat from WWI UXBs is considered negligible and will not be further addressed in this report.

9.1.2. Second World War

At the start of WWII, the Luftwaffe planned to destroy key military installations, including RAF airfields and Royal Navy bases, during a series of daylight bombing raids, mainly in the south, south-east and east of England. However some small scale raids occurred in Merseyside also.

After the Battle of Britain these tactics were modified to include both economic and industrial sites across the entire country. Targets included dock facilities, railway infrastructure, power stations, weapon manufacturing plants and gas works. As a result of aircraft losses, daylight raids were reduced in favour of attacking targets under the cover of darkness.

As the war progressed the strategy changed to one of attempting to destroy the morale of the civilian population by the "carpet bombing" of major UK cities including Liverpool. By May 1941, concentrated attacks ceased as the Luftwaffe was diverted east to prepare for 'Operation Barbarossa', the invasion of the Soviet Union.

9.2. Aerial Delivered Ordnance in the Second World War

9.2.1. Generic Types of WWII German Air-delivered Ordnance

The nature and characteristics of the ordnance used by the Luftwaffe allows an informed assessment of the hazards posed by any unexploded items that may remain today. Detailed illustrations of German air delivered ordnance are presented at ***Annex E***.

- HE Bombs: In terms of weight of ordnance dropped, HE bombs were the most frequent weapon deployed. Most bombs were 50kg, 250kg or 500kg (overall weight, about half of which was the high explosive) though large bombs of up to 2000kg were also used. HE bombs had the weight, velocity and shape to easily penetrate the ground intact if they failed to explode. Post-raid surveys would not always have spotted the entry hole or other indications that a bomb penetrated the ground and failed to explode and contemporary ARP documents describe the danger of assuming that damage, actually caused by a large UXB, was due to an exploded 50kg bomb. Unexploded HE bombs therefore present the greatest risk to present–day intrusive works.
- Blast Bombs/ Parachute Mines: Blast bombs generally had a slow rate of descent and were extremely unlikely to have penetrated the ground. Non-retarded mines would have shattered on most ground types, if they had failed to explode. There have been extreme cases when these items have been found unexploded, but this was where the ground was either very soft or where standing water had reduced the impact. BACTEC does not consider there to be a significant threat from this type of munition on land.
- Large incendiary bombs: This type of bomb ranged in size from 36kg to 255kg and had a number of inflammable fill materials (including oil and white phosphorus), and a small explosive charge. They were designed to explode and burn close to the surface but their shape and weight meant that they did have penetration capability. If they penetrated the ground complete combustion did not always occur and in such cases they remain a risk to intrusive works.
- 1 kg Incendiary Bombs (IB): These bombs, which were jettisoned from air-dropped containers, were unlikely to penetrate the ground and in urban areas would usually have been located in post-raid surveys. However, if bombs did not initiate and fell in water or dense vegetation, or became mixed with rubble in bomb damaged areas they could have been overlooked. Some variants had explosive heads and these present a risk of detonation during intrusive works.
- Anti-personnel (AP) Bomblets: 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.
- Specialist Bombs (smoke, flare, etc): These types do not contain high explosive and therefore a detonation consequence is unlikely. They were not designed to penetrate the ground.

9.2.2. German Air-delivered Ordnance Failure Rate

It has been estimated that 10% of the German HE bombs dropped during WWII failed to explode as designed. This estimate is probably 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, and is probably an underestimate.

The reasons for failures include:

- Fuze or gaine malfunction due to manufacturing fault, sabotage (by forced labour) or faulty installation.
- Clockwork mechanism failure in delayed action bombs.
- Failure of the bomber aircraft to arm the bombs (charge the electrical condensers which supplied the energy to initiate the detonation sequence) 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), 7000 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 (see recent press articles, ***Annex F-1***).

9.2.3. UXB Ground Penetration

9.2.3.1. General Considerations

The actual penetration depth of aerial delivered bombs into the ground will have been determined by the mass and shape of the bomb, the velocity and angle of the bomb on impact (dependent on the height of release) and the nature of the ground and ground cover; the softer the ground, the greater the potential penetration. Peat, alluvium and soft clays are easier to penetrate than gravel and sand. Bombs are brought to rest or are commonly deflected by bedrock or large boulders.

9.2.3.2. The "j" Curve Effect

An air-dropped bomb falling from normal bombing altitude (say 5000m) into homogeneous ground will continue its line of flight but turn in an upwards curve towards the surface as it comes to rest. This offset from vertical is generally thought to be about one third of the penetration depth, but can be up to 15m depending on ground conditions or the bomb's angle of impact.

9.2.3.3. Second World War Bomb 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 1328 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.

The median penetration of 430 x 50kg German bombs in London Clay was 4.6m and the maximum penetration observed for the SC50 bomb was 9m.

They concluded that the largest common German bomb, 500kg, had a likely penetration depth of 6m in sand or gravel but 8.7m in clay. The maximum observed depth for a 500kg bomb was 10.2m and for a 1000kg bomb 12.7m. Theoretical calculations suggested that significantly greater penetration depths were probable.

9.2.4. Initiation of Unexploded Bombs

Unexploded bombs do 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:

- Direct impact onto the main body of the bomb: 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) to initiate a buried iron bomb. Such violent action can cause the bomb to detonate.
- Re-starting the clock timer in the fuze: Only a small proportion of German WWII bombs employed clockwork fuzes. It is probable that significant corrosion has taken place within the fuze mechanism over the last 70 years that would prevent clockwork mechanisms from functioning, nevertheless it was reported that the fuze in a UXB dealt with by 33 EOD Regiment in Surrey in 2002 did re-commence.
- Induction of a static charge, causing a current in an electric fuze: The majority of German WWII bombs employed electric fuzes. It is probable that significant corrosion has taken

place within the fuze mechanism over the last 60 years such that the fuze circuit could not be activated.

- Friction impact initiating the (shock-sensitive) fuze explosive: This is the most likely scenario resulting in the bomb detonating.

Annex F-2 details UXB incidents where intrusive works have caused UXBs to detonate, resulting in death or injury and damage to plant.

9.3. Second World War Bombing of Liverpool

During WWII Liverpool was home to the most important port outside London; a total of 74,000 aircraft and 4.7 million troops passed through the city. By early 1941 it represented a major naval base and headquarters for Britain's North Atlantic Campaign. Once London's port facilities were immobilised, following an intense bombing campaign, Liverpool became even more important to the British war effort. Furthermore, 100 warships were built at the Cammell Laird shipyards.

Consequently the docks and the city experienced repeated bombing by the Luftwaffe and by the end of the war, Liverpool was the second most heavily bombed city in Britain, behind London.

A Luftwaffe Target Map (presented in ***Annex G***) shows that Prince's Dock and associated infrastructure, within which the site was located, was earmarked for attack.

German bombing over Liverpool was sporadic in the autumn of 1940, however the raids grew in intensity towards the end of the year. By 23rd October 1940 Liverpool had suffered 200 air raids, increasing to 300 by 12th December.

The most intense periods of bombing were the 'Christmas Raids' of December 1940 and the week-long 'May Blitz' of 1941. The former was a three consecutive night attack (20th – 22nd December) which resulted in the deaths of 365. The bombing decreased in severity after the New Year.

The May 1941 Blitz was a seven-night bombardment that devastated the city. 500 roads were closed and one third of the houses in Liverpool damaged or destroyed. It involved 681 Luftwaffe bombers dropping 2,315 HE bombs and other devices such as numerous 1kg incendiaries. The raids put 69 out of 144 cargo berths out of action and inflicted 2,895 casualties. The final raid over the city occurred on the 10th January 1942.

The heaviest raid took place during the night of the 3rd May 1941 which coincidently saw the largest explosion on Merseyside during the war when the ammunition ship *SS Malakand* in Huskisson Dock No.2 exploded. The vessel contained 1,000 tonnes of bombs/shells and the resulting explosion destroyed several acres of the surrounding docks.

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, although some other organisations, such as the docks, maintained separate records. However it is understood that the vast majority of these original records for Liverpool were destroyed as a result of enemy action during WWII.

9.3.1. Second World War Bombing Statistics

The following table summarises the quantity of German bombs (excluding 1kg incendiaries) 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
High Explosive Bombs (all types)	2,332
Parachute Mines	117
Oil Bombs	50
Phosphorus Bombs	0
Fire Pot	0
Total	2,499
Items Per 1,000 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. However it is estimated that during the seven consecutive nights Blitz in May 1941, approximately 112,000 1kg incendiaries were dropped over the city.

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.

9.3.2. Liverpool Bomb Damage Plot Map

A bomb damage map for Liverpool was obtained from Liverpool Record Office and is presented in ***Annex H***. This map records fire damage, high explosive (blast) damage and damage resulting from parachute (land) mine strikes.

Although of small scale, the map records no damage in the area immediately surrounding the site, although *serious HE Bomb Damage* is recorded to the south-east of the site.

Note, this map does not appear to record bomb damage to many of the Liverpool docks which are known to have been heavily bombed and therefore the accuracy of this source should not be relied upon.

9.3.3. Liverpool May Blitz Bomb Damage Plot Map

A bomb damage plot map for the 'May Blitz' of Liverpool was obtained from the Liverpool Echo and is presented in ***Annex I***. This map plots two damage reports within the Prince's Dock area, both dated the night of 3rd / 4th May 1941.

- Large fires cause damage at Princes Dock.
- Large fires alongside the dock on the west side of Bath Street.

9.3.4. Liverpool Docks Bomb Plot Map - 1940

A report entitled *Bomb Census Maps* for *Liverpool Docks* was obtained from Liverpool Record Office. These maps are compiled from records held at the National Archives and Battle Honours Ltd during November 2005. Images of this report showing the site are presented in ***Annex J***.

The first map shows a number of incendiary bomb incidents recorded in the area surrounding Prince's Dock during the raid of 20th / 21st December 1940.

The second map shows an incendiary bomb strike either on site or immediate adjacent during the raid of 21st / 22nd December 1940.

9.3.5. Written and Anecdotal Evidence

A collection of local ARP records covering incidents between 1940 and 1942 was obtained from Liverpool Record Office. The incidents below were identified in close proximity to the study area; approximate distances from the closest site boundary have been given. Note however this should not be considered a comprehensive record of all bombing in the area, as records may be missing or incomplete.

Date	Weapon	Location	Remarks
25/06/1940	HE Bombs	Princes Dock	Locomotive Shed destroyed
22/12/1940	HE Bombs	Princes Dock	Large scale raid
13/05/1941	Machine Gun	Princes Dock	Machine gunning recorded across the Princes Dock
03/05/1941	IB shower	Princes Dock	Large Fires recorded at Princes Dock, causing substantial damage to the warehouses, possibly on site.
25/06/1941	HE Bombs	Princes Dock	Severe damage from HE bombs recorded across the Princes Dock

9.3.6. World War II-era Aerial Photography

WWII-era aerial photography of the site was obtained from Historic England and Britain From Above. Mid and post-WWII images are presented in ***Annex K*** and described below.

9.3.6.1. August 1945

This image was taken approximately three years after the cessation of German bombing in Liverpool. A detailed assessment of any possible structural damage within the study area is impossible due to the low resolution of the photograph, however no destroyed / cleared warehousing is visible within Prince's Docks.

Note, the damage to Prince's Docks is highly likely to have been repaired prior to this photograph being taken, due to the importance of Liverpool's docks, handling all Britain's supply convoys from America throughout WWII.

9.3.6.2. May 1952

This photograph was taken approximately seven years after the cessation of the war and is of higher resolution.

It confirms that the site was occupied exclusively by a railway and associated buildings.

The area of clearance north-east of the site is still visible, although no further evidence of bomb damage is visible in this image.

9.3.7. Abandoned Bombs

A post-air raid survey of buildings, facilities and installations would have included a search for evidence of bomb entry holes. If evidence 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, nor 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.

Dynasafe BACTEC holds no records of officially registered abandoned bombs at or near the site of any intrusive works.

9.3.8. Site Specific Bomb Penetration Considerations

When considering an assessment of the bomb penetration at the Prince's Dock site the following parameters would be used:

- Geology – 3.5m of Made Ground (soft fine to coarse sand), 7.9m of Made Ground (coarse gravel), 0.1m of Made Ground (concrete).
- Impact Angle and Velocity – 80-90^{O} from horizontal and 267 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.

Taking into account the above-mentioned factors it has been assessed that a 500kg bomb would have had a maximum bomb penetration depth of between **6-8m** below WWII quayside ground level. Penetration depth could potentially have been greater if the UXB was larger (though only 4% of German bombs used in WWII over Britain were of that size). Note that UXBs may be found at any depth between just below the WWII ground level and the maximum penetration depth.

Note, a German UXB landing in the dock basin on site will have experienced rapid deceleration through the water column and therefore will not have had any significant penetration potential into the basin floor.

9.4. Likelihood of Post-raid UXO Detection

Utilising the above information, it is possible to make an assessment of the likelihood that evidence of unexploded ordnance would have been noted on a site during the war and the incident dealt with or recorded at the time. Factors such as bombing density, frequency of access, ground cover, damage and failure rate have been taken into consideration.

9.4.1. Density of Bombing

Bombing density is an important consideration for assessing the possibility that UXBs remain in an area. A very high density of bombs can for example result in increased levels of damage sustained to structures, greater likelihood of errors in record keeping and a higher risk that UXBs fell over the area.

Central Liverpool experienced a high bombing density during WWII, as confirmed by official statistics. A comparison of the historical sources records an incendiary bomb strike either on or immediately adjacent to the site and Prince's Dock appears to have sustained bomb strikes on at least five separate occasions.

9.4.2. Damage

If structures on a site have been subject to significant bomb or fire damage, rubble and debris are likely to have been present; similarly a HE bomb strike on open ground is likely to have resulted in a degree of soil disturbance. Under such conditions there is a greater risk of the entry holes of unexploded bombs dropped during subsequent raids being obscured and going unnoticed. Note that the entry hole of a SC50 UXB (the most commonly deployed German HE bomb) could have been as little as 20cm in diameter.

Following the destruction of London's Docks, Liverpool's docks became even more vitally important to the war effort and therefore the damage sustained would have been prioritised for repair.

This is substantiated by the lack of observable bomb damage to any of the Prince's Dock warehouses surrounding the dock basin on the 1945 photograph, even though it is known that a good deal of these large sheds were gutted by fire during May 1941. Therefore it is quite possible that the study area sustained substantial damage and the building occupying the

western half of the site on the 1945 photograph was in fact constructed after the Liverpool Blitz but before August 1945.

Consequently a quantity of rubble could have existed on site for a time and debris may have been strewn across the eastern section of the site also. Had a subsequent unobserved UXB then landed here, it could have gone unrecorded and remained undetected. Note that the entry hole of an SC50 UXB (the most commonly deployed German HE bomb) could have been as little as 20cm in diameter.

In addition, such a scenario could have resulted in the weapon coming to rest beneath adjacent undamaged quayside / railway lines due to the J-Curve Effect.

9.4.3. Frequency of Access

Unexploded ordnance at sites where human access was infrequent would have a higher chance of being overlooked than at those sites which were subject to greater occupancy. The importance of a site or facility to the war effort is also an important consideration as such sites are likely to have been both frequently accessed and are also likely to have been subject to post-raid checks for evidence of UXO.

As a developed site within in a busy docks complex, the study area would have been frequently / regularly accessed and may have been subject to routine post-raid checks for damage and signs of UXO.

However, following the likely bomb damage on site, the ruins will have been abandoned for a time and as the vast majority of German air raids on Liverpool occurred at night, it is conceivable that a subsequent UXB could have fallen here unnoticed.

9.4.4. Ground Cover

The degree and type of groundcover present during WWII would have had a significant effect on the visual evidence at ground level which may have indicated the presence of buried UXO.

A UXB strike to the hard-standing / railway tracks on site will have caused obvious damage, even without detonating, which would have been noted and dealt with at the time.

Had a UXB fallen into the dock basin itself it will have been immediately obscured from view beneath the water line and subsequently could have become buried under debris / sediment in the post-war period.

9.4.5. Bomb Failure Rate

There is no evidence to suggest that the bomb failure rate in the vicinity of the site would have been different from the "approximately 10%" figure normally used.

10. The Threat from Allied Military Ordnance

10.1. General

BACTEC has found evidence to suggest that the surrounding area of the site had former military use which could have led to ordnance contamination.

The following potential military uses have been considered:

- Anti-Aircraft Defences
- Home Guard
- Training or firing ranges or the storage of ammunition
- Military bases
- Defensive minefields (including pipemines)
- Defensive Positions

- Manufacture of explosives or ordnance

The most likely source of Allied ordnance is from anti-aircraft fire, as discussed in the following section.

10.1.1. Anti-Aircraft Artillery and Projectiles

At the start of the war two types of 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 was 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. Before the war all the clockwork fuses used by the Royal Artillery had come from Switzerland. When that source of supply was cut off, Britain had been forced to make its own. After four years of war, the country still lacked the engineering skills to produce a reliable fuse.

This resulted in a considerable number of AA projectiles either exploding prematurely, killing the gunners or failing to explode at all; falling to the ground as UXBs. In January 1944 more people in London were killed by HAA shells than by German bombs. Details of the most commonly deployed WWII AAA projectiles are shown below:

Gun type	Calibre	Shell Dimensions	Shell Weight	HE Fill Weight
3.7 Inch	94mm	94mm x 438mm	12.7kg	1.1kg
4.5 Inch	114mm	114mm x 578mm	24.7kg	1.7kg
40mm	40mm	40mm x 311mm	0.84kg	70g

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 risk.

Three HAA batteries were located within a 5km radius of the site during WWII. Numerous unexploded AAA shells were recovered during and following WWII and are still occasionally encountered on sites today. Illustrations of anti-aircraft projectiles and rockets are presented at ***Annex L***.

11. Ordnance Clearance and Post-WWII Ground Works

11.1. 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.

11.2. EOD Bomb Disposal and Clearance 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 official information regarding bomb disposal/clearance tasks on this site. A search of the BACTEC EOD clearance tasks database has not identified any Army EOD activity on or close to the site.

11.3. Post-War Redevelopment

In the post-war period, the rail tracks and warehouse on site were removed and the quayside extended westwards into the basin. No post-war redevelopment of the site is understood to have occurred.

12. The Overall Explosive Ordnance Threat Assessment

12.1. General Considerations

Taking into account the quality of the historical evidence, the assessment of the overall threat to any intrusive works from unexploded ordnance must evaluate the following risks:

- That the site was contaminated with unexploded ordnance
- That unexploded ordnance remains on site
- That such items could be encountered during any intrusive works
- That ordnance may be activated by the works operations
- The consequences of encountering or initiating ordnance

12.2. The Risk that the Site was Contaminated with Unexploded Ordnance

For the reasons discussed in *Section 9* BACTEC believes that there is a risk that UXO contaminated the study area. This is based on the following:

- Liverpool was the second most heavily bombed city in the UK during WWII with the docks representing the primary Luftwaffe target area. Consequently the site occupied an area of very high bombing density, as confirmed by official statistics and mapping.
- A comparison of the historical sources records an incendiary bomb strike either on or immediately adjacent to the site and Prince's Dock appears to have sustained bomb strikes during at least five separate air raids.
- During this conflict the site was occupied by a section of the dock basin, a dockside goods shed and adjacent open ground (likely hard-standing) crossed by railway lines.
- The site was situated immediately west of Bath Street during the war and it is known that large fires destroyed dockside warehousing on the west side of Bath Street. Therefore as the 1945 aerial photograph doesn't show any damage to this area, it is considered highly likely that these warehouses were destroyed during 1940-41 and re-built prior to 1945.
- Note that following the destruction of London's Dock systems, Liverpool's docks became even more vitally important to the war effort and therefore any damage sustained would have been prioritised for repair.
- Therefore it is quite possible that the study area sustained substantial fire damage. Following this, the site will have been abandoned for a time until the ruins could be cleared and as nearly all German air raids on Liverpool occurred at night, it is conceivable that a subsequent UXB could have fallen here unnoticed and become immediately obscured from view within the wreckage. Note that the entry hole of an SC50 UXB (the most commonly deployed German HE bomb) could have been as little as 20cm in diameter.
- In addition, such a scenario could have resulted in the weapon coming to rest beneath the adjacent quayside / railway lines due to the J-Curve Effect.

- Furthermore, had a UXB fallen within the dock basin occupying the western third of the site, it will have been immediately obscured from view beneath the water line and subsequently could have become buried under debris / sediment in the post-war period.

No evidence has been located to suggest that the site formerly had any military occupation or usage that could have led to contamination with British / Allied items of UXO.

12.3. The Risk that Unexploded Ordnance Remains on Site

The risk from deep buried German HE UXBs will have only been mitigated at the specific locations of any post-war pile foundations and within the volume of any basement level bulk excavations. As such works do not appear to have been carried out on site post-war, this risk remains unmitigated down to the maximum bomb penetration depth.

Furthermore, the partial in-filling of the dock basin post-war could conceivably have resulted in the burial of both smaller and larger items of UXO within the western portion of the site.

12.4. The Risk that Ordnance may be Encountered during the Works

The most likely scenarios under which a 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.

12.5. The Risk that Ordnance 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. The most violent activity on most construction sites is percussive piling.

As a result items that are shallow buried present a lower risk than those that are deep buried, since the force of impact is usually lower and they are more likely to be observed – when immediate mitigating actions can be taken.

12.6. The Consequences of Encountering or Initiating Ordnance

Clearly the consequences of an inadvertent detonation of UXO during construction operations would be catastrophic with a serious risk to life, damage to plant and a total site shutdown during follow-up investigations.

Since the risk of initiating ordnance is comparatively low if appropriate mitigation measures are undertaken, the most important consequence of the discovery of ordnance will be economic. This would be particularly so in the case of high profile locations and could involve the evacuation of the public.

The unexpected discovery of ordnance may require the closing of the site for any time between a few hours and a week with a potentially significant cost in lost time. Note also that the suspected find of ordnance, if handled solely through the authorities, may also involve loss of production since 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.

12.7. BACTEC's Assessment

Taking into consideration the findings of this study, Dynasafe BACTEC considers the risk across the site to be ***Medium-High.***

	Level of Risk			
Type of Ordnance	**Negligible**	**Low**	**Medium**	**High**
German High Explosive Bombs			✓	
German 1kg Incendiary Bombs			✓	
British Anti-Aircraft Shells		✓		
British / Allied SAA and LSA		✓		

13. Proposed Risk Mitigation Methodology

13.1. General

Dynasafe BACTEC believes the following risk mitigation measures should be deployed to support the proposed works at the Prince's Dock site.

13.2. Recommended Risk Mitigation Measures

- ***Site Specific Explosive Ordnance Safety and 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 2007. All personnel working on the site should be instructed on the identification of UXB, 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 UXB threat should be held in the site office for reference and as a reminder.
- ***The Provision of Unexploded Ordnance Site Safety Instructions:*** These written instructions contain information detailing actions to be taken in the event that unexploded ordnance is discovered. They are to be retained on site and will both assist in making a preliminary assessment of a suspect object and provide guidance on the immediate steps to be taken in the event that ordnance is believed to have been found.
- ***Explosive Ordnance Disposal (EOD) Engineer presence on site to support shallow intrusive works:*** When on site the role of the EOD Engineer 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 Explosive Ordnance Safety and 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 threat, 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.
- ***Intrusive Magnetometer Survey of any pile / boreholes locations down to the maximum bomb penetration depth:*** BACTEC can deploy a range of intrusive magnetometry 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. A site meeting would be required between BACTEC and the client to determine the methodology suitable for this site. Target investigation or avoidance will be recommended as appropriate.

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The key published documents consulted during this assessment are listed below:

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North

Report Reference:	Client:	
6426TA	Moda Living	DYNASAFE
	Project: Prince's Dock, Liverpool	

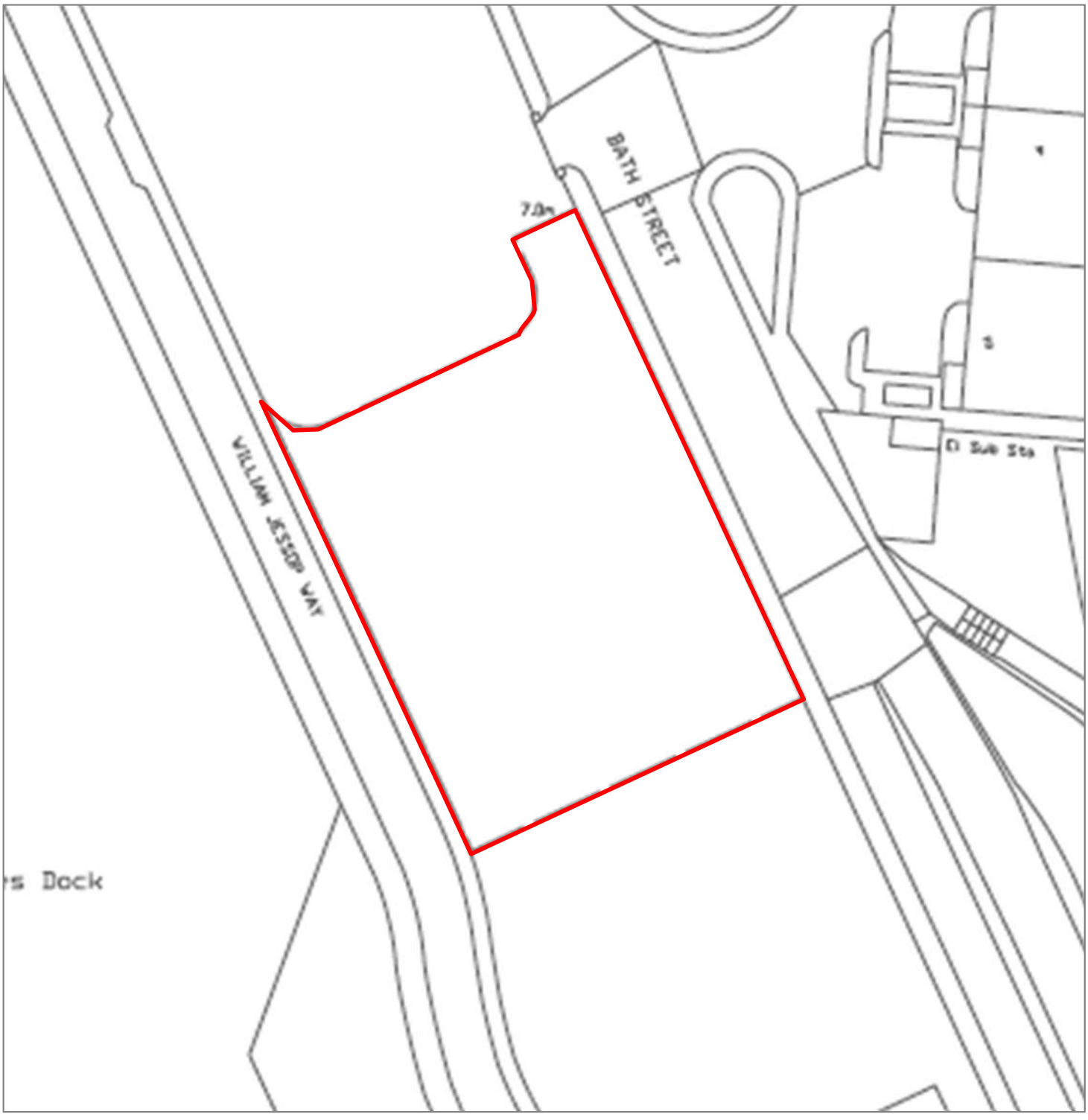
North

Approximate site boundary

Report Reference:	Client:	
6426TA	Moda Living	DYNASAFE
	Project: Prince's Dock, Liverpool	

Source: Google Earth ™ Mapping Services

North

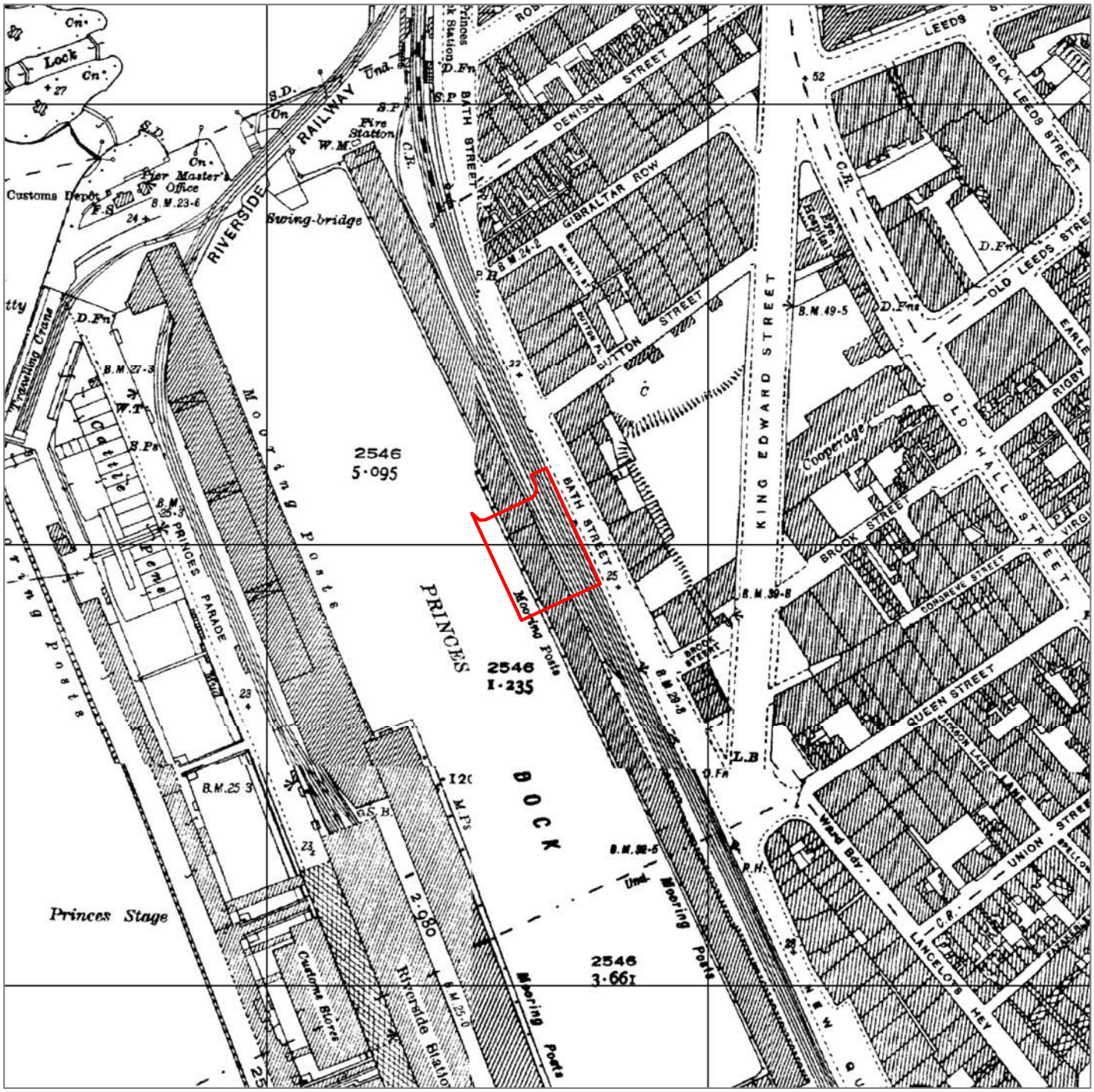


Site boundary

Report Reference:	Client:	
6426TA	Moda Living	DYNASAFE
	Project: Prince's Dock, Liverpool	

Source: Arup Ltd

North

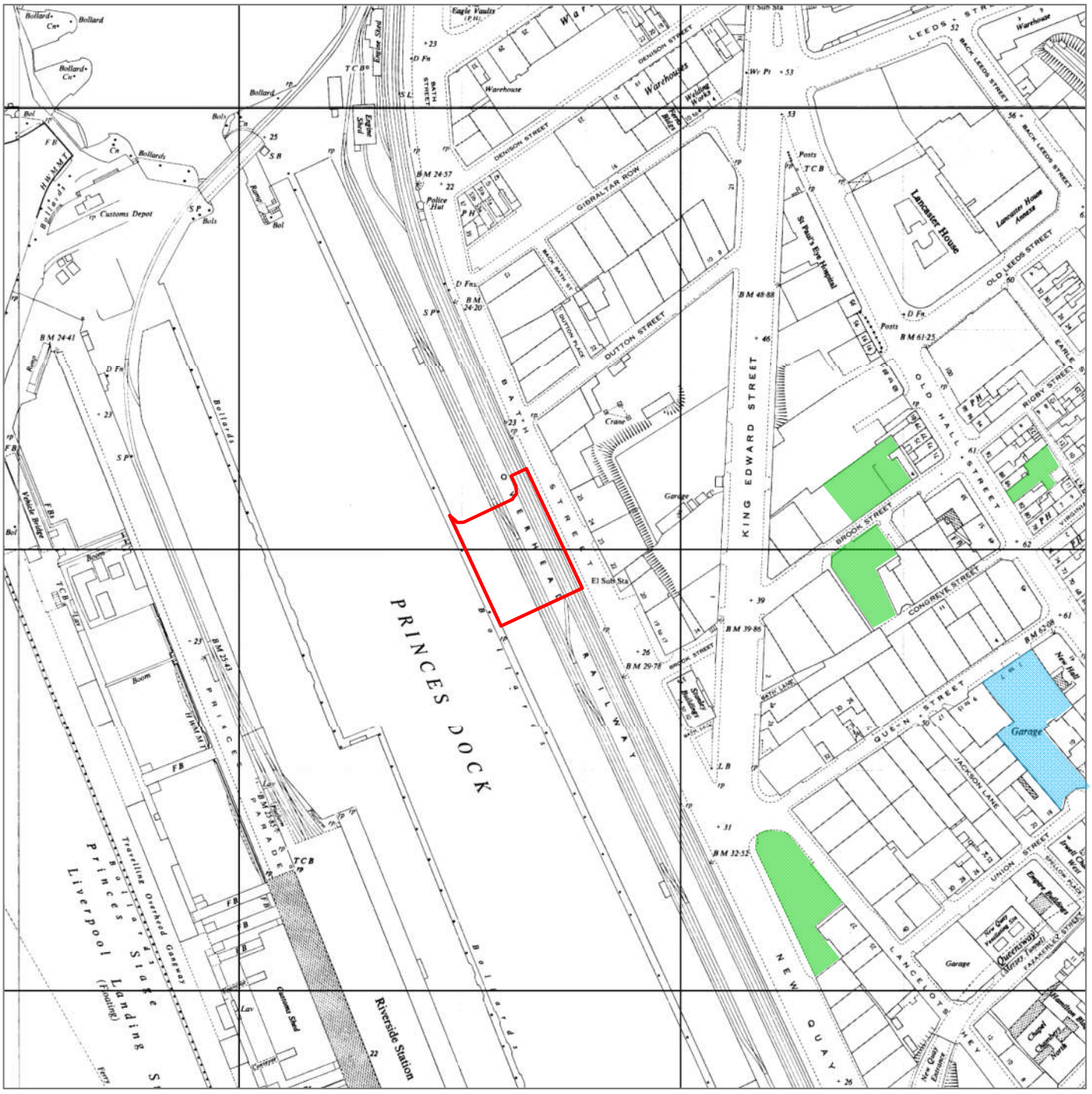


Approximate site boundary

Report Reference:	Client:	
6426TA	Moda Living	DYNASAFE
	Project: Prince's Dock, Liverpool	

Source: Landmark Maps

North



Approximate site boundary

Redevelopment

Clearance

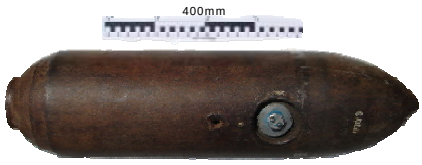
Report Reference:	Client:	
6426TA	Moda Living	DYNASAFE
	Project: Prince's Dock, Liverpool	

Source: Landmark Maps

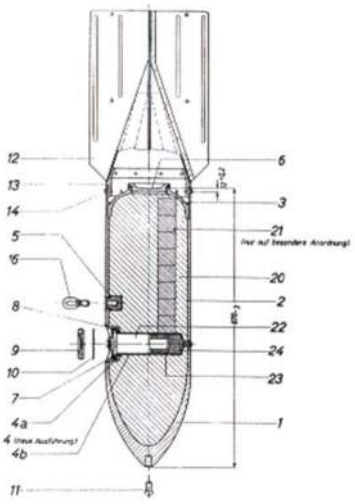
SC 50

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.

50kg bomb, London Docklands



Minus tail section

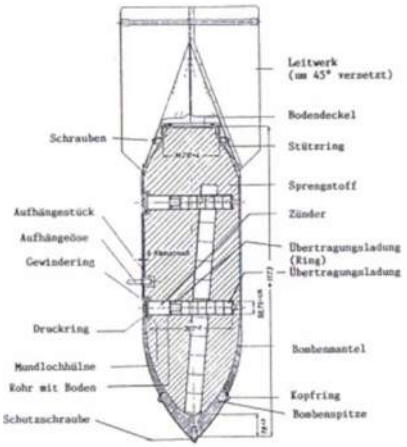


SC-50 JA (Güteklasse 1)

SC 250

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.

250kg bomb, Hawkinge

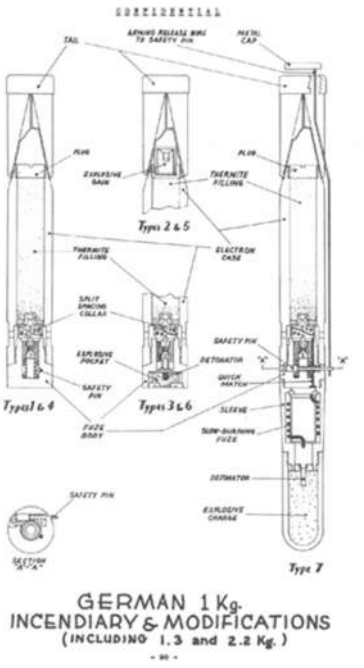


SC-250 JA (Güteklasse I)

1kg Incendiary Bomb

Bomb weight:	1.0 and 1.3kg (2.2 and 2.87lb)
Filling:	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:	Jettisoned from air-dropped containers. Magnesium alloy case. Sometimes fitted with high explosive charge

1. Scaffold pipe
2. Incendiary 1kg bomb
3. Incendiary bomb recently found on site in UK



GERMAN 1 Kg. INCENDIARY & MODIFICATIONS (INCLUDING 1.3 and 2.2 Kg.)

Report Reference:	Client:	
6426TA	Moda Living	DYNASAFE
	Project: Prince's Dock, Liverpool	

Source: Dynasafe BACTEC Limited and various historical sources

The Telegraph

11:50AM GMT 24 Mar 2015

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Giant WWII bomb dug up by builders in London

A massive evacuation procedure is carried out in Bermondsey, south London, after the 1,000lb explosive measuring 5ft long was uncovered

Express & Echo

6.1 °C

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Road closed after German bomb found in Axminster garden

By Exeter Express and Echo | Posted: June 03, 2014

A major road in Axminster has been closed after an air-dropped German bomb was found in a garden.

Mother-of-two digs up unexploded WWII bomb in garden and casually flings it on the rubbish thinking it was an old exhaust pipe

- Carole Fisher-White, 56, unearthed a mortar shell in her back garden
- It was only when sons said it looked like a bomb that the penny dropped
- Royal Navy bomb disposal team called to defuse the device
- The 29mm Spigot Mortar was was an infantry anti-tank weapon
- Also known as the Blacker Bombard it was used by the Home Guard

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

00:20 / 00:28 SHARE

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

Unexploded Second World War grenade discovered by a curious dog

By Charlotte Cox

Police and Army bomb disposal experts were called to the address in Peakdale Avenue, Heald Green.

A dog called Snoop has sniffed out a suspected Second World War grenade in a Stockport garden.

Police and Army bomb disposal experts were called to the address in Peakdale Avenue, Heald Green.

They took the grenade to nearby parkland and destroyed it in a controlled explosion.

Page last updated at 14:23 GMT, Thursday, 5 June 2008 15:23 UK

BBC

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Unexploded bomb 'started to tick'

An unexploded World War II bomb started to tick and ooze liquid as experts tried to defuse it, police have said.

The large bomb was found in a river at Sugar House Lane, near Bromley-by-Bow Tube station in east London, on Monday.

Rush-hour travel was disrupted as overnight work to make the bomb safe continued into Thursday morning.

"It measures approximately the size and length of a man, and weighs around 1,000kg (2,200lb).

Royal Navy clearance divers dispose of 70-year old German bomb

Posted on August 8, 2013

The team of four from the Southern Diving Unit 1 at HM Naval Base Devonport, Plymouth, blew up the air-dropped bomb in-situ in a controlled explosion where it was found by contractors for SW Water laying a mains in a field at St Eval Kart Circuit near Wadebridge, north Cornwall yesterday.

1994

RESCUE workers search for survivors after a Second World War bomb exploded at a building site in Berlin, killing three people and injuring at least eight others.

A fire brigade spokesman said he feared the final death toll could be higher. One worker was still missing, believed to be trapped under a machine. "We've found human remains 100 metres away but we can't tell if they belong to the dead already found," the spokesman said.

The blast, set off by drilling work on Frankfurter Allee, one of east Berlin's busiest avenues, trapped workers under building machinery and sent huge chunks of concrete tumbling through the air.

A large office block was being built on the site of the explosion which sent shoppers scrambling for shelter and paralysed dense afternoon traffic. One eyewitness said: "There was a bang, then silence, and then it started raining stones and dirt."

Dozens of cars within a 250-metre radius were wrecked and the top two floors of a nearby apartment block caved in.

Radio reports claimed that the total number of injured stood at 14.

Blown up by history

2008

2006

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.

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.

2010

2006

The bomb went off as the machine lifted up earth and debris

A World War Two bomb has exploded at a construction site near a west German town, killing a man and injuring eight others, police say.

The explosion occurred after a digger accidentally struck the device during excavation work in Euskirchen in the state of North Rhine-Westphalia.

The machine's operator died on the spot. Two of those hurt were critically wounded, the dpa news agency reports.

Related

2014

Top Left: WWII bomb killed 3, injured 8 (Berlin – 1994)
Middle Left: WWII bomb killed 3 in Goettingen, Germany – 2010.
Bottom Left: Excavator operator killed by WWII bomb in Euskirchen, Germany – 2014.
Top Right: WWII bomb injures 17 at construction site in Hattingen, Germany - 2008.
Middle Right: A highway construction worker in Germany accidentally struck a WWII bomb, killing himself and wrecking several passing cars - 2006.
Bottom Right: Destroyed piling rig and dump truck after detonation of WWII UXB (buried at 12m bgl) in Austria - 2006.

North

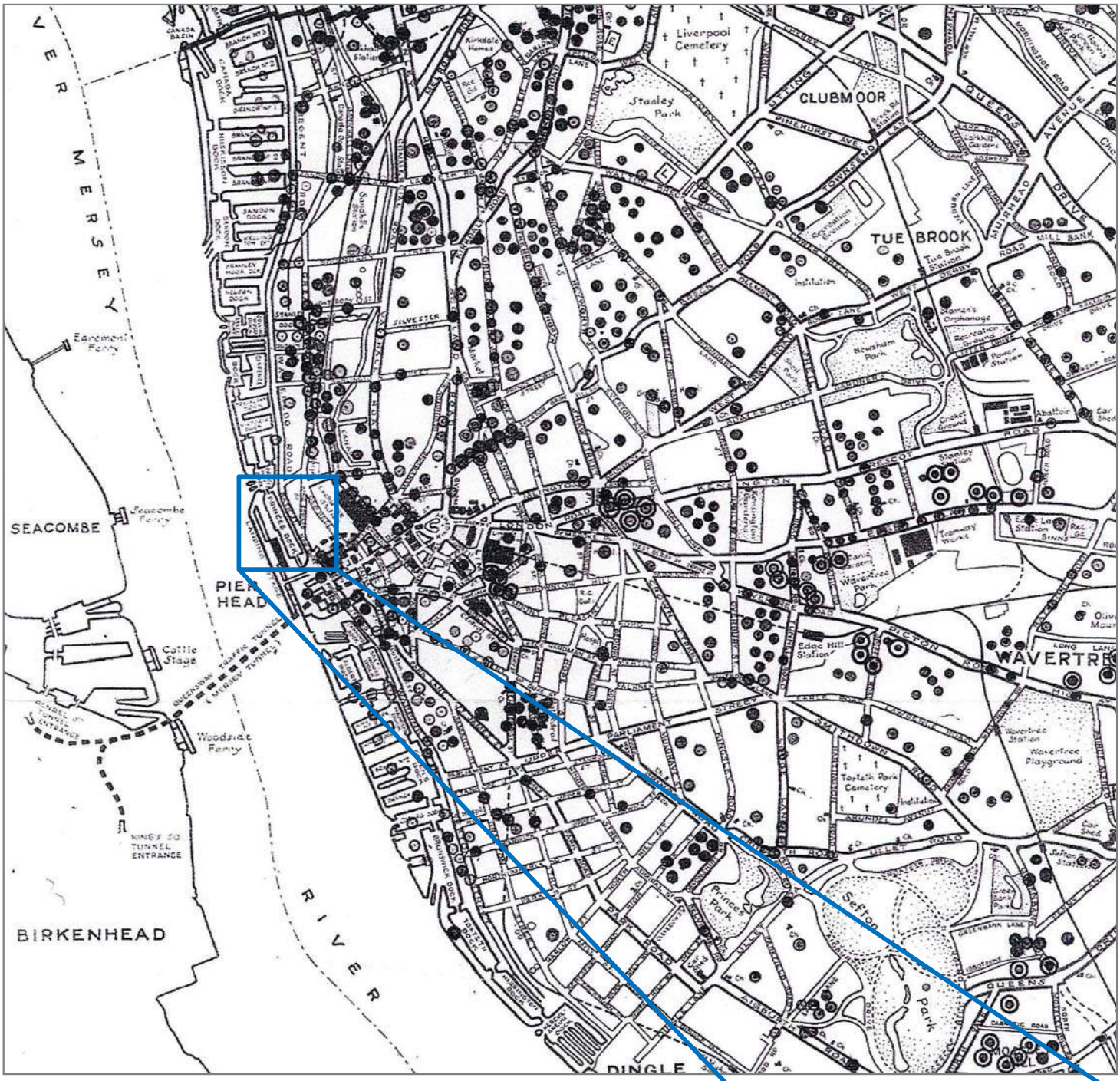
Approximate site location

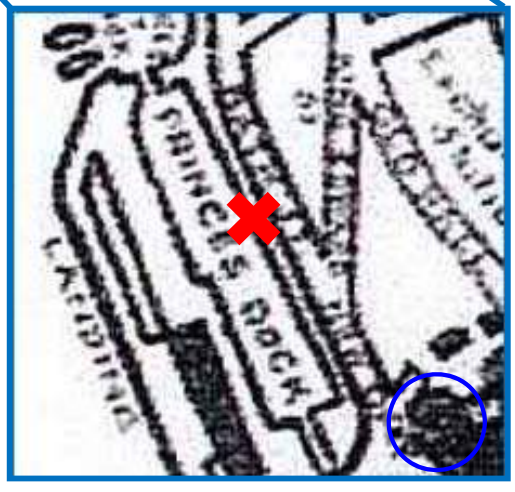
Luftwaffe bombing targets

Report Reference:	Client:	
6426TA	Moda Living	DYNASAFE
	Project: Prince's Dock, Liverpool	

Source: The National Archives

North



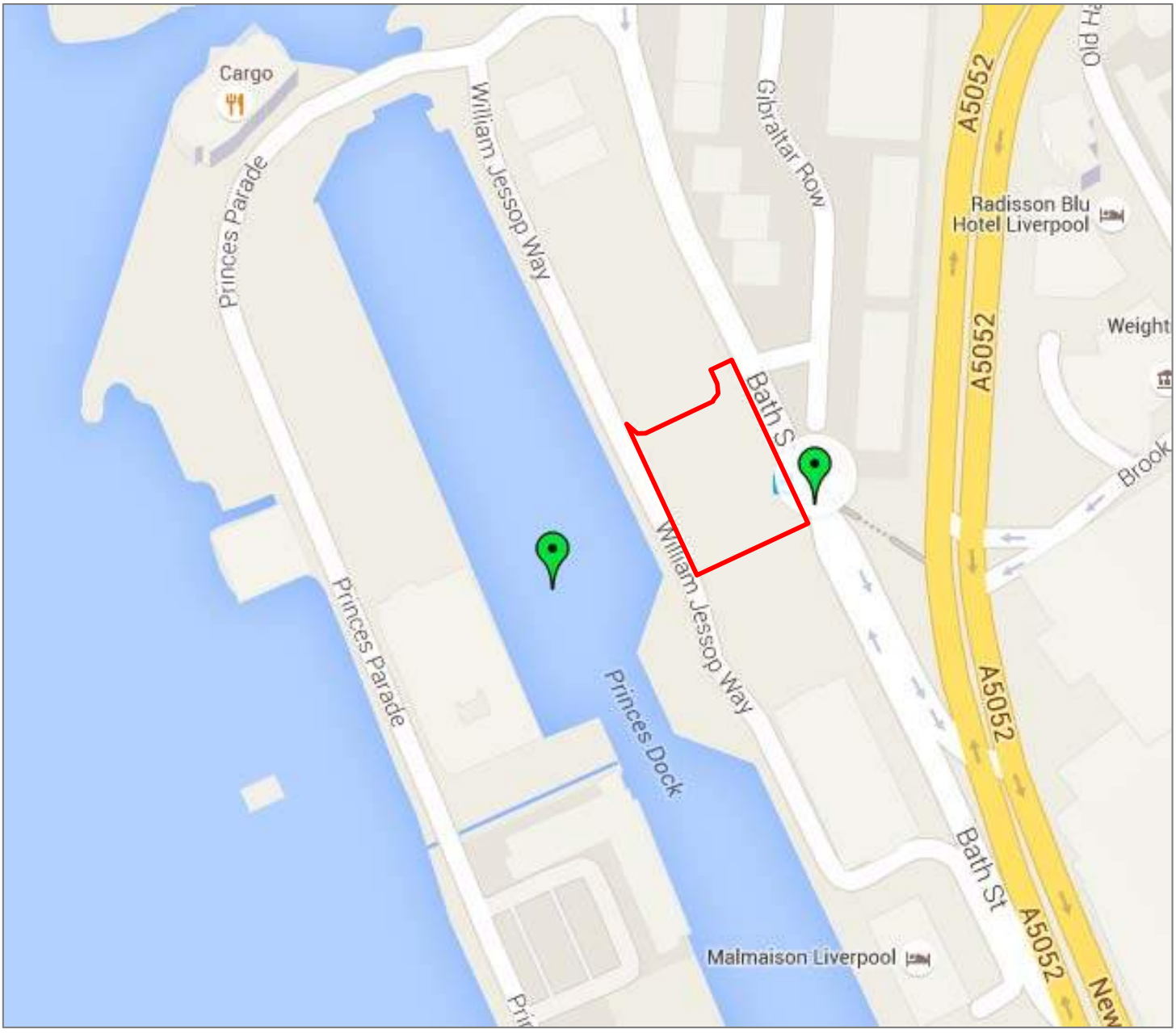


- ✖ Approximate site location
- ● Serious HE bomb damage
- ◉ Serious fire damage
- ○ Parachute Mine damage

Report Reference:	Client:	
6426TA	Moda Living	DYNASAFE
	Project: Prince's Dock, Liverpool	

Source: Liverpool Record Office

North

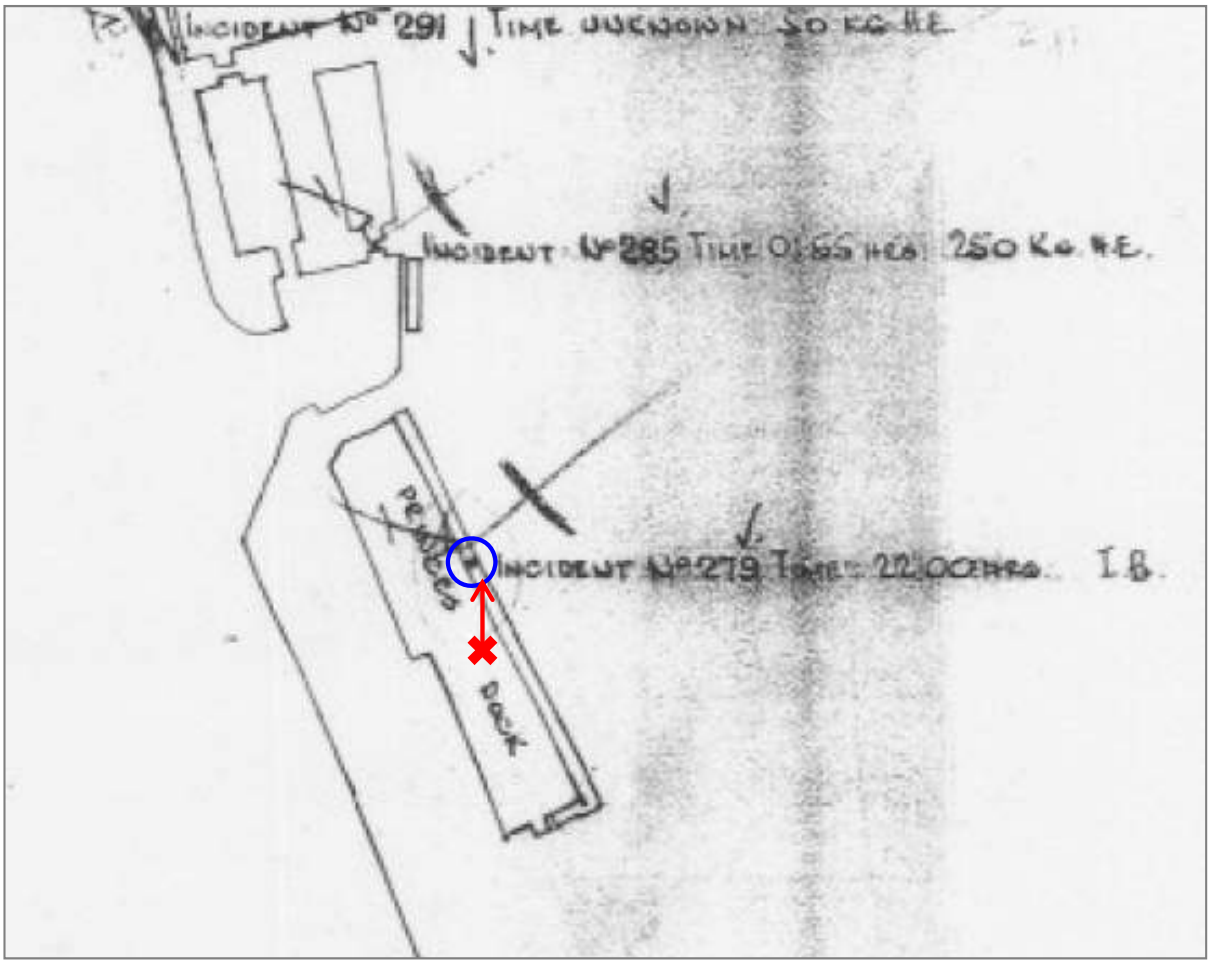


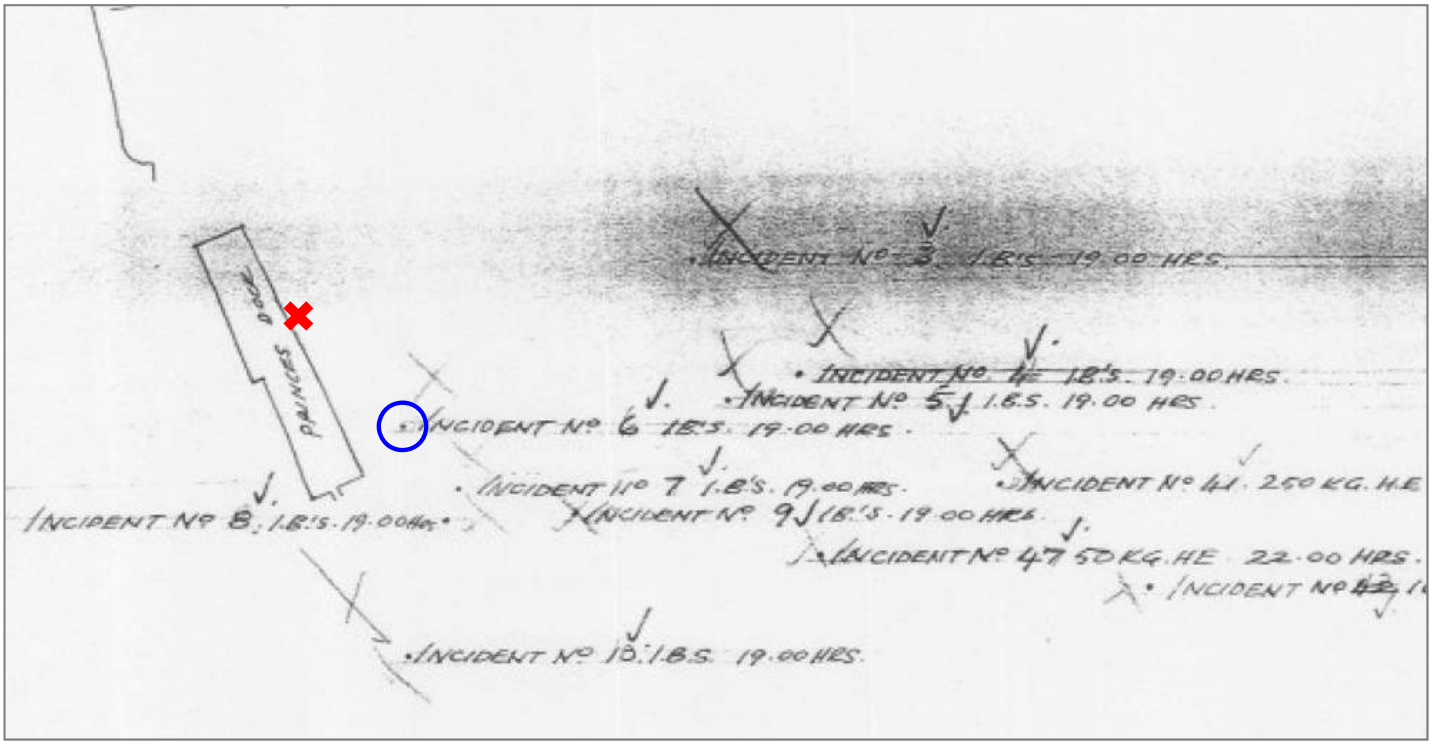
Approximate Site Boundary

Approximate bomb damage location

Report Reference:	Client:	
6426TA	Moda Living	DYNASAFE
	Project: Prince's Dock, Liverpool	

Source: The Liverpool Echo



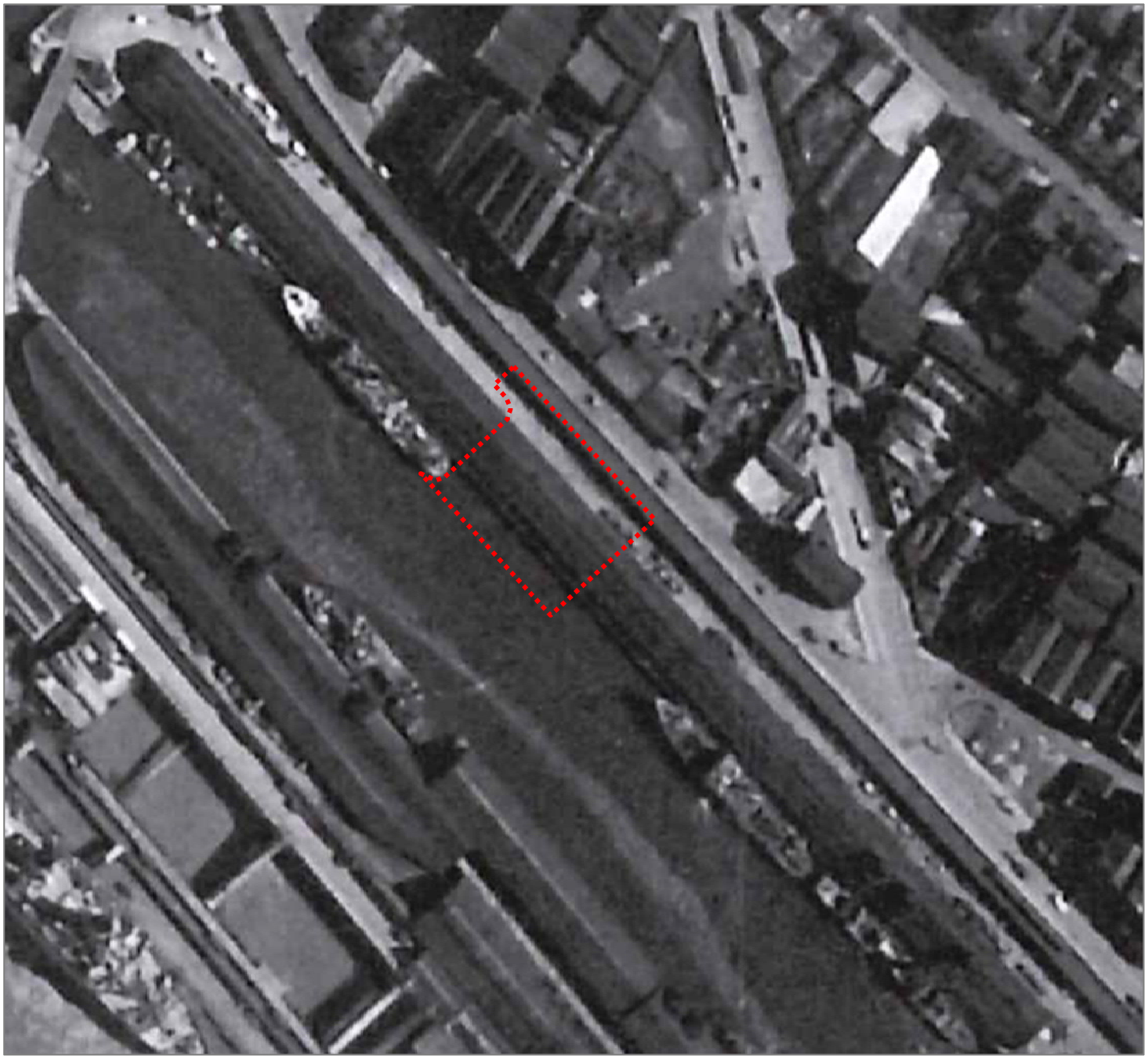


✖ Approximate site location
○ Closest bombing incident to site

Report Reference:	Client:	
6426TA	Moda Living	DYNASAFE
	Project: Prince's Dock, Liverpool	

Source: Liverpool Record Office

North



Approximate site boundary

Report Reference:	Client:	
6426TA	Moda Living	DYNASAFE
	Project: Prince's Dock, Liverpool	

Source: Historic England

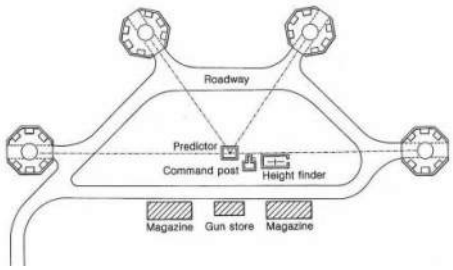
Report Reference:	Client:	
6426TA	Moda Living	DYNASAFE
	Project: Prince's Dock, Liverpool	

Source: Britain From Above

3.7 inch Anti-Aircraft Projectile

Weight:	12.7kg (28lb)
Dimensions:	94 x 360mm (3.7 x 14.7in)
Carriage:	Mobile and Static Versions
Rate of Fire:	10-20 rounds per minute
Ceiling:	9-18,000m (29-59,000ft)
Muzzle Velocity:	792m/s (2,598ft/s)
Remarks:	4.5 inch projectiles were also commonly utilised

This AA shell was uncovered on a construction site in North London in February 2009.



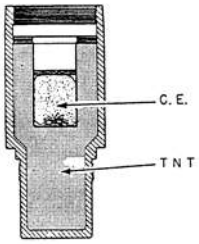
Layout plan for a typical HAA battery site.

Hyde Park 1939 3.7 Inch QF gun on mobile mounting

3.7 inch AA Projectile Minus Fuze

Rockets / Unrotated Projectiles

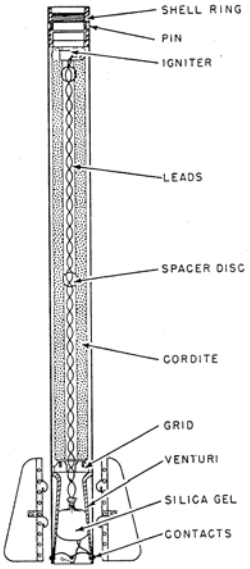
Weight:	Overall: 24.5kg (54lb) Warhead: 1.94kg (4.28lb)
Dimensions:	1930mm x 82.6mm (76 x 3.25in)
Carriage:	Mobile – transported on trailers
Ceiling:	6770m (22,200ft)
Maximum Velocity:	457mps (1,500 fps)



MK II HE Shell (3.5kg)

Rocket Battery in action

Home Guard soldiers load an anti-aircraft rocket at a 'Z' Battery



2" U.P AA Rocket

40mm Bofors Gun Projectile

Weight:	0.86kg (1.96lb)
Dimensions:	40mm x 310mm (1.6in x 12.2in)
Rate of Fire:	120 rounds per minute
Ceiling:	23,000ft (7000m)
Muzzle Velocity:	2,890 ft/s (881m/s)
Remarks:	Mobile batteries – normally few records of where these guns were located

Unexploded 40mm Bofors projectile recovered from a marine environment

40mm Bofors gun and crew at Stanmore in Middlesex, 28 June 1940.

Report Reference: 6426TA	Client: Moda Living	DYNASAFE
	Project: Prince's Dock, Liverpool	

Source: Dynasafe BACTEC Limited and various historical sources