Examples of Land Service Ammunition finds in the UK

Annex: H3



Unexploded Second World War bomb discovered under Somerset footpath

By Western Daily Press | Posted: January 21, 2014

The unexploded bomb was found in Somerset

Comments (0)

An unexploded bomb dropped in Britain during the Second World War has finally been discovered – underneath a popular footpath in Somerset.



23 August 2014 Last updated at 15:01

Unexploded WW2 bomb found at Kenfig Pool, Bridgend

Dean Smith believes the shell was made in Germany

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

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

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

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

Related Stories

'Panic' as dog nearly thrown grenade

WW2 bomb found at wind farm exploded

WWII bomb found in kitchen cupboard



Mortar thought to be from WWII found on Oshawa's Camp-X grounds

August 24, 2018 | 5:42 am

What is believed to be a World War II mortar has been discovered in south Oshawa. A man out in Intrepid Park, the site of the Camp-X Second World War training grounds, discovered the round with his metal detector on Tuesday evening. Durham police are held the scene overnight awaiting military officials from Trenton to come and properly detonate the mortar.



Unexploded bomb found in farmer's field

17 May 2010

A live Second World War mortar shell was blown up by Army experts after a farmer found it in his field.

The discovery was made in the field alongside the A20 between Folkestone and Dover.

The mortar shell, which was around a foot long and 3in in diameter, was around 50ft from the main road.

The farmer alerted police and PC Trevor Moody and PCSO Michelle Brady went to the field.

PC Moody contacted the Army who sent in a bomb disposal unit.

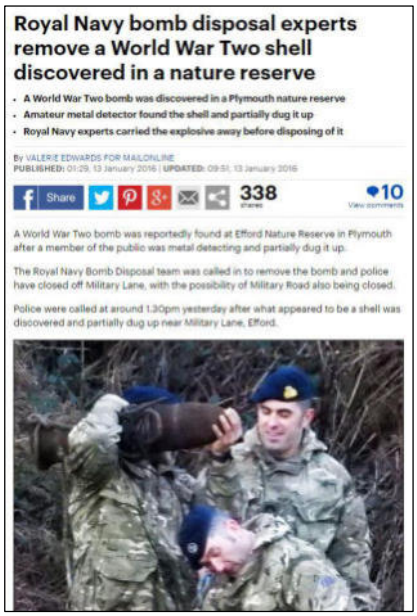
An Army officer confirmed the live shell was from the Second World War and was packed with high explosives.

They moved it a safe distance away from the A20 and carried out a controlled explosion.

PC Moody said: "Given that we live in an area that saw much action during the Second World War, it is not uncommon for us to be alerted about unexploded bombs."

The incident was on Thursday.

• Click here for more news from Kent



Royal Navy bomb disposal experts remove a World War Two shell discovered in a nature reserve

- A World War Two bomb was discovered in a Plymouth nature reserve
- Amateur metal detector found the shell and partially dug it up
- Royal Navy experts carried the explosive away before disposing of it

By VALERIE EDWARDS FOR MAILONLINE

PUBLISHED: 01:29, 13 January 2016 | UPDATED: 09:51, 13 January 2016

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A World War Two bomb was reportedly found at Efford Nature Reserve in Plymouth after a member of the public was metal detecting and partially dug it up.

The Royal Navy Bomb Disposal team was called in to remove the bomb and police have closed off Military Lane, with the possibility of Military Road also being closed.

Police were called at around 1.30pm yesterday after what appeared to be a shell was discovered and partially dug up near Military Lane, Efford.



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

© Jonathan Pow

Bomb Beach Alley: Rockets were found after a landslide on Mappleton beach in 2012



Army bomb disposal team called to Blacksole Bridge in Herne Bay

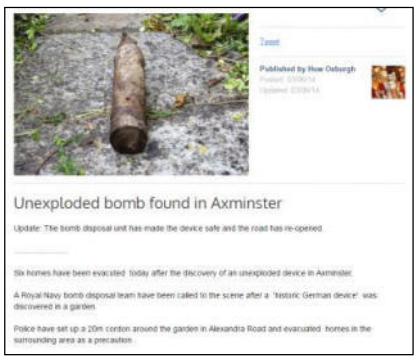
by Aiden Barlow abarlow@thekmgroup.co.uk 08 July 2015

It was like a scene from Dad's Army when Army bomb disposal experts found wartime explosives made by the Home Guard in makeshift bottles.

A team was called to the Blacksole Bridge in Herne Bay after the wartime bombs were found.

The team from the Royal Logistics Corps set up a 30 metre exclusion zone for pedestrians around the railway embankment after the suspected homemade phosphorous bombs were found.

The scene at Blacksole Bridge after wartime explosives were found in the railway cutting



Unexploded bomb found in Axminster

Update: The bomb disposal unit has made the device safe and the road has re-opened.

Six homes have been evacuated today after the discovery of an unexploded device in Axminster.

A Royal Navy bomb disposal team have been called to the scene after a 'historic German device' was discovered in a garden.

Police have set up a 20m cordon around the garden in Alexandra Road and evacuated homes in the surrounding area as a precaution.



Storms and floods unearth unexploded wartime bombs

By Claire Marshall

BBC environment correspondent

There has been a dramatic increase in the number of wartime bombs unearthed because of the winter storms and flooding.

Bomb disposal teams in the South West have dealt with double the number of unexploded ordnance than in the same period last year.

Since mid December, the Royal Navy's Southern Dive Unit has recovered or disposed of 244 items of ordnance.

During the same period last year, they dealt with just 108 items.

The storms have uncovered a lethal past

Almost 70 years after the end of WWII, one legacy of that conflict continues to turn up on beaches and harbours around Britain.

Unexploded shells, bombs and mines continue to be discovered every year, and the Royal Navy's Southern Dive Unit is tasked with making these devices safe.

Its area of responsibility stretches for some 2,250km (1,400 miles). It begins from the highwater mark in Hull and proceeds seaward to the territorial limit, and then runs clockwise around the British Isles - including the Isle of Wight, Channel Islands, and Isles of Scilly - to finish in Liverpool.

Related Stories

Ancient trees revealed by storms

Land Service Ammunition (LSA) resulting from historic military activity is commonly encountered across the UK by the public and construction industry alike. Such finds are much more common in rural areas than in urban environments, and can often be anticipated in areas such as former RAF stations or ranges. However, many such items are encountered entirely by surprise where the landowner or developer has no knowledge of any previous military use of the land.

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Project: **Plot 2, Park Works, Manchester**

Ref: **DA12563-00**

Source: Various news sources

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Manchester 'World War 2 bomb' fears: Hotel on LOCKDOWN as bomb squad probes WW2 device

POLICE cordoned off a street in Manchester and placed the Lowry Hotel on lockdown after a suspected World War 2 bomb was discovered nearby.

Chapel Street in Salford, Greater Manchester were cordoned off between Blackfriars Road and Bailey Street as police as investigated a device found at a construction site.

The bomb squad arrived on scene and residents of The Edge building opposite the construction site were told to evacuate.

Lowry Hotel has reportedly not been evacuated; however, Greater Manchester Police (GMP) had set up a 100m cordon which surrounds the area.

The GMP in a statement on Twitter said: "Police were called to reports of a suspicious item on a building site by Clowes Street and Chapel Street in Ordsall.

"Bomb disposal experts are making their way to the scene and a 100m cordon has been put in place which includes areas around the Lowry Hotel. It is believed the item could be a device from WW2."

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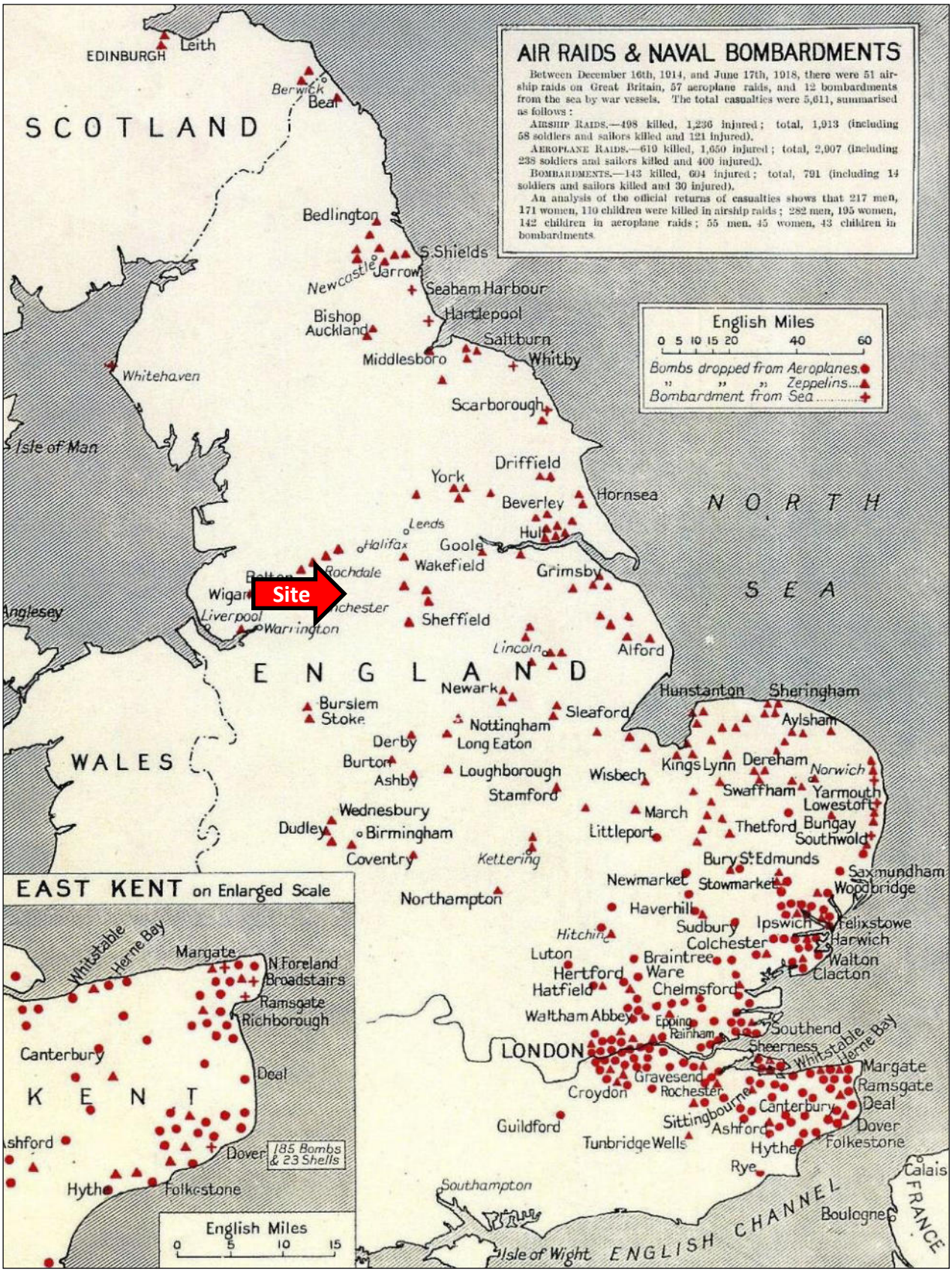
WWI Map of Air Raids and Naval Bombardments

Annex: I



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Source: J. Morris, *German Air Raids on Britain*

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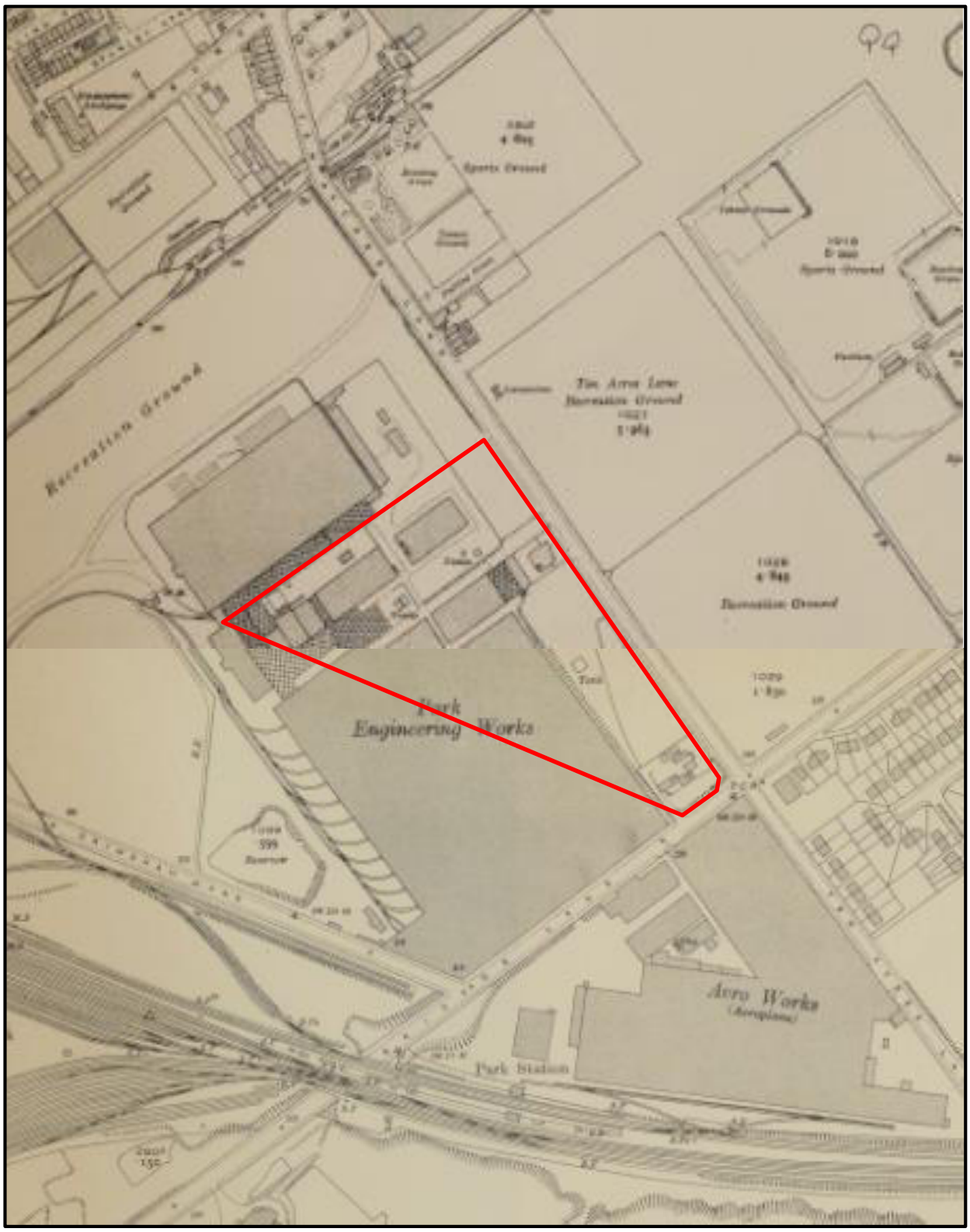
Manchester Bomb Plot & Damage Map

Annex: J



Recorded HE bomb Recorded incendiary bomb Damaged building

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Approximate site boundary

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Source: The University of Manchester Library

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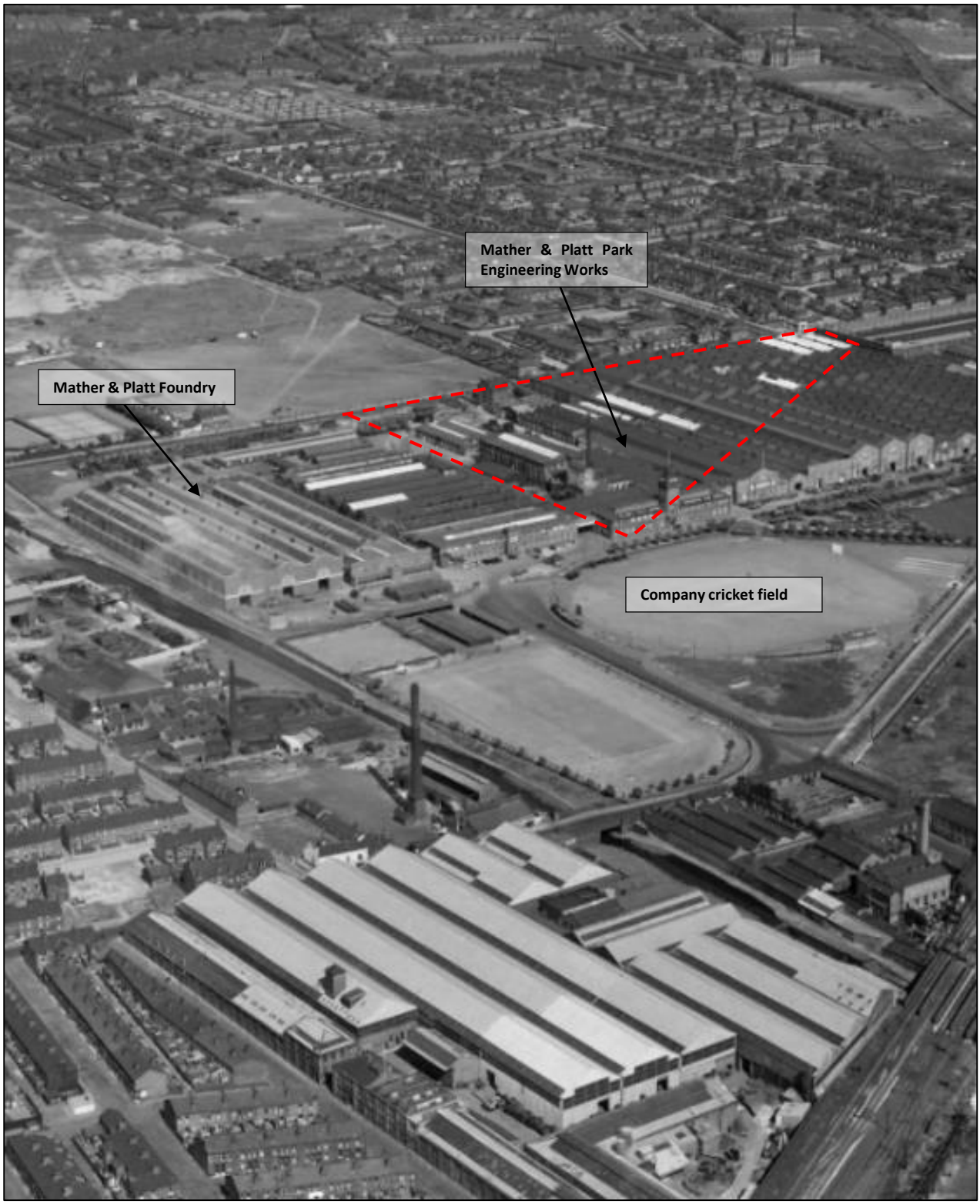
The R & J Dempster Ltd Gas Plant Works and environs, Newton Heath, 1953



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Source: Britain From Above

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An example of WWI era Avro aeroplanes manufactured at Park Works, and the Avro Factory which was located south of the site, on the south side of Briscoe Road.



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Source: https://www.baesystems.com/en/heritage/brownsfield-mill--newton-heath--alexandra-park--yeandon--hamble--trafford-park--failsworth-and-ashton-under-lyne

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Women working at the Mather and Platt works to assist the War effort.





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Source: https://gm1914.wordpress.com/2016/10/13/manchesters-industrial-war-a-view-from-the-factories/

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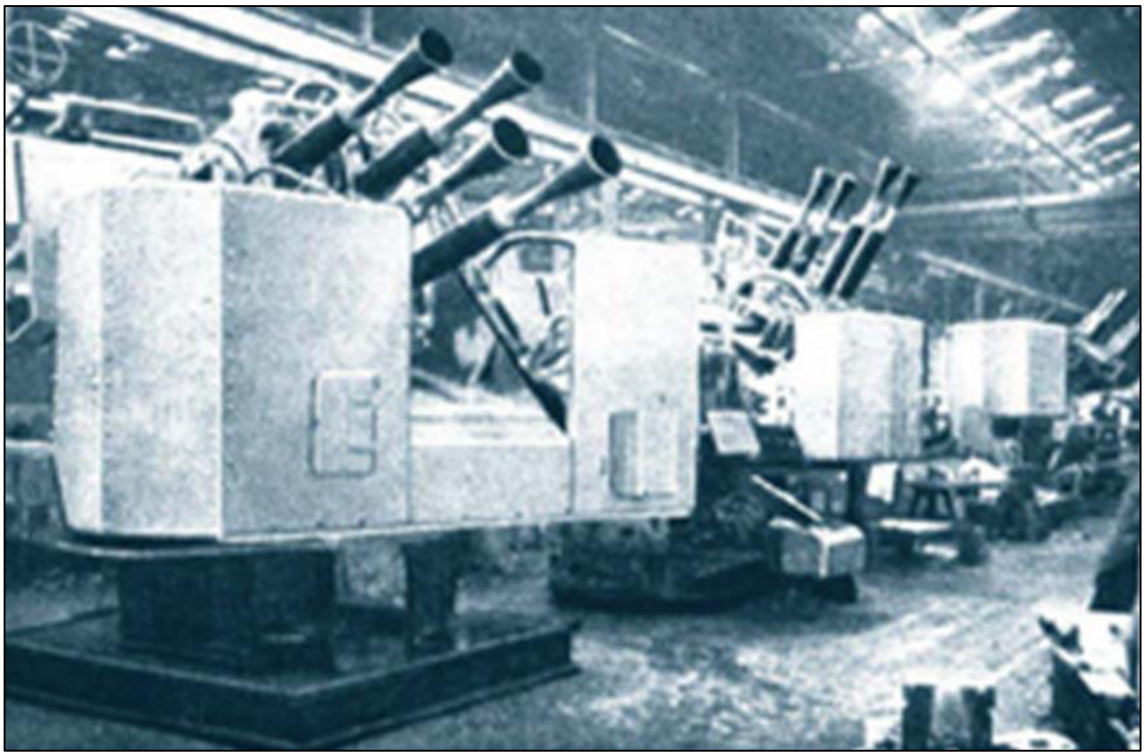
Barrage balloons produced by Mather and Platt



Mather and Platt Ack Ack gun mounting for ships



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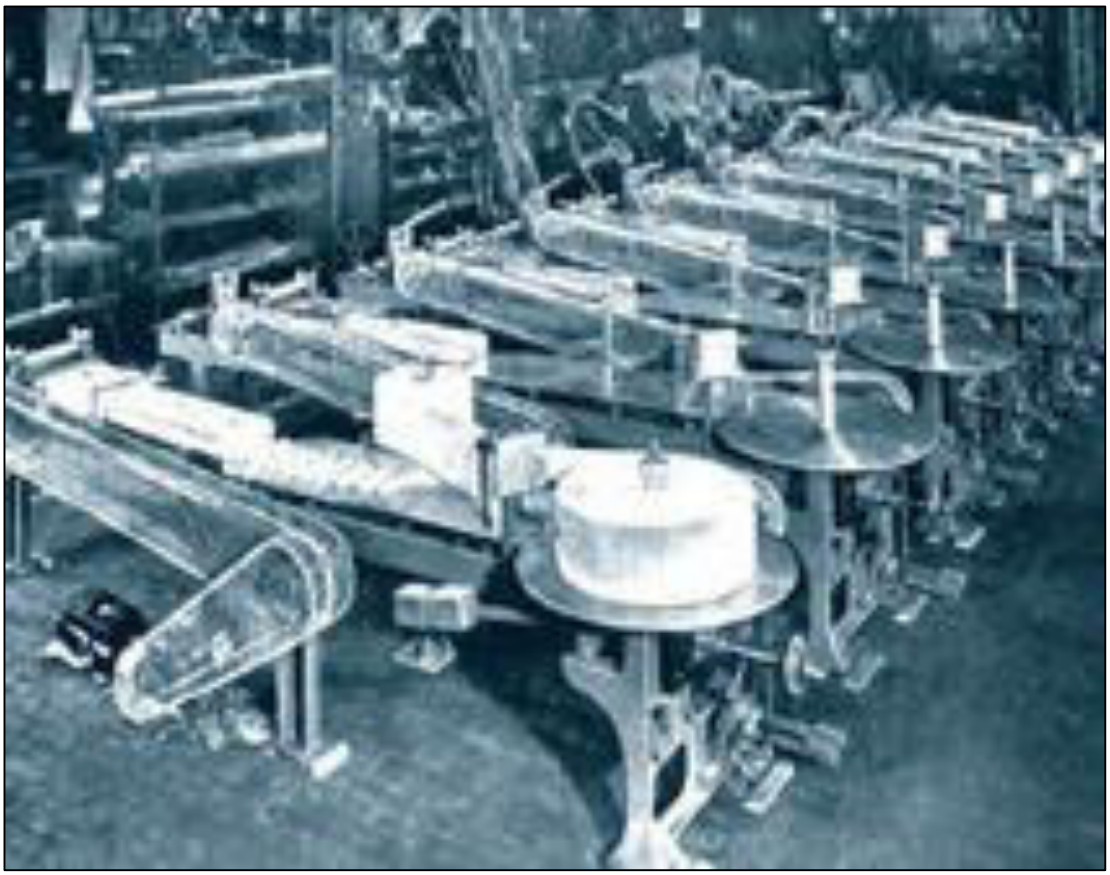
Batch of paper corrugating and scrolling machines ready for delivery to munitions filling factories



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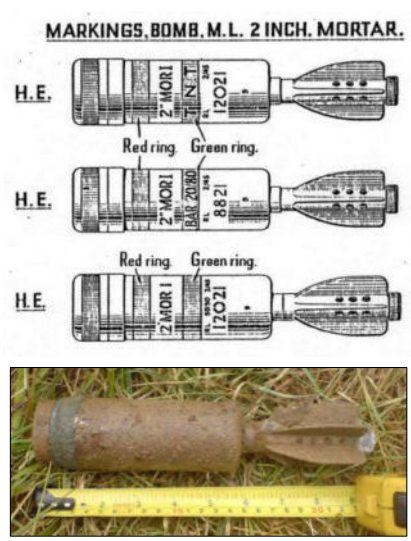
2 inch Mortar High Explosive

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





2 inch Mortar Smoke

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

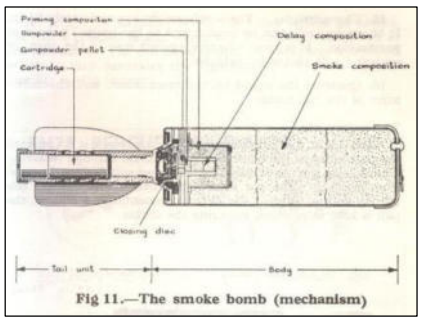
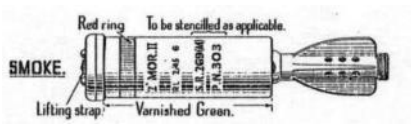


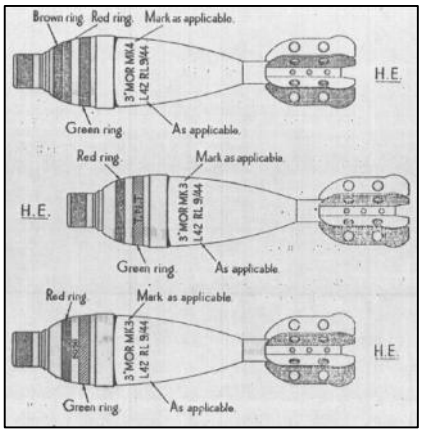
Fig 11.—The smoke bomb (mechanism)



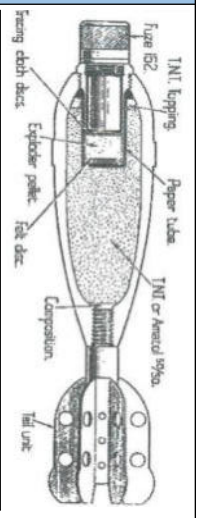


3 inch Mortar High Explosive

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







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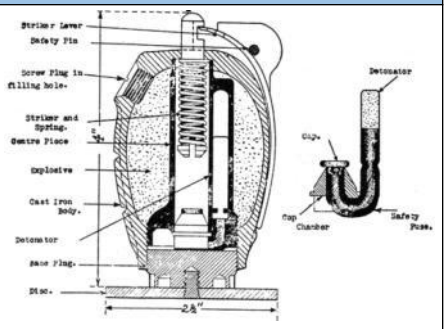
Examples of Land Service Ammunition – Grenades

Annex: **M2**

No. 36 'Mills' Grenade

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





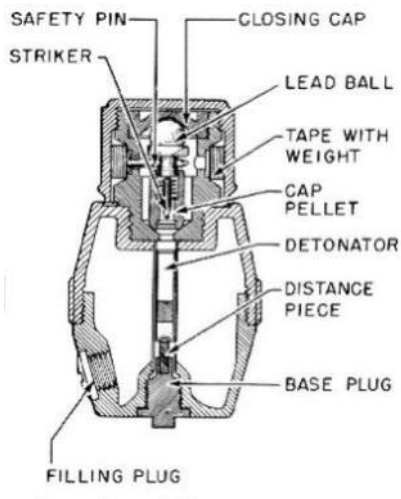


Left: baseplate and detonator removed

No. 69 Grenade

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

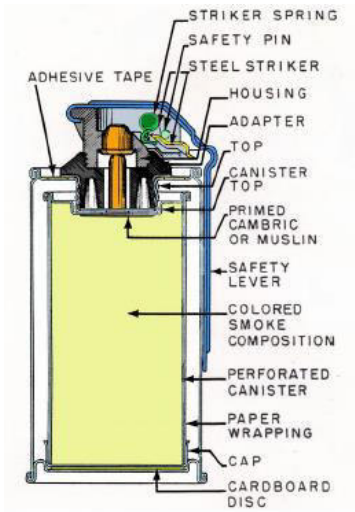




No. 83 Smoke Grenade

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





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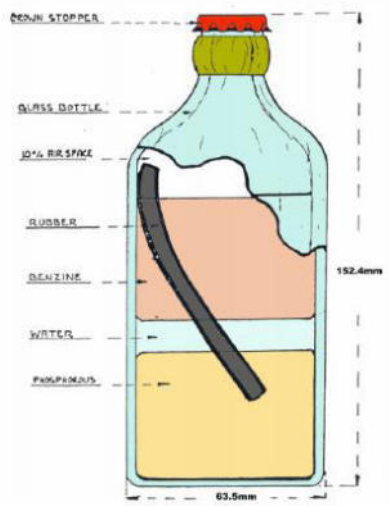
No. 76 Self Igniting Phosphorous (SIP) Grenade

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



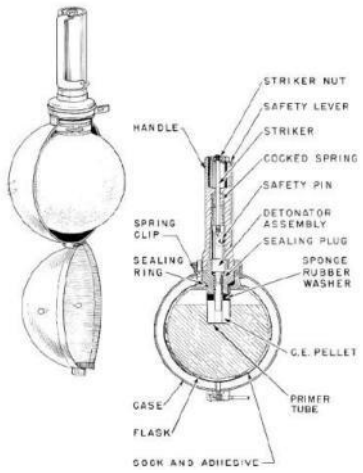


No. 74 Grenade ("Sticky Bomb") Mk1

Weight	Approx. 1.1kg (2.25lb)
Filling	Approx. 600g Nobel's No.283 (Nitro-glycerine) (1.33lb)
Design	A glass ball on the end of a Bakelite (plastic) handle. The inside of the ball would contain the explosive filling and the outside a very sticky adhesive coating.
Use	An anti-tank grenade primarily issued to the home guard. It required the user to come in very close proximity with the target and smash the glass explosive container against it.
Remarks	Timer fuze was located in the handle. This would explode after 3-6 secs. 9.5in Long 4.5in Diameter







Flame Fougasse Bomb

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





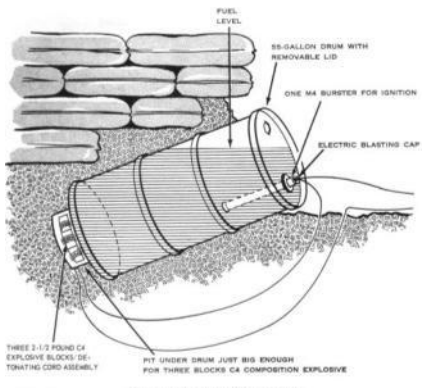


Figure 11. Flame fougasse (55-gallon drum).

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Examples of Small Arms Ammunition

Examples of British Small Arms Ammunition

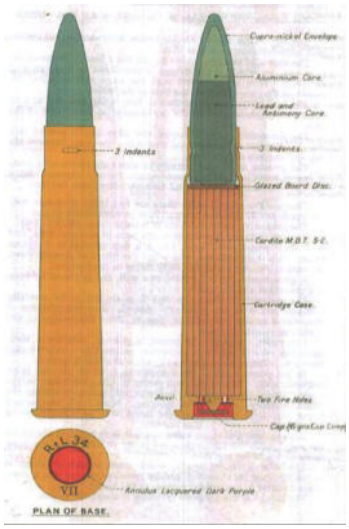


.303 Rifle

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

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





Buried and Decayed Ammunition





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Examples of Anti-Aircraft Projectiles

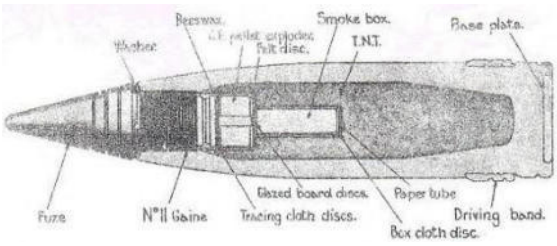
Annex: O

3.7 Inch QF Anti-Aircraft Projectile

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





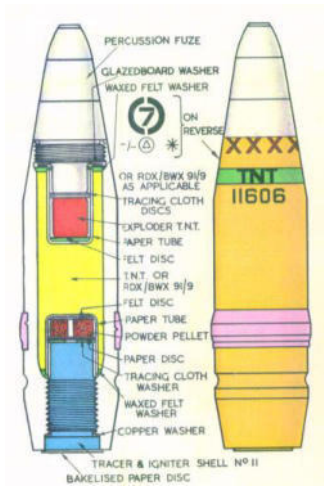


40mm Bofors Projectile

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



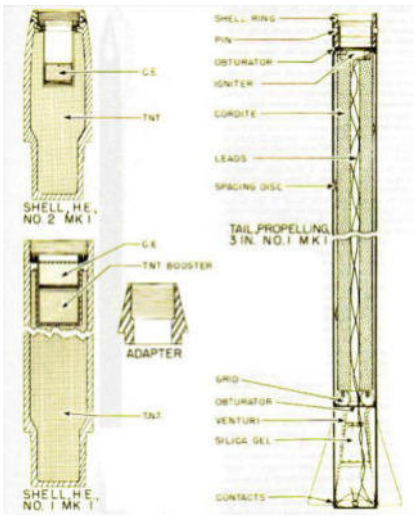




3in Unrotated Projectile (UP) Anti-Aircraft Rocket ("Z" Battery)

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





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Client: **TRC Companies Ltd**

Project: **Plot 2, Park Works, Manchester**

Ref: **DA12563-00**

Source: Various sources

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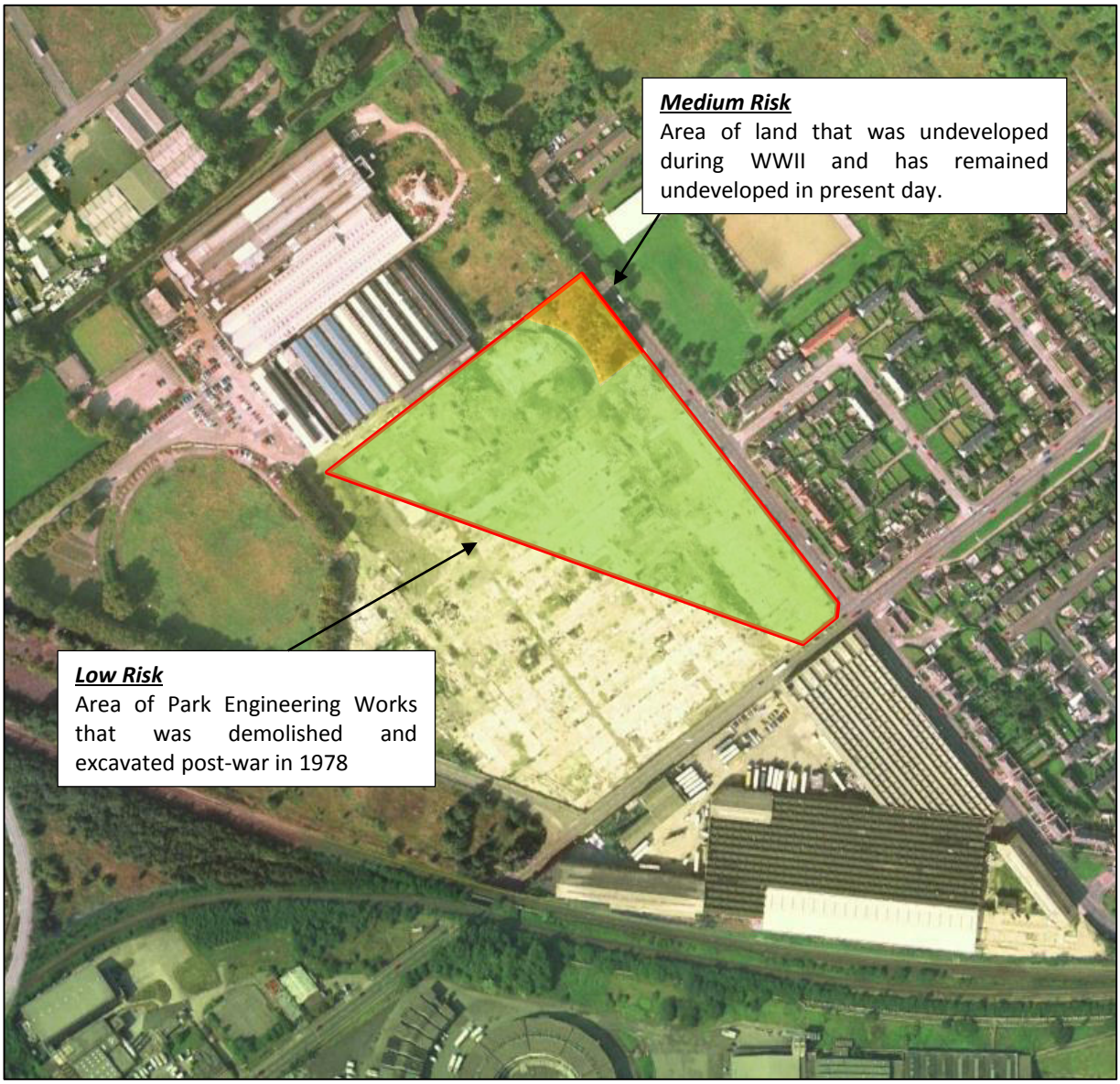
Risk Map – 2000 Imagery

Annex: **P**



For indicative purposes – not to scale

Low Risk

Medium Risk

All Risk Areas:

- Site Specific Unexploded Ordnance Awareness Briefings to all personnel conducting intrusive works

Medium Risk Area:

- Unexploded Ordnance (UXO) Specialist Presence on Site to support shallow intrusive works
- Intrusive Magnetometer Survey of all Borehole and pile locations down to a maximum bomb penetration depth

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Client: **TRC Companies Ltd**

Approximate site boundary

Project: **Plot 2, Park Works, Manchester**

Ref: **DA12563-00**

Source: 1st Line Defence

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Detailed Unexploded Ordnance (UXO) Risk Assessment

Project Name	Plot 1, Park Works, Manchester
Client	TRC Companies Ltd
Site Address	Plot 1, Park Works, Manchester, M40 2BA
Report Reference	DA12562-00
Date	28/01/21
Originator	SB

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Executive Summary

Site Location and Description

The site is located in Newton Heath, Manchester. Rochdale Canal borders the site in the north, with industrial structures along Bower Street situated opposite. To the east the site is bordered by scrubland adjacent to industrial structures, to the south by open grassland near to a railway and to the west by further industrial structures.

The site is currently occupied in its entirety by open ground and does not appear to serve any specific function.

The site is approximately centred on the OS grid reference: **SJ 86876 99936.**

Proposed Works

The exact nature of proposed works was not available at the time of writing, however, information provided by the client indicates the development on site will be of a commercial nature, providing employment opportunities.

Geology and Bomb Penetration Depth

The British Geological Survey (BGS) map shows Pennine Middle Coal Measures Formation - mudstone, siltstone and sandstone, of the Carboniferous Period. Local environment was previously dominated by swamps, estuaries and deltas. Superficial deposits include till, devensian – diamicton, of the Quaternary Period. Local environment was previously dominated by ice age conditions.

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

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

UXO Risk Assessment

1st Line Defence has assessed that there is an overall **Low Risk** from German and anti-aircraft unexploded ordnance at the site of proposed works. There is also an assessed **Low-Medium Risk** from Allied ordnance. This assessment is based on the following factors:

German Aerial Delivered Ordnance

- During WWII the site was located within the County Borough of Manchester, which according to Home Office bombing statistics sustained an overall low density of bombing, with 27.1 items of ordnance recorded per 1,000 acres. Anecdotal evidence suggests that even though there were possible railway and industrial targets in the area, there was very little bombing in Newton Heath, where the site is located, and it is thought that bombing in Manchester was more concentrated in the city centre and dock area.
- Pre-war OS mapping dated 1922-1932, indicates the site to consist entirely of open ground, likely associated with the industrial structures in close proximity. Post-war OS mapping dated 1951 denotes the site remained as open ground, serving as a sports ground.
- A Manchester bomb plot and damage map does not record any strikes within the site boundary or in its immediate vicinity with the closest recorded strike approximately 320m north-west and the closest recorded instance of damage a further 100m west of the boundary. Whilst this map is not considered to be entirely comprehensive, it does confirm the low localised density of bombing in the area. Additionally, no reference to bombing or damage at the Mather & Platt Park Engineering Works could be found in written records or published historical accounts.
- Whilst open areas of land can be of possible concern, post-war oblique photography dated 1953, indicates the site to have been well-maintained in good condition with no obvious signs of ground disturbances apparent. Due to the site's close proximity with industrial structures and function as a sports ground it is anticipated that the site would have been frequently accessed by the employees of the nearby premises. Given this, it is considered more likely that obvious indicators of UXO, such as entry holes and craters, would have been seen and recorded on site.
- In summary, the site is not considered to be at significant risk of German air-delivered UXO contamination. Whilst the risk of indicators of UXO going unnoticed within the open area of the site cannot be entirely discounted, evidence

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UXO Risk Assessment

suggests the recorded strikes and damage were too far removed to have affected the site area, whilst there is also no obvious positive evidence of bomb damage within or in proximity to the site boundary. The risk of contamination is therefore not considered to be any higher than the 'background level' for this area of the UK.

Allied Ordnance

- The surrounding industrial properties, 65m south-east, known formerly as the Mather & Platt Park Engineering Works, are understood to have become government run enterprises in both WWI and WWII. During both periods the works was requisitioned for the manufacture of ordnance components, other war related materials and the production of Avro 504 aeroplanes in association with the nearby Avro Works.
- Research suggests that during WWI Park Works was mainly involved in the manufacture of projectile casings and fuzes, as well as specialising in Howitzer (large calibre artillery guns) relining. During WWII the factory predominantly became known as a gun factory and was again used to produce ordnance components such as fuzes and weapon cases. Various munition parts such as rocket and anti-aircraft projectors, as well as cordite rolling mills were manufactured here. Due to the limitations of the available record it is assumed that Park Works may have produced an even greater diverse range of other wartime items and materials also.
- Munition components produced at Park Works are largely thought to have been subsequently transported to dedicated munition filling factories (known as ROF's) to be filled with explosives. Such items may however have been stored at the factory site prior to their transit. Given its significant wartime output and the variety of items made, the production and usage of explosives at the Park Factory also cannot be entirely discounted. The production of fuzes in particular would have entailed the production of a small explosive component and these types of item can still pose a health risk if disturbed today.
- The site itself appears to have formed a recreational area within the wider grounds of the former Park Works and was not situated directly adjacent to any of the works main structures. It is therefore not considered likely that the site area would have been chosen for the storage, testing, or disposal of ordnance, although this possibility cannot be entirely discounted. Especially as records of such practice were rarely kept.
- Subsequently, because structures in the wider site area are known to have been utilised to produce various ordnance components throughout both WWI and WWII, there is considered to be a slightly elevated risk of Allied UXO at the site of proposed works. Whilst this type of ordnance manufacture may not have occurred directly within the site boundary, due to the proximity of the site to these structures it is not inconceivable that ordnance may have been disposed of within the site area. However as the site was not situated directly adjacent to the main factory buildings and was used recreationally, this risk is not considered to be significant enough to warrant proactive UXO risk mitigation measures. UXO awareness briefings are instead advised as a precautionary measure.

Post-War Redevelopment

- Post-war the site has seen no significant development and is still occupied by an area of open ground. The risk of UXO remaining is only considered to be mitigated at the location of and down to the depth of any post-war redevelopment on site. Within the footprints of post-WWII redevelopments, the risk from shallow-buried UXO (especially Allied items/components) should have been encountered/removed during initial excavations. The risk will remain within virgin geology below and amongst these post-war works.

Recommended Risk Mitigation Measures

The following risk mitigation measures are recommended to support the proposed works at the Plot 1, Park Works, Manchester site:

All Works

- UXO Risk Management Plan
- Site Specific UXO Awareness Briefings to all personnel conducting intrusive works.

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Glossary

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

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

Site: Plot 1, Park Works, Manchester
Client: TRC Companies Ltd

1. Introduction

1.1. Background

1st Line Defence has been commissioned by TRC Companies Ltd to conduct a Detailed Unexploded Ordnance (UXO) Risk Assessment for the works proposed at the Plot 1, Park Works, Manchester site.

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

UXO in the UK can originate from three principal sources:

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

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

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

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2. Method Statement

2.1. Report Objectives

The aim of this report is to conduct a comprehensive assessment of the potential risk from UXO at Plot 1, Park Works, Manchester. The report will also recommend appropriate site and work-specific risk mitigation measures to reduce the risk from explosive ordnance during the envisaged works to a level that is as low as reasonably practicable.

2.2. Risk Assessment Process

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

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

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

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

2.3. Sources of Information

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

- The National Archives and Manchester Central Library.
- Historical mapping datasets.
- Historic England National Monuments Record.
- Relevant information supplied by TRC Companies Ltd.
- Available material from 33 Engineer Regiment (EOD) Archive (now 28 Regt).
- 1st Line Defence's extensive historical archives, library and UXO geo-datasets.
- Open sources such as published books and internet resources.

Research involved a visit to The National Archives and Manchester Central Library.

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3. Background to Bombing Records

3.1. General Considerations of Historical Research

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

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

3.2. German Bombing Records

During WWII, bombing records were generally gathered locally by the police, Air Raid Precaution (ARP) wardens and military personnel. These records typically contained information such as the date, the location, the amount of damage caused and the types of bombs that had fallen during an air raid. This information was made either through direct observation or post-raid surveys. The Ministry of Home Security Bomb Census Organisation would then receive this information, which was plotted onto maps, charts, and tracing sheets by regional technical officers. The collective record set (regional bomb census mapping and locally gathered incidents records) would then be processed and summarised into reports by the Ministry of Home Security Research and Experiments Branch. The latter were tasked with providing the government 'a complete picture of air raid patterns, types of weapons used and damage caused- in particular to strategic services and installations such as railways, shipyards, factories and public utilities.'[1]

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

3.3. Allied Records

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

[1] http://www.nationalarchives.gov.uk/help-with-your-research/research-guides/bomb-census-survey-records-1940-1945/.

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4. UK Regulatory Environment and Guidelines

4.1. General

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

4.2. CDM Regulations 2015

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

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

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

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

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

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

4.4. CIRIA C681

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

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

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recommended that this document is acquired and studied where possible to allow a better understanding of the background to both the risk assessment process and the UXO issue in the UK in general.

4.5. Additional Legislation

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

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5. The Role of Commercial UXO Contractors and The Authorities

5.1. Commercial UXO Specialists

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

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

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

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

5.2. The Authorities

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

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

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

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

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6. The Site

6.1. Site Location

The site is located in Newton Heath, Manchester. Rochdale Canal borders the site in the north, with industrial structures along Bower Street situated opposite. To the east the site is bordered by scrubland adjacent to industrial structures, to the south by open grassland near to a railway and to the west by further industrial structures.

The site is approximately centred on the OS grid reference: **SJ 86876 99936.**

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

6.2. Site Description

The site is currently occupied in its entirety by open ground and does not appear to serve any specific function.

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

7. Scope of the Proposed Works

7.1. General

The exact nature of proposed works was not available at the time of writing, however, information provided by the client indicates the development on site will be of a commercial nature, providing employment opportunities.

8. Ground Conditions

8.1. General Geology

The British Geological Survey (BGS) map shows Pennine Middle Coal Measures Formation - mudstone, siltstone and sandstone, of the Carboniferous Period. Local environment was previously dominated by swamps, estuaries and deltas. Superficial deposits include till, devensian – diamicton, of the Quaternary Period. Local environment was previously dominated by ice age conditions.

8.2. Site Specific Geology

Site specific window sample data has been provided by TRC Companies Ltd. See below for a brief typical example of the geology encountered.

Example Window Sample	
Depth (m)	**Description**
0-0.3	Made Ground – grassy
0.3-1.6	Made Ground – brown and orange brown gravelly fine to coarse sand
1.6-2	Made Ground – stiff brown mottled grey slightly gravelly sandy clay
2-4	Clay – firm brown mottled grey slightly gravelly sandy

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9. Site History

9.1. Introduction

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

9.2. Summary of the Historical Background of the Site

Since the 1900s the local area of the site has been occupied by the Mather and Platt Park Engineering Works (also known as the Park Works). The factory was famous for its contribution to the textile industry, and would manufacture items such as electrical pumps and generators. At the outbreak of war the factory came under control of the government in order to meet the demand for munitions. See **Section 13.2** for further information on the locality's wartime usage. Much of the factory was demolished in the 1990s with the foundry and main office building remaining in present day.

9.3. Ordnance Survey Historical Maps

Relevant historical maps were obtained for this report and are presented in **Annex D.** See below for a summary of the site history shown on acquired mapping.

Pre-WWII		
Date	**Scale**	**Description**
1922-1932	1:2,500	Pre-war OS mapping dated 1922-1932 appears to show the site boundary to consist entirely of open ground with a small structure located in the southern-eastern section of the site. The site is bordered to the north by *Rochdale Canal* and *Grimshaw Lane Bridge*, to the east by open ground and structures associated with *Park Engineering Works,* to the south by further open ground along Grimshaw Lane as well as railway, whilst the site is bordered to the west by a *Dye Works* and *Gas Plant Works* along Grimshaw Lane.

Post-WWII		
Date	**Scale**	**Description**
1951	1:2,500	Post-war OS mapping dated 1951, indicates the site was occupied by open ground in the form of a Sports Ground, with trees lining the perimeter of the site boundary. A *Bowling Green* is located to the immediate east of the site, whilst an additional *Sports Ground* and *Running Track* is located to the immediate south of the site boundary. Remaining surrounding areas appear to have maintained their pre-war composition.

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9.4. Pre-WWII Photography of the Site

Pre-WWII aerial photography has been obtained from the Aerofilms collection available from *Britain From Above*. This imagery provides a view of the site in 1932 (see **Annex E**). See below for a description:

Title of Photograph	Comments
1932 – Park Engineering Works and Environs, Newton Heath	This photography dated 1932, shows the site to consist of open ground with a small structure located in the south-eastern section of the site. Rochdale Canal borders the site to the immediate north, whilst structures associated with Mather & Platt Park Engineering Works are located to the south-east of the site boundary, with the Avro Aeroplane Factory located further south-east. A company cricket field for Mather & Platt employees is located to the immediate south of the site boundary, whilst Grimshaw Lane is located to the south-west of the site boundary.

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10. Introduction to German Aerial Delivered Ordnance

10.1. General

During WWI and WWII, the UK was 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 the nature of bombing techniques often resulted in neighbouring areas to targets sustaining collateral damage.

In addition to raids which concentrated on specific targets, indiscriminate bombing of large areas also took place. This occurred most prominently in the London 'Blitz', though affected 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. Although 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 research for this section of the report will concern German aerial delivered ordnance dropped during WWII, although WWI bombing will also be considered.

10.2. Generic Types of WWII German Aerial Delivered Ordnance

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

Generic Types of WWII German Aerial Delivered Ordnance		
Type	**Frequency**	**Likelihood of detection**
High Explosive (HE) bombs	In terms of weight of ordnance dropped, HE bombs were the most frequently deployed by the Luftwaffe during WWII.	Although efforts were made to identify the presence of unexploded ordnance following an air raid, often the damage and destruction caused by detonated bombs made observation of UXB entry holes impossible. The entry hole of an unexploded bomb can be as little as 20cm in diameter and was easily overlooked in certain ground conditions (see **Annex F1**). Furthermore, ARP documents describe the danger of assuming that damage, actually caused by a large UXB, was due to an exploded smaller bomb. UXBs therefore present the greatest risk to present–day intrusive works.
1kg Incendiary bombs (IB)	In terms of the number of weapons dropped, small IBs were the most numerous. Millions of these were dropped throughout WWII.	IBs had very limited penetration capability and in urban areas would often have been located in post-raid surveys. If they failed to initiate and fell in water, on soft vegetated ground, or bombed rubble, they could easily go unnoticed.
Large Incendiary bombs (IB)	These were not as common as the 1kg IBs, although they were more frequently deployed than PMs and AP bomblets.	If large IBs did penetrate the ground, complete combustion did not always occur and in such cases they could remain a risk to intrusive works.
Aerial or Parachute mines (PM)	These were deployed less frequently than HE and IBs due to size, cost and the difficulty of deployment.	If functioning correctly, PMs would generally have had a slow rate of descent and were very unlikely to have penetrated the ground. Where the parachute failed, mines would have simply shattered on impact if the main charge failed to explode. There have been extreme cases when these items have been found unexploded. However, in these scenarios, the ground was either extremely soft or the munition fell into water.
Anti-personnel (AP) bomblets	These were not commonly used and are generally considered to pose a low risk to most works in the UK.	SD2 bomblets were packed into containers holding between 6 and 108 submunitions. They had little ground penetration ability and should have been located by the post-raid survey unless they fell into water, dense vegetation or bomb rubble.

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10.3. Failure Rate of German Aerial Delivered Ordnance

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

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

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

10.4. UXB Ground Penetration

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

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

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

10.4.1. The J-Curve Effect

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

10.4.2. WWII UXB Ground Penetration Studies

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

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

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10.4.3. Site Specific Bomb Penetration Considerations

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

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

It has not been possible to determine maximum bomb penetration capabilities at this stage due to the limitations of site-specific geotechnical information currently available. Specifically data provided is not deep enough for an accurate assessment (see Section 8.2). If required, an assessment can be made once further information becomes available or by an UXO Specialist on-site.

10.5. V-Weapons

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

Although these weapons caused considerable damage, their range was limited by their position of deployment across Europe and as a result the vast majority of V-weapon strikes were directed against targets in the south-east of England, predominantly in the London Boroughs and Home Counties. This limitation of capability meant targets in Manchester were generally too far to be considered for V-weapon strikes by the Luftwaffe.

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

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11. The Likelihood of Contamination from German Aerial Delivered UXBs

11.1. World War I

During WWI Britain was targeted and bombed by Zeppelin Airships, as well as Gotha and Giant fixed-wing aircraft. A WWI map of air raids and naval bombardments across England is presented in **Annex I**. This source does not record any WWI bombing incidents to have affected the site.

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

11.2. World War II Bombing of the County Borough of Manchester

The Luftwaffe's main objective for the attacks on Britain was to inhibit the country's economic and military capability. To achieve this they targeted airfields, depots, docks, warehouses, wharves, railway lines, factories, and power stations. As the war progressed the Luftwaffe bombing campaign expanded to include the indiscriminate bombing of civilian areas in an attempt to subvert public morale.

During WWII the site was located within the County Borough of Manchester, which sustained an overall low-moderate density of bombing, as represented by bombing density figures, see the following section. Manchester was not targeted with the same intensity and frequency as other major British cities such as Liverpool, Coventry and Birmingham, however it was still subject to several major raids. Manchester's Blitz was commonly called the 'Christmas Blitz' – the heaviest raids occurred on the nights of 22/23 and 23/24 December 1940, killing an estimated 684 people and injuring 2,364.

There were several Luftwaffe targets located in Manchester. Newton Heath Train Maintenance Depot was located approximately 2.2km north of this target and due to its size and composition, may have formed a potential Luftwaffe target in its own right. Wartime targeting systems did however tend to be inaccurate and consequently neighbouring targets would often sustain collateral bombing. Manchester was protected by a number of barrage balloons which forced aircraft to approach their targets at higher altitudes – reducing bomb accuracy.

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

Records of bombing incidents for Manchester are presented in the following sections.

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11.3. WWII Home Office Bombing Statistics

The following table summarises the quantity of German aerial delivered bombs (excluding 1kg incendiaries and anti-personnel bombs) dropped on the County Borough of Manchester between 1940 and 1945.

Record of German Ordnance Dropped on the County Borough of Manchester		
Area Acreage		**27,255**
Weapons	High Explosive bombs (all types)	712
	Parachute mines	18
	Oil bombs	7
	Phosphorus bombs	0
	Fire pots	0
	Pilotless aircraft (V-1)	1
	Long range rocket bombs (V-2)	0
Total		**738**
Number of Items per 1,000 acres		**27.1**

Source: Home Office Statistics
This table does not include UXO found during or after WWII.

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

11.4. Manchester Bomb Plot and Damage Map

A bomb census map complied by Manchester City Council showing high explosive and incendiary bomb strikes on the borough was obtained from Manchester Archives. This primarily concerned the 'Manchester Blitz' period of 22nd-24th December 1940, though it records various other incidents occurring on different dates in 1940 and 1941. The section showing the area of the site is presented in **Annex J**.

Manchester Bomb Plot and Damage Map – Annex J	
Date Range	**Comments**
1940 – 1941	No bomb strikes are recorded within the site boundary or in the immediate surrounding area of the site footprint. Although, the site footprint is not occupied with structures and largely comprises open ground (no structures exist for damage to be attested to). The closest recorded HE bomb strike is located approximately 320m north-west of the site boundary concerning structures associated with the Gas Plant Works. Damage is recorded in the wider vicinity of the site, approximately 100m west of the site boundary concerning industrial structures associated with Dye Works along Grimshaw Lane.

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11.5. Anecdotal Account of Newton Heath at War

An anecdotal account, from the BBC website 'WWII People's War', was found concerning the wartime activity of a local resident[2]. See the extract below:

'When the night raids started we all thought we would get a good share of bombs, if only for the railway yards target. But also up the road about 2 miles was the large Avro aircraft factory and we were in the middle….As it turned out we didn't get many bombs around us. This was probably due to the presence of four huge anti-aircraft guns, of 4" calibre I think, installed on Broadhurst Fields about half a mile away, complete with searchlight battery. A bit more of a favourite playground lost, but as youngsters we were completely enthralled at the sight of them, and it was very comforting during a raid to hear the deafening crump of the big guns'. [3]

Whilst this source cannot be considered a definitive account, it would suggest that the frequency and density of bombing was relatively low in the locality of the site location.

11.6. Manchester Emergency Committee's Log of Bombing Incidents 22-24th December 1940

The published source *Blitz Britain: Manchester and Salford* by Graham Phythian presents a transcript of the document 'Manchester Emergency Committee's Log of Bombing Incidents 22-24th December 1940' (hence covering the 'Manchester Blitz' period). This is stated to have been obtained from the Emergency Committee Records/Police Museum and Archives, though it was not possible to obtain the original documents. No references could be found to the nearby *Park Engineer Works*, or surrounding roadways.

11.7. Red Sky Over Manchester

Our Blitz, Red Sky over Manchester is an illustrated booklet published in January 1941 that documented the 'Christmas Blitz' on Manchester in December 1940. This publication indicates that between 2nd and 3rd October 1940, houses on Grimshaw Lane, Newton Heath were demolished.[4] There is no reference to the site area or the nearby *Park Engineering Works*.

11.8. Manchester Air Raid Damage Files

Air Raid Damage files for Manchester were obtained from The National Archives. These reports recorded information such as the date, time, type and damage caused by major bomb incidents in Manchester and are therefore not often comprehensive. No relevant information regarding the site area could be located.

11.9. Manchester War Damage to Houses Cards.

War damage cards were obtained from Manchester Central Library. These contain an alphabetical list of road names, indicating the house number, date, category of damage, and any other relevant particulars. Whilst no key has been provided, it has been assumed that 'classification' refers to the significance of damage, with 'A' being total destruction, 'B' being serious damage, etc. This record set does not record damage to structures in the immediate area of the site.

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[2] *https://www.bbc.co.uk/history/ww2peopleswar/stories/43/a2413243.shtml*
[3] *http://www.bbc.co.uk/history/ww2peopleswar/stories/43/a2413243.shtml*
[4] *https://issuu.com/cyberbadger/docs/our-blitz_red_sky_over_manchester*

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11.10. Post WWII-Era Aerial Photography

Post WWII-era aerial photography for the site area was obtained from the Aerofilms Collection available from *Britain from Above*. This photography provides a record of the potential composition of the site during the war, as well as its condition immediately following the war (**see Annex K**).

WWII-Era Aerial Photography	
Date	**Description**
1953 – R & J Dempster Ltd Gas Plant Works and Environs, Newton Heath	Post-war oblique photography dated 1953, indicates the site boundary to consist of a well-maintained area of open recreational ground. Rochdale Canal borders the site to the immediate north as well as industrial structures associated with the Gas Plant Works further north, whilst structures associated with Mather & Platt Park Engineering Works are located to the south-east of the site boundary, with Avro Aeroplane Factory located further south-east. A company cricket field for Mather & Platt employees is located to the immediate south of the site boundary, whilst Grimshaw Lane is located to the south-west of the site boundary. A Dye Works borders the site to west.

11.11. Abandoned Bombs

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

11.12. Bomb Disposal Tasks

The information service from the Explosive Ordnance Disposal (EOD) Archive Information Office at 33 Engineer Regiment (EOD) (now 29 Regt) 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 TRC Companies Ltd will be advised.

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11.13. Evaluation of German Aerial Delivered UXO Records

Factors	Conclusion
Density of Bombing *It is important to consider the bombing density when assessing the possibility that UXBs remain in an area. High bombing density could allow for error in record keeping due to extreme damage caused to the area.*	During WWII, the site was situated in the County Borough of Manchester which was subject to a low-moderate density of bombing according to Home Office statistics, with an average of 27 incidents recorded per 1,000 acres. Anecdotal evidence suggests that despite prominent industrial fixtures in the area of Newton Heath, such as the Avro Factory, the local bombing density was considered to be lower. This is supported by the Manchester Bomb Plot and Damage Mapping which focuses on bombing incidents in Manchester during the main Blitz period between 1940 and 1941. No strikes are recorded within the site boundary or within its immediate surroundings, with the closest recorded HE bomb strike located approximately 320m north-west of the site boundary concerning structures associated with the Gas Plant Works. Comprehensive histories of the nearby Mather & Platt's Park Engineering Works were also consulted and no reference of bombing to the factory or immediate surrounds could be found.
Damage *If buildings or structures on a site sustained bomb or fire damage, any resulting rubble and debris could have obscured the entry holes of unexploded bombs dropped during the same or later raids. Similarly, a high explosive bomb strike in an area of open agricultural land will have caused soil disturbance, increasing the risk that a UXB entry hole would be overlooked.*	The Manchester Bomb/Damage Mapping does not record any damage on site or to any structures within the immediate surrounding area. The closest recorded instances of damage are located approximately 100m west of the site concerning structures associated with a Dye Works. It should be noted however, no structures were present on site pre and post-war and this mapping only attributes damage to structures. 1953 oblique aerial photography indicates the open ground within the site boundary to be reasonably well-maintained in its function as a sports ground. No obvious signs of damage is apparent on site or to structures within the wider area of the site.
Ground Cover *The nature of the ground cover present during WWII would have a substantial influence on any visual indication that may indicate UXO being present.*	The site was occupied in its entirety by open ground. 1932 oblique aerial imagery indicates the site to have consisted of open ground with little purpose, whereas 1953 oblique aerial imagery shows the site to be relatively well-maintained in fulfilling its function as a sports ground. Had the open areas been subject to regular maintenance, as may have been the case here due to its potential occupation as a sports ground for employees of the industrial r premises in the vicinity, it is considered more probable that evidence of unexploded bombs would have been noted and reported. However, as with all open areas, this can never be guaranteed. Overall however, ground cover here should have been more favourable to UXO detection than for example land which was entirely unused, such as gardens of destroyed and abandoned properties, marsh/scrubland etc.

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Access Frequency *UXO in locations where access was irregular would have a greater chance of passing unnoticed than at those that were regularly occupied. The importance of a site to the war effort is also an important consideration as such sites are likely to have been both frequently visited and subject to post- raid checks for evidence of UXO.*	No reason could be found to suggest that the site would not have been subject to frequent and regular access throughout the war, as the site was occupied by open recreational ground in close proximity to Mather & Platt Park Engineering Works, which appears to have survived the war undamaged. Whilst the open areas of the site boundary would likely have been subject to less checks and access than the Mather & Platt Park Engineering Works and additional industrial structures itself, they should still have been subject to monitoring and at least somewhat frequent access. It may be noted however that the discovery of UXO in the open areas would have generally relied on the vigilance of the Mather & Platt Park Engineering Works employees as well as employees of neighbouring industrial companies.
Bomb Failure Rate	There is no evidence to suggest that the bomb failure rate in the locality of the site would have been dissimilar to the 10% normally used.
Abandoned Bombs	1st Line Defence holds no records of abandoned bombs at or within the site vicinity.
Bombing Decoy sites	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.

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12. Introduction to Allied Explosive Ordnance

12.1. General

Many areas across the UK may be at risk from Allied UXO because of both wartime and peacetime military use. Typical military activities and uses that may have led to a legacy of military UXO at a site include former minefields, home guard positions, anti-aircraft emplacements, training and firing ranges, military camps, as well as weapons manufacture and storage areas.

Although land formerly used by the military was usually subject to clearance before returned to civilian use, items of UXO are sometimes discovered and can present a potential risk to construction projects.

This section of the report discusses the generic types of Allied ordnance typically encountered on areas associated with former military activity.

12.2. Land Service Ammunition

Mather & Platt Park Engineering Works became a government controlled enterprise throughout both WWI and WWII and produced munition components such as projectile casings and fuzes, as well as a range of other war related materials (see Section 13.2 for more information). Whilst no positive evidence of LSA production was found at Park Works, the variety of items produced is known to have been vast, and as such cannot be discounted.

The term LSA covers items of ordnance that are propelled, placed, or thrown during land warfare. These items may be filled or charged with explosives, smoke, incendiary, or pyrotechnics and can be divided into five main groups:

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

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In the UK unexploded or partially exploded mortars and grenades are the most common items of LSA encountered, as they could be transported and utilised anywhere. They are mostly encountered in areas used for military training and are often found discarded on or near historical military bases. Images of the most commonly found items of LSA are presented in **Annex M.**

12.3. Small Arms Ammunition

It is also conceivable that Small Arms Ammunition (SAA) was produced at the Mather & Platt Park Engineering Works, although no positive evidence has been found to support this. SAA refers to the complete round or cartridge designed to be discharged from varying sized hand-held weapons such as rifles, machine guns and pistols. SAA can include bullets, cartridge cases and primers/caps.

12.4. Defending the UK From Aerial Attack

During WWII the War Office employed a number of defence tactics against the Luftwaffe from bombing major towns, cities, manufacturing areas, ports and airfields. These can be divided into passive and active defences (examples are provided in the table below).

Active Defences	Passive Defences
• Anti-aircraft gun emplacements to engage enemy aircraft. • Fighter aircraft to act as interceptors. • Rockets and missiles were used later during WWII.	• Blackouts and camouflaging to hinder the identification of Luftwaffe targets. • Decoy sites were located away from targets and used dummy buildings and lighting to replicate urban, military, or industrial areas. • Barrage balloons forced enemy aircraft to greater altitudes. • Searchlights were often used to track and divert adversary bomber crews during night raids.

Active defences such as anti-aircraft artillery present a greater risk of UXO contamination than passive defences. Unexploded ordnance resulting from dogfights and fighter interceptors is rarely encountered and difficult to accurately qualify.

12.4.1. Anti-Aircraft Artillery (AAA)

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

Anti-Aircraft Artillery	
Item	**Description**
HAA	These large calibre guns such as the 3.7" QF (Quick Firing) were used to engage high flying enemy bombers. They often fired large HE projectiles, which were usually initiated by integral fuzes, triggered by impact, area, time delay or a combination of aforementioned mechanisms.
LAA	These mobile guns were intended to engage fast, low flying aircraft. They were typically rotated between locations on the perimeters of towns and strategically important industrial works. As they could be moved to new positions with relative ease when required, records of their locations are limited. The most numerous of these were the 40mm Bofors gun which could fire up to 120 x 40mm HE projectiles per minute to over 1,800m.

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Variations in HAA and LSA Ammunition	**Gun type**	**Calibre**	**Shell Weight**	**Shell Dimensions**
	3.0 Inch	76mm	7.3kg	76mm x 356mm
	3.7 Inch	94mm	12.7kg	94mm x 438mm
	4.5 Inch	114mm	24.7kg	114mm x 578mm
	40mm	40mm	0.9kg	40mm x 311mm
Z-AA	The three inch unrotated rocket/projectile known as the UP-3 had initially been developed for the Royal Navy. The UP-3 was also used in ground-based single and 128-round launchers known as ''Z'' batteries. The rocket, containing a high explosive warhead was often propelled by cordite.			

The closest recorded HAA to the site was located approximately 1.8km north-west of the site, however the range of a projectile can be up to 15km. The site would also have been in range of mobile light anti-aircraft guns.

The conditions in which anti-aircraft projectiles may have fallen unnoticed within a site area are analogous to those regarding aerial delivered ordnance. Unexploded anti-aircraft projectiles could essentially have fallen indiscriminately anywhere within range of the guns. The chance of such items being observed, reported and removed during the war depends on factors such as land use, ground cover, damage and frequency of access – the same factors that govern whether evidence of a UXB is likely to have been noted. More information about these factors with regards to this particular site can be found in the German Aerial Delivered Ordnance section of this report.

Illustrations of Anti-Aircraft artillery, projectiles and rockets are presented at **Annex O**.

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13. The Likelihood of Contamination from Allied Ordnance

13.1. Introduction

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

- The clearance of ordnance from depots, storage facilities etc. were not always effectively managed, or undertaken to equivalent degrees of certainty. In addition, search and detection equipment used over seventy years ago following WWII has proved ineffective both for certain types of UXO and at depths beyond capability.
- During periods of heightened activity, ordnance was sometimes lost in transit, particularly between stores and assigned locations.
- Appropriate ordnance disposal procedure was not always adhered to. It was not uncommon for excess or unwanted ordnance to be buried or burnt within the perimeters of a weapon's production establishment as a means of disposal. Records of such practice were rarely kept.

There are several factors that may serve to either affirm, increase, or decrease the level of risk within a site with a history of military usage. Such factors are typically dependent upon the proximity of the proposed area of works to training activities, munition productions and storage, as well as its function across the years.

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

13.2. Wartime Production at the Mather & Platt Park Engineering Works

The site is located 65m from structures associated with the Mather & Platt Park Engineering Works in Newton Heath, Manchester. It is understood that the Park Works was requisitioned by the Government and the Ministry of Munitions during both WWI and WWII. It was commonplace for such factories to be requisitioned and overhauled from their peacetime productions in order to meet the surge in demand for munitions and other war related products during wartime.

During WWI, and until 1947, a portion of the factory was used to help with the production of Avro aircraft, such as the Avro 504s – a First World War biplane. Other types of aircraft later built at Newton Heath included three-engine aircraft such as the Avro Five, Six and Eighteen, the Avro 621 Tutor and the Avro 652A Anson. The Avro Factory was located south east of the proposed site, and on the outbreak of war required more space in order to produce larger quantities, so A. V Roe was offered a lease of bays in the Park Works factory in order to meet demand, See **Annex L1**. [5]

However, it was in 1915 the factory became controlled under the Munitions of War Act, and began to produce a range of munition components including 'large quantities' of projectile casings and fuzes for the war effort, and a department specialising in Howitzer relining was established. (A Howitzer is a large calibre artillery gun for long range indirect fire, and the factory is thought to have been responsible for the reconditioning of the barrels of older guns.) In addition to munition components, throughout WWI the factory produced other items such as motors for submarines and gear boxes for tanks. An electrolyser machine was also built here in the hopes of eradicating typhoid on ships. [6]

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[5] *https://www.baesystems.com/en/heritage/brownsfield-mill--newton-heath--alexandra-park--yeandon--hamble--trafford-park--failsworth-and-ashton-under-lyne*

[6] *https://sites.google.com/site/thebookofthejubilee1958/a-history-of-mather-and-platt-limited*

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At the outbreak of WWII the factory was again requisitioned by the Government and was used to produce a multitude of munition and weapon components. Projectile casings, were again manufactured here. In addition, fuzes were also manufactured in the factory, along with aircraft fuselage and pumps which understood to have been produced on masse. Sources suggest that Park Works became a known gun factory throughout WWII, and produced gun mountings, Bofors predictors, rocket projectors and cordite rolling mills. [7] Bofors predictors were used in Heavy Anti-Aircraft Batteries, whilst rocket projectors were more commonly used in Z Batteries. Its recorded that few engineering firms in the world could rival the diversified production of Mather and Platt during this time, See **Annex L**.

[7] https://sites.google.com/site/historyofmatherplattltd/

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13.3. Evaluation of Contamination Risk from Allied UXO

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

Sources of Allied UXO Contamination	Conclusion
Military Camps *Military camps present an elevated risk from ordnance simply due to the large military presence and likelihood of associated live ordnance training.*	1st Line Defence could find no evidence of a military camp within the site.
Anti-Aircraft Defences *Anti-Aircraft defences were employed across the country. Proximity to anti-aircraft defences increases the chance of encountering AA projectiles.*	1st Line Defence could find no evidence of Anti-Aircraft defences such as a HAA or LAA gun emplacement occupying or bordering the site. The closest HAA was located approximately 1.8km north-west of the site, however the range of a projectile can be up to 15km. The conditions in which HAA or LAA projectiles may have fallen unnoticed within a site footprint are analogous to those regarding German aerial delivered ordnance.
Home Guard Activity *The Home Guard regularly undertook training and ordnance practice in open areas, as well as burying ordnance as part of anti-invasion defences.*	1st Line Defence has no evidence of any Home Guard activities on the site.
Defensive Positions *Defensive positions suggest the presence of military activity, which is often indicative of ordnance storage, usage or disposal.*	There is no evidence of any defensive features formerly located on or bordering the site footprint.
Training or firing ranges *Areas of ordnance training saw historical ordnance usage in large numbers, often with inadequate disposal of expended and live items. The presence of these ranges significantly impact on the risk of encountering items of ordnance in their vicinity.*	There is no evidence of such features affecting the site.
Defensive Minefields *Minefields were placed in strategic areas to defend the country in the event of a German invasion. Minefields were not always cleared with an appropriate level of vigilance.*	There is no evidence of defensive minefields affecting the site.

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Ordnance Manufacture *Ordnance manufacture indicates an increased chance that items of ordnance were stored, or disposed of, within a location.*	The site of proposed works is known to have been in proximity of structures associated with historical ordnance manufacture activities. In both WWI and WWII Park Works became a Government owned enterprise to produce munition components for the war effort. Whilst it is not possible to determine exactly where in the Park Works ordnance manufacture had taken place, it must be considered a possibility that it may have occurred in factory structures in the surroundings of the site boundary. Evidence indicates that a range of munition components and weapon parts were manufactured at the nearby Park Engineering Works. Items such as projectile casings and fuzes were produced. Whilst such items are predominantly thought to have been subsequently transferred to dedicated munitions filling factories, they may have been stored on within Park Works and the surrounding vicinity prior to their transit. Such items may also have been disposed of unofficially on site if deemed faulty or as excess. It was not uncommon for excess or unwanted ordnance such as fuzes to be buried or burnt within the wider premises of a factory as a means of disposal. Records of such practice were rarely kept.
Military Related Airfields *Military airfields present an elevated risk from ordnance simply due to the large military presence and likelihood of associated live ordnance training or bombing practice.*	The site was not situated within the perimeters or vicinity of a military airfield.

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14. The Likelihood of UXO Contamination Summary

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

UXO Contamination Summary	
Quality of the Historical Record	The research has evaluated pre- and post-WWII Ordnance Survey maps, pre and post WWII oblique aerial photography, the Manchester bomb plot and damage map, air raid damage files, and anecdotal record. The record set is of generally good quality and corresponds to suggest that there is no recorded evidence of bombing on site. In addition, various anecdotal accounts correlate to explain the types of ordnance manufacture that was occurring to the immediate south-east of the site at the former Mather & Platt Park Engineering Works.
German Aerial Delivered Ordnance	• During WWII the site was located within the County Borough of Manchester, which according to Home Office bombing statistics sustained an overall low density of bombing, with 27.1 items of ordnance recorded per 1,000 acres. Anecdotal evidence suggests that even though there were possible railway and industrial targets in the area, there was very little bombing in Newton Heath, where the site is located, and it is thought that bombing in Manchester was more concentrated in the city centre and dock area. • Pre-war OS mapping dated 1922-1932, indicates the site to consist entirely of open ground, likely associated with the industrial structures in close proximity. Post-war OS mapping dated 1951 denotes the site remained as open ground, serving as a sports ground. • A Manchester bomb plot and damage map does not record any strikes within the site boundary or in its immediate vicinity with the closest recorded strike approximately 320m north-west and the closest recorded instance of damage a further 100m west of the boundary. Whilst this map is not considered to be entirely comprehensive, it does confirm the low localised density of bombing in the area. Additionally, no reference to bombing or damage at the Mather & Platt Park Engineering Works could be found in written records or published historical accounts. • Whilst open areas of land can be of possible concern, post-war oblique photography dated 1953, indicates the site to have been well-maintained in good condition with no obvious signs of ground disturbances apparent. Due to the site's close proximity with industrial structures and function as a sports ground it is anticipated that the site would have been frequently accessed by the employees of the nearby premises. Given this, it is considered more likely that obvious indicators of UXO, such as entry holes and craters, would have been seen and recorded on site. • In summary, the site is not considered to be at significant risk of German air-delivered UXO contamination. Whilst the risk of indicators of UXO going unnoticed within the open area of the site cannot be entirely discounted, evidence suggests the recorded strikes and damage were too far removed to have affected the site area, whilst there is also no obvious positive evidence of bomb damage within or in proximity to the site boundary. The risk of contamination is therefore not considered to be any higher than the 'background level' for this area of the UK.

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Allied Ordnance	• The surrounding industrial properties, 65m south-east, known formerly as the Mather & Platt Park Engineering Works, are understood to have become government run enterprises in both WWI and WWII. During both periods the works was requisitioned for the manufacture of ordnance components, other war related materials and the production of Avro 504 aeroplanes in association with the nearby Avro Works. • Research suggests that during WWI Park Works was mainly involved in the manufacture of projectile casings and fuzes, as well as specialising in Howitzer (large calibre artillery guns) relining. During WWII the factory predominantly became known as a gun factory and was again used to produce ordnance components such as fuzes and weapon cases. Various munition parts such as rocket and anti-aircraft projectors, as well as cordite rolling mills were manufactured here. Due to the limitations of the available record it is assumed that Park Works may have produced an even greater diverse range of other wartime items and materials also. • Munition components produced at Park Works are largely thought to have been subsequently transported to dedicated munition filling factories (known as ROF's) to be filled with explosives. Such items may however have been stored at the factory site prior to their transit. Given its significant wartime output and the variety of items made, the production and usage of explosives at the Park Factory also cannot be entirely discounted. The production of fuzes in particular would have entailed the production of a small explosive component and these types of item can still pose a health risk if disturbed today. • The site itself appears to have formed a recreational area within the wider grounds of the former Park Works and was not situated directly adjacent to any of the works main structures. It is therefore not considered likely that the site area would have been chosen for the storage, testing, or disposal of ordnance, although this possibility cannot be entirely discounted. Especially as records of such practice were rarely kept. • Subsequently, because structures in the wider site area are known to have been utilised to produce various ordnance components throughout both WWI and WWII, there is considered to be a slightly elevated risk of Allied UXO at the site of proposed works. Whilst this type of ordnance manufacture may not have occurred directly within the site boundary, due to the proximity of the site to these structures it is not inconceivable that ordnance may have been disposed of within the site area. However as the site was not situated directly adjacent to the main factory buildings and was used recreationally, this risk is not considered to be significant enough to warrant proactive UXO risk mitigation measures. UXO awareness briefings are instead advised as a precautionary measure.

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15. The Likelihood that UXO Remains

15.1. Introduction

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

15.2. UXO Clearance

Former military sites (or at least certain areas within their footprint) are often subject to clearance before they are returned to civilian use by the MoD. If a site is retained by the military, it is possible that no clearance operations have ever been undertaken. However, UXO is sometimes still discovered even on sites where clearance operations are known to have been undertaken. The detail and level of survey and targeted investigation undertaken by the military will depend on the former use of the site and purpose of the clearance (i.e. disposal, redevelopment, return to agriculture, etc.).[8] The level of clearance will also depend on the available technology, resources and practices of the day.

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

15.3. Post-War Redevelopment

Post-war the site has seen no significant development and is still occupied by an area of open ground. The risk of UXO remaining is only considered to be mitigated at the location of and down to the depth of any post-war redevelopment on site. Within the footprints of post-WWII redevelopments, the risk from shallow-buried UXO (especially Allied items/components) should have been encountered/removed during initial excavations. The risk will remain within virgin geology below and amongst these post-war works.

[8] *CIRIA C681*

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16. The Likelihood of UXO Encounter

16.1. Introduction

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

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

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

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

16.2. Land Service/Small Arms Ammunition Encounter

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

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17. The Likelihood of UXO Initiation

17.1. Introduction

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

17.2. Initiating Aerial Delivered Ordnance

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

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

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

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

17.3. Land Service /Small Arms Ammunition Initiation

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

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

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

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18. Consequences of Initiation/Encounter

18.1. Introduction

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

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

18.2. Consequences of Detonation

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

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

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19. 1st Line Defence Risk Assessment

19.1. Risk Assessment Stages

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

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

19.2. Assessed Risk Level

1st Line Defence has assessed that there is an overall **Low Risk** from German and anti-aircraft unexploded ordnance at the site of proposed works. There is also an assessed **Low-Medium Risk** from Allied ordnance.

Ordnance Type	Risk Level			
	Negligible	Low	Medium	High
German Unexploded HE Bombs		✓		
German 1kg Incendiary Bombs		✓		
Anti-Aircraft Artillery Projectiles		✓		
WWI and WWII-era Ordnance Components (Including Land Service and Small Arms Ammunition)		✓		

This report has been undertaken with due diligence, and all reasonable care has been taken to access and analyse relevant historical information. By necessity, when dealing historical evidence, and when making assessments of UXO risk, various assumptions have to be made which we have discussed and justified throughout this report. Our reports take a common-sense and practical approach to the assessment of risk, and we strive to be reasonable and pragmatic in our conclusions.

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

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20. Proposed Risk Mitigation Methodology

20.1. General

The following risk mitigation measures are recommended to support the proposed works at Plot 1, Parks Works, Manchester:

Type of Work	Recommended Mitigation Measure
All Works	• **UXO Risk Management Plan** It is recommended that a site-specific plan for the management of UXO risk be written for this site. This plan should be kept on site and be referred to in the event that a suspect item of UXO is encountered at any stage of the project. It should detail the steps to be taken in the event of such a discovery, considering elements such as communication, raising the alarm, nominated responsible persons etc. Contact 1st Line Defence for help/more information. • **Site Specific UXO Awareness Briefings to all personnel conducting intrusive works.** As a minimum precaution, all personnel working on the site should be briefed on the basic identification of UXO and what to do in the event of encountering a suspect item. This should in the first instance be undertaken by a UXO Specialist. Posters and information on the risk of UXO can be held in the site office for reference.

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

1st Line Defence Limited **28/01/21**

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

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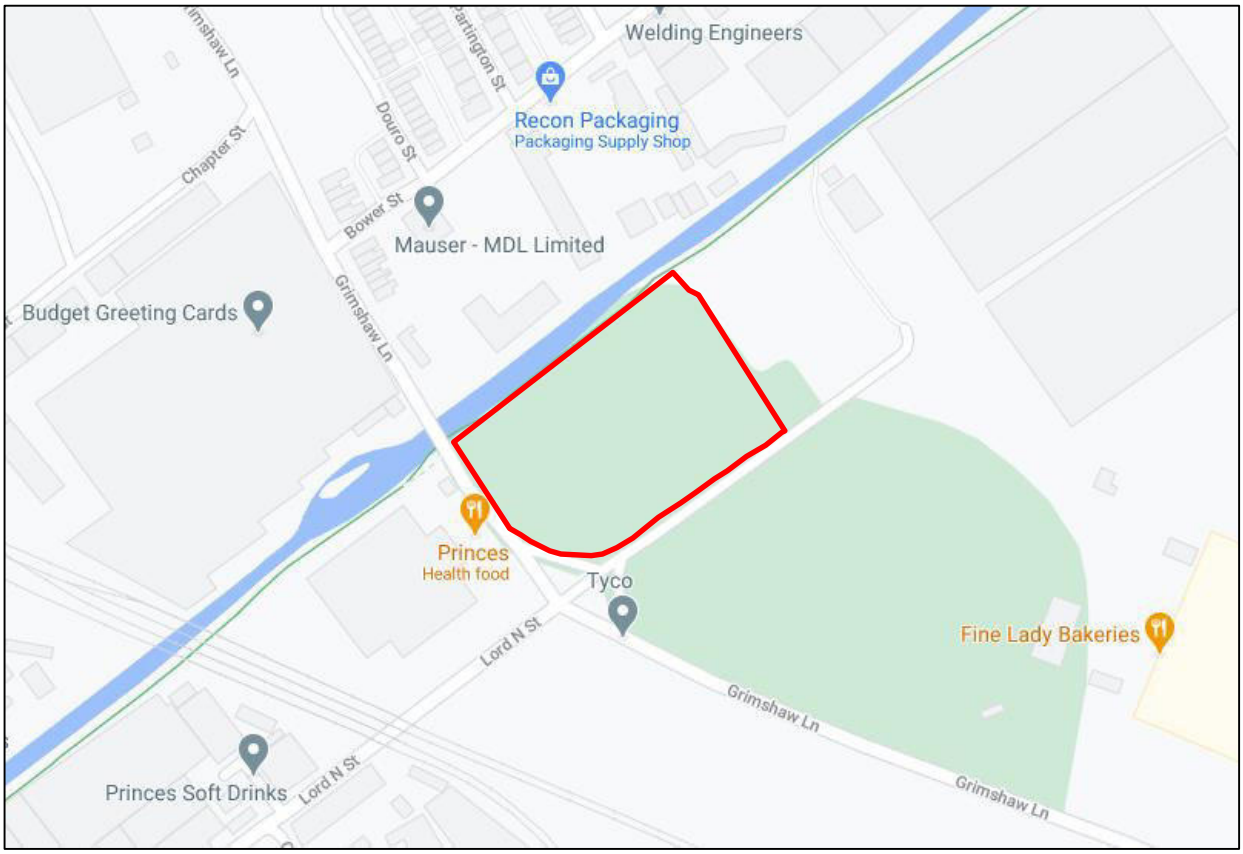
Site Location Maps

Annex: **A**





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Client:	**TRC Companies Ltd**	**Approximate site boundary**	N
Project:	**Plot 1, Park Works, Manchester**		
Ref:	**DA12562-00**	Source: Google Maps	

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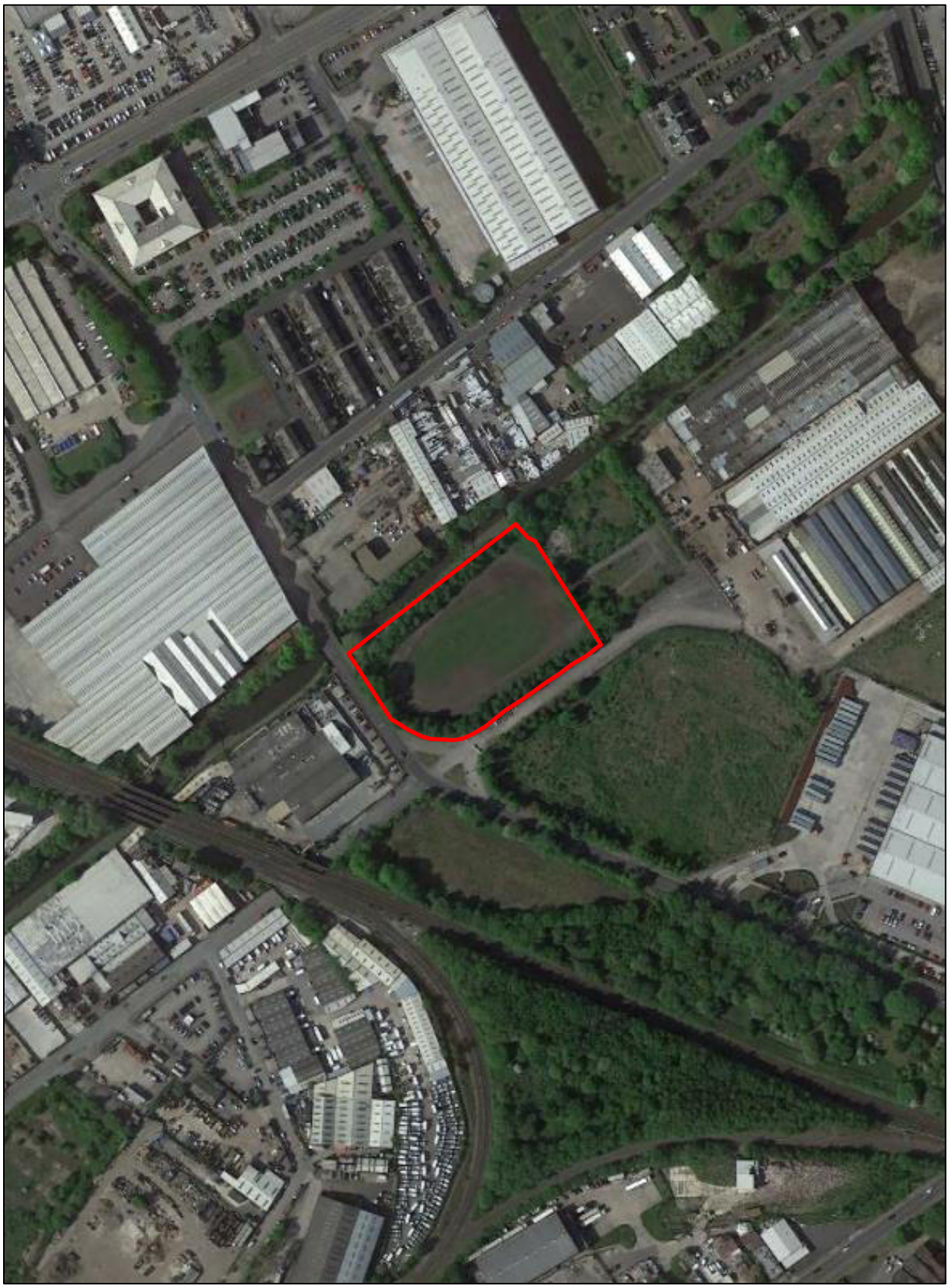
Recent Aerial Photography

Annex: **B**



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Project: **Plot 1, Park Works, Manchester**

Ref: **DA12562-00**

Source: Google Earth ™ Mapping Services

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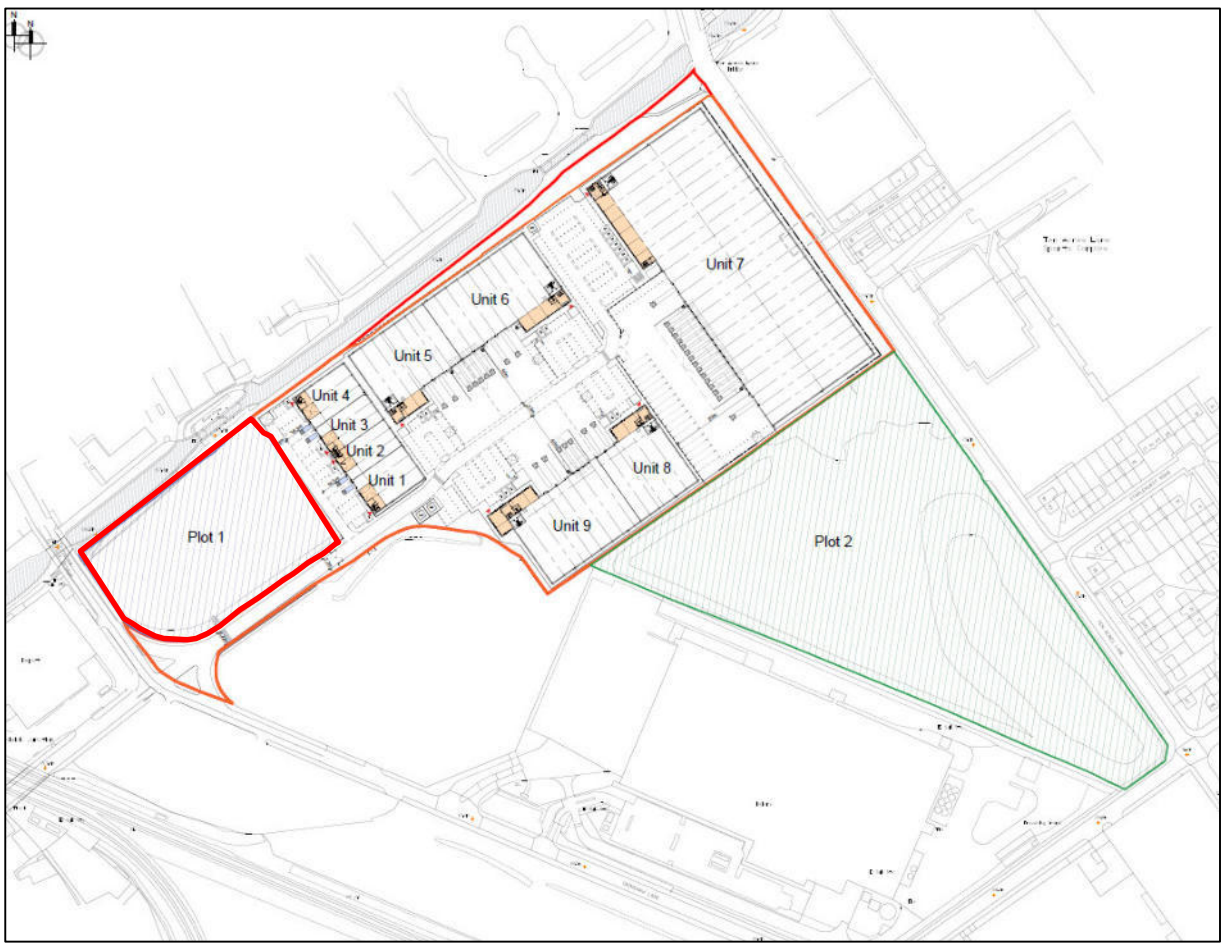
Client Provided Site Plan

Annex: **C**



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Tel: +44 (0)1992 245 020

Client: **TRC Companies Ltd**

Approximate site boundary

Project: **Plot 1, Park Works, Manchester**

N

Ref: **DA12562-00**

Source: TRC Companies Ltd

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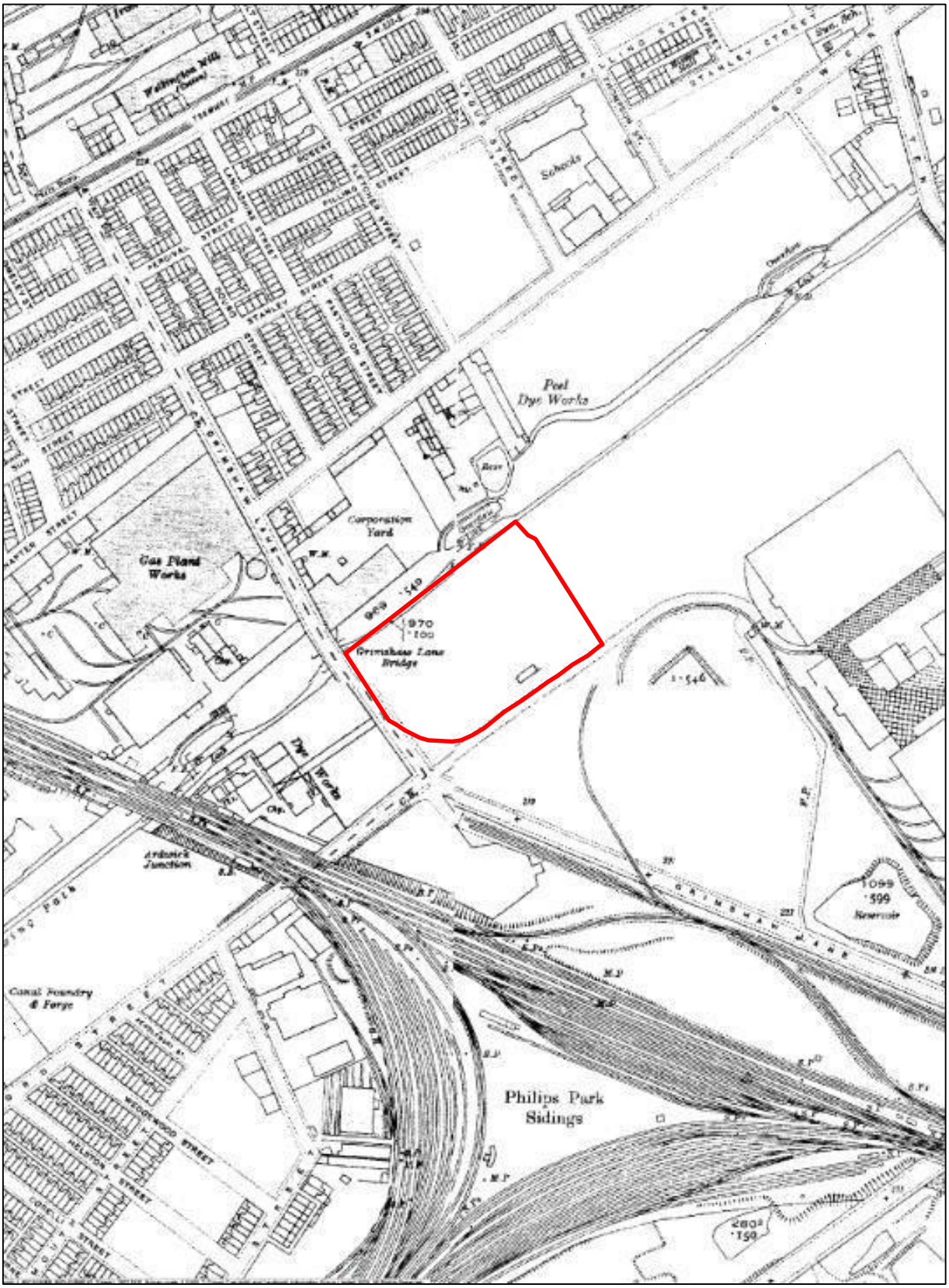
Pre-WWII Historical Map

Annex: **D1**



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Tel: +44 (0)1992 245 020

Client: **TRC Companies Ltd**

Project: **Plot 1, Park Works, Manchester**

Ref: **DA12562-00**

Source: Landmark Maps

Approximate site boundary

N

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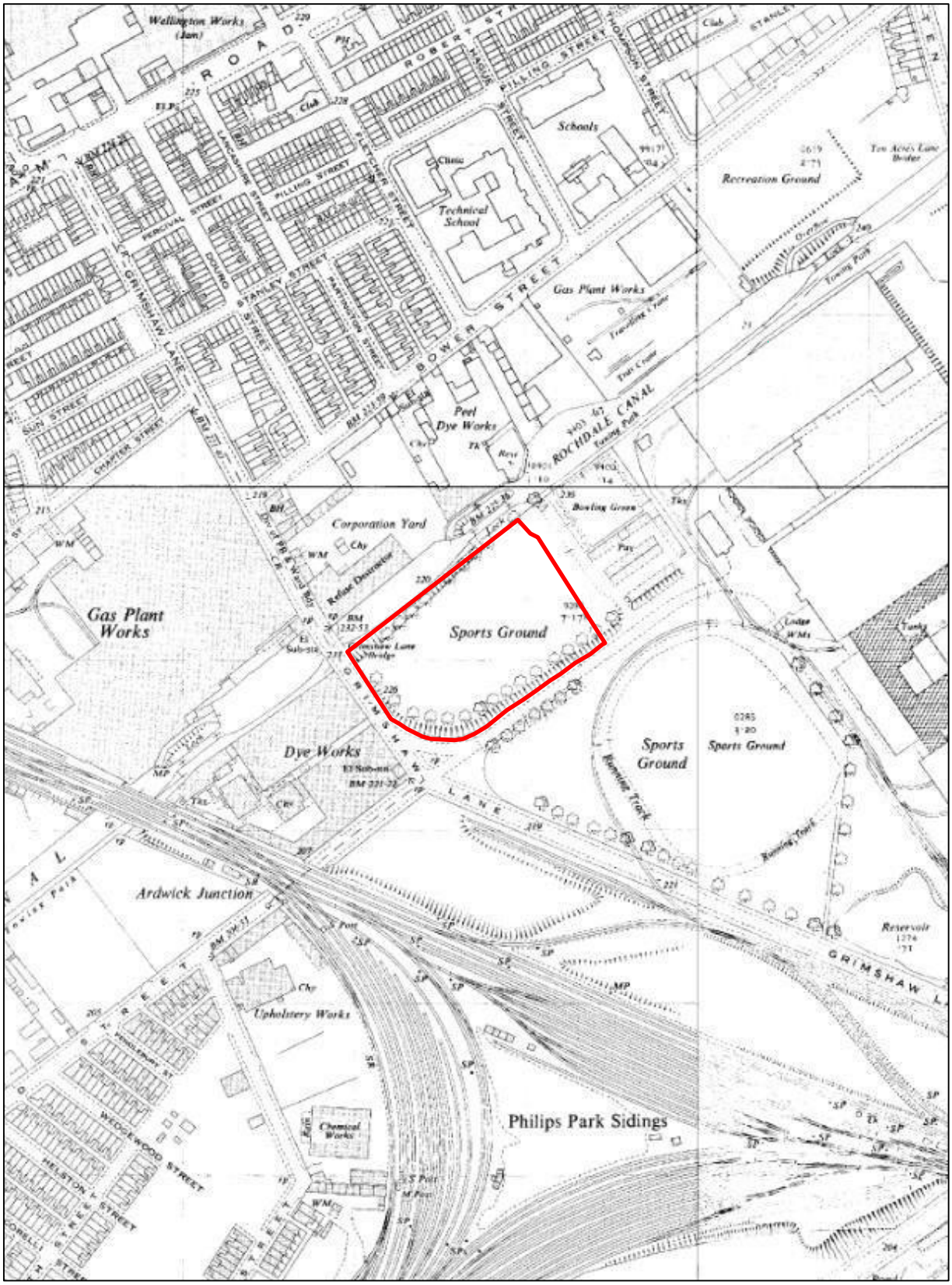
Post-WWII Historical Map

Annex: **D2**



1ST LINE DEFENCE	Client: **TRC Companies Ltd**	**Approximate site boundary**	N
	Project: **Plot 1, Park Works, Manchester**		
	Ref: **DA12562-00**	Source: Landmark Maps	

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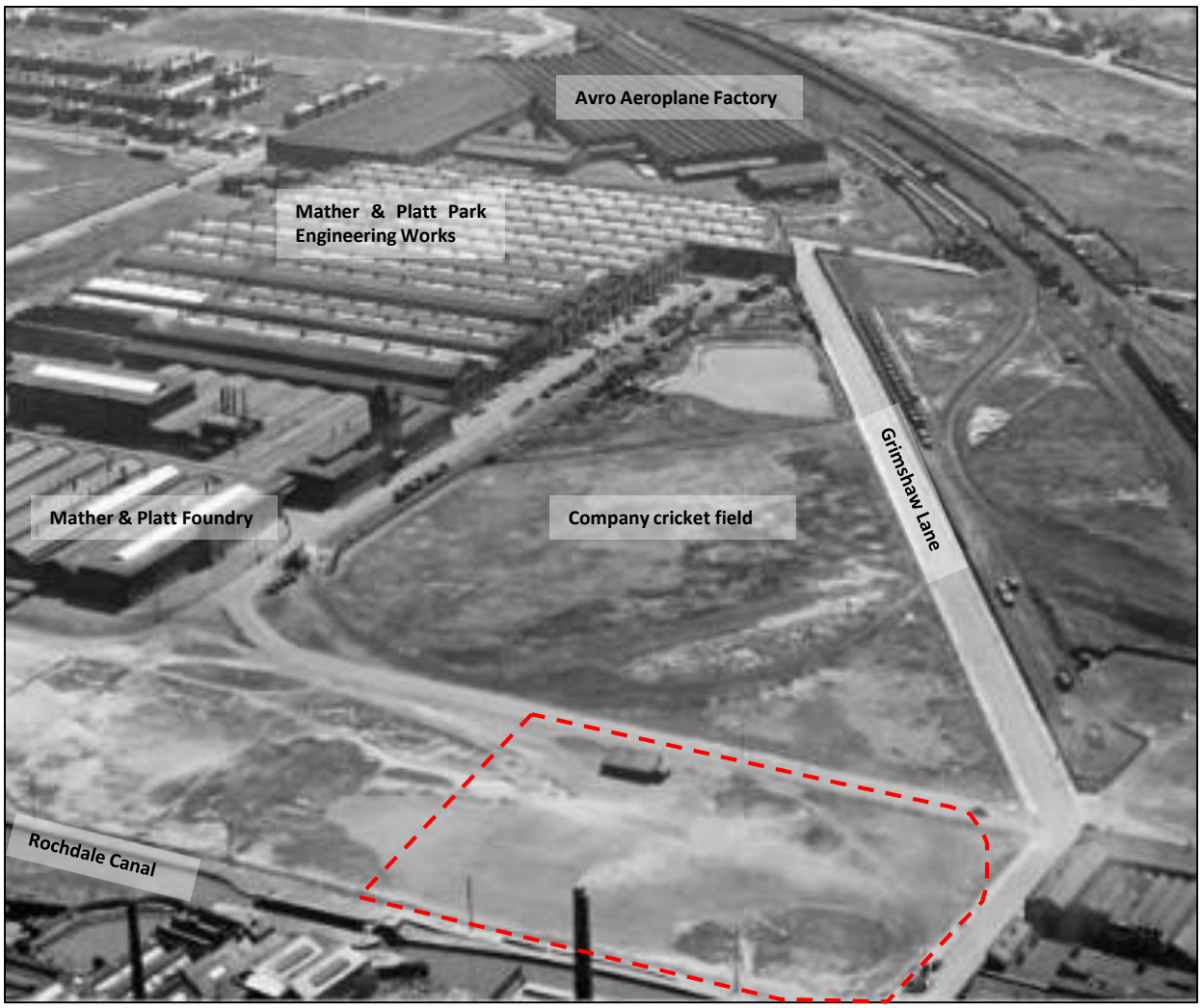
The Park Engineering Works and environs, Newton Heath, 1932



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Client: **TRC Companies Ltd**

Approximate site boundary

Project: **Plot 1, Park Works, Manchester**

Ref: **DA12562-00**

Source: Britain from Above

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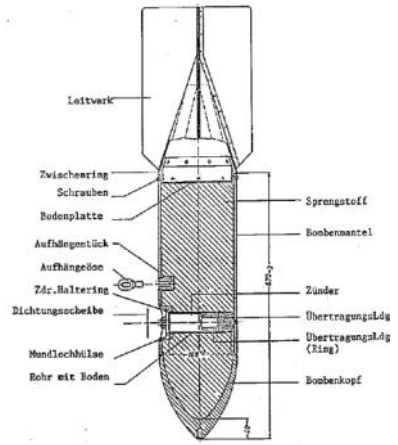
Examples of German Air-Delivered Ordnance

SC 50kg High Explosive Bomb

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

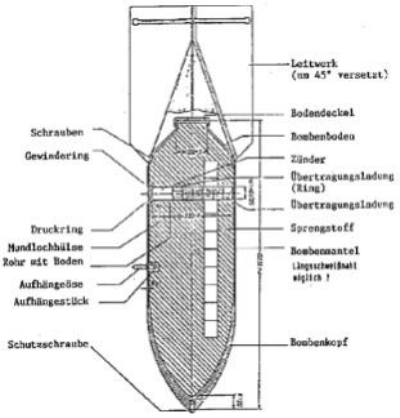






SC 250kg High Explosive Bomb

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



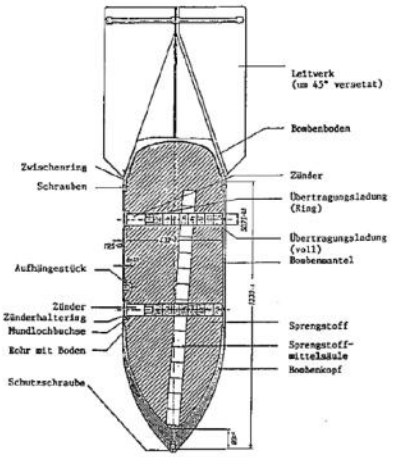


SC250 bomb being loaded onto German bomber

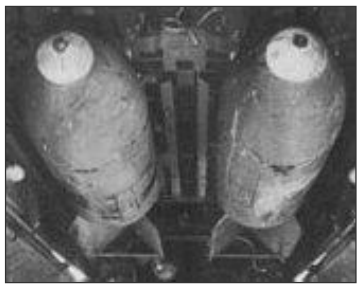


SC 500kg High Explosive Bomb

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







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Ref: **DA12562-00**

Source: Various sources

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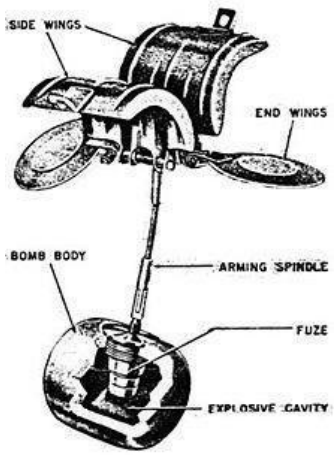
Examples of German Air-Delivered Ordnance

SD2 Anti-Personnel 'Butterfly Bomb'

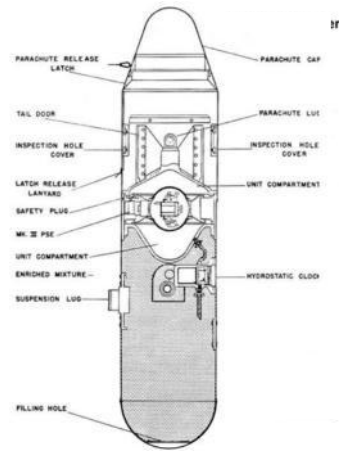
Bomb Weight	Approx. 2kg (4.41lb)
Explosive Weight	Approx. 7.5oz (225 grams) of Amatol surrounded by a layer of bituminous composition.
Fuze Type	41 fuze (time) , 67 fuze (clockwork time delay) or 70 fuse (anti-handling device)
Body Diameter	3in (7.62 cm) diameter, 3.1in (7.874) long
Use	Designed as an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





Parachute Mine (Luftmine B / LMB)

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



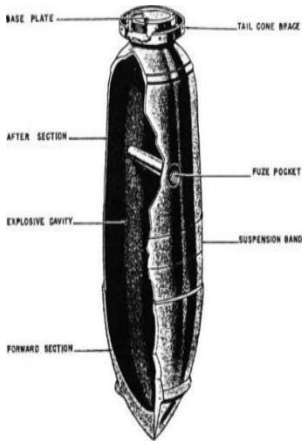






SC 1000kg

Bomb Weight	Approx. 993-1027kg (2,189-2,264lb)
Explosive Weight	Approx. 530-620kg (1168-1367lb)
Fuze Type	Electrical impact/mechanical time delay fuze.
Filling	Mixture of 40% amatol and 60% TNT, but when used as an anti-shipping bomb it was filled with Trialen 105, a mixture of 15% RDX, 70% TNT and 15% aluminium powder.
Bomb Dimensions	2800 x 654mm (110 x 25.8in)
Body Diameter	654mm (18.5in)
Use	SC type bombs 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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Source: Various sources

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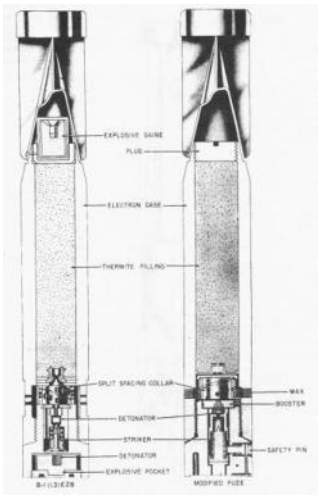
1kg Incendiary Bomb

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

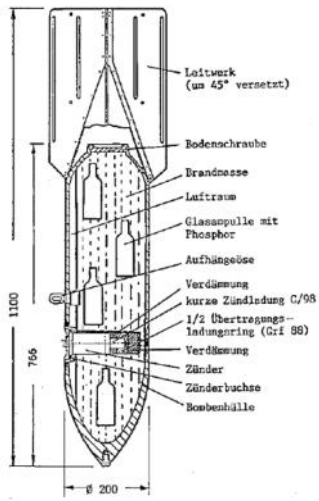


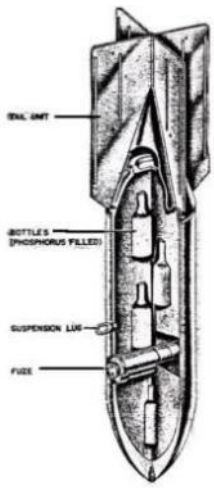




C50 A Incendiary Bomb

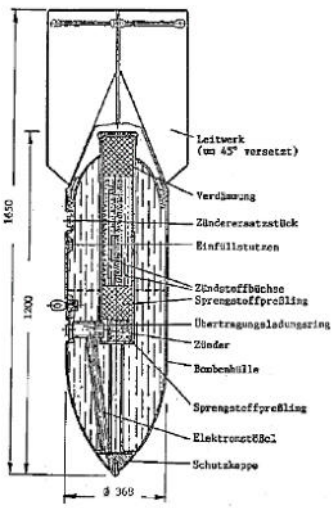
Bomb Weight	Approx. 41kg (90.4lb)
Explosive Weight	Approx. 0.03kg (0.066lb)
Incendiary Filling	12kg (25.5lb) liquid filling with phosphor igniters in glass phials. Benzine 85%; Phosphorus 4%; Pure Rubber 10%
Fuze Type	Electrical impact fuze
Bomb Dimensions	1,100 x 280mm (43.2 x 8in)
Use	Against any targets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





Flam C-250 Oil Bomb

Bomb Weight	Approx. 125kg (276lb)
Explosive Weight	Approx. 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 ground troops, against troop barracks and industrial installations. Thin casing – not designed for ground penetration





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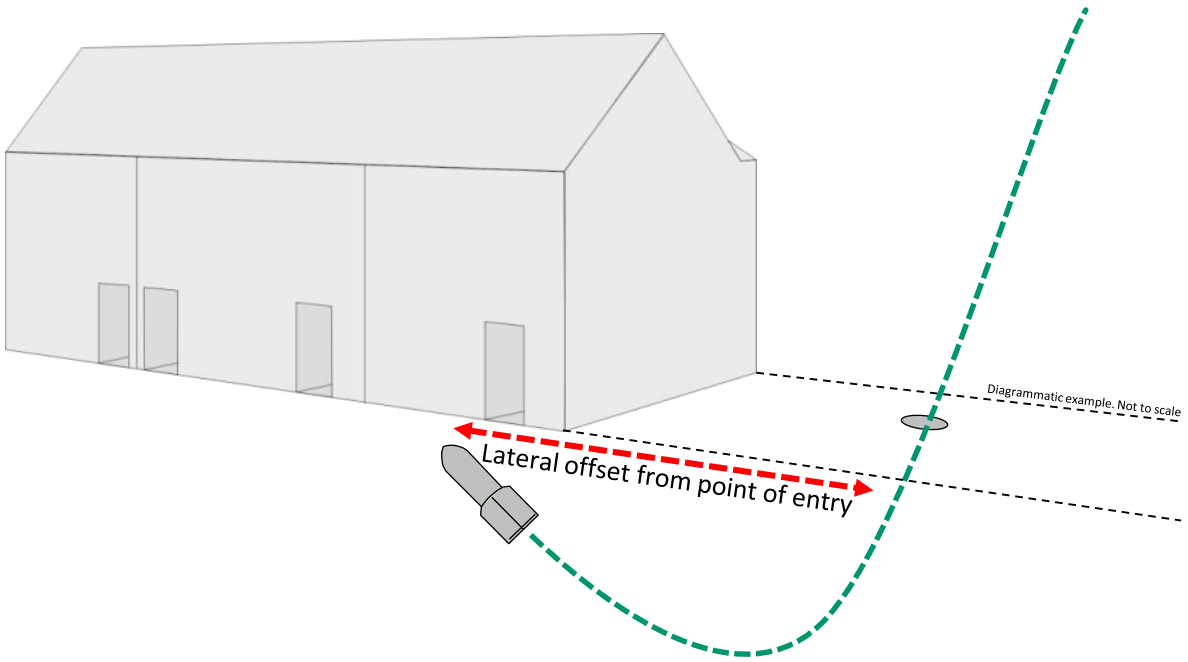
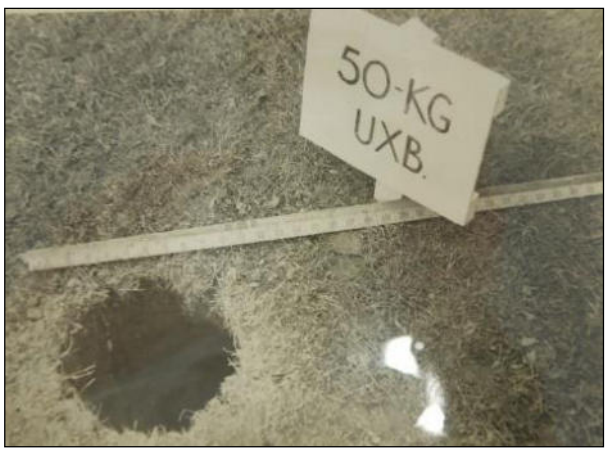
The 'J-Curve' Effect Principle









Top: J-curve Effect - Due to angle of entry, unexploded bombs would often end their trajectory at a lateral offset from point of entry, often ending up beneath adjacent extant structures/sites. The photograph above shows 250kg bomb found in Bermondsey pointing upwards, demonstrating 'J-curve'

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

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Ref: **DA12562-00** Source: Various sources

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BBC NEWS

Bermondsey bomb: World War Two device safely removed



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

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

March 2015

BBC NEWS

Bethnal Green WW2 bomb: Experts remove unexploded device



An unexploded World War Two bomb that prompted the evacuation of 700 people in east London has been made safe and removed by the military.

Families spent the night in a school hall after the 500lb bomb was found in the basement of a building site on Temple Street, in Bethnal Green, on Monday afternoon.

A 200m (650ft) exclusion zone was set up around the device.

August 2016

BBC NEWS

Bath WW2 bomb scare: Device defused, police say



A 500lb World War Two bomb found on the site of a former school in Bath has been defused and made safe.

The discovery of the bomb on Thursday **led to the evacuation of hundreds of homes** and many road closures in the Lansdown area of the city.

A cordon around the site was lifted on Friday evening, more than 24 hours after residents were asked to leave their homes.

May 2016

BBC NEWS

London City Airport reopens after WW2 bomb moved



London City Airport has reopened after an unexploded 500kg World War Two bomb was safely moved from the area.

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

All flights were cancelled on Monday after an exclusion zone was put in place, **with the closure affecting up to 16,000 passengers and nearby residents being evacuated from their homes.**

May 2015

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Ref: **DA12562-00** Source: BBC News

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Examples of Unexpected Detonation of WWII Bombs

Annex: **H2**

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

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



BASF Provides Some Details

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

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

1st March 2013

SPIEGEL ONLINE

Blast Kills One

World War II Bomb Explodes on German Motorway

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



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

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

23rd October 2006

WWII bomb injures 17 at Hattingen construction site



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

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

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

19th September 2013

BBC NEWS

World War II bomb kills three in Germany



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

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

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

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

2nd June 2010



June 2006

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Source: Various news sources

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Examples of Land Service Ammunition finds in the UK

Annex: H3



Unexploded Second World War bomb discovered under Somerset footpath

By Western Daily Press | Posted: January 21, 2014

The unexploded bomb was found in Somerset

Comments (0)

An unexploded bomb dropped in Britain during the Second World War has finally been discovered – underneath a popular footpath in Somerset.



23 August 2014 Last updated at 15:01

Unexploded WW2 bomb found at Kenfig Pool, Bridgend

Dean Smith believes the shell was made in Germany

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

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

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

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

Related Stories

'Panic' as dog nearly thrown grenade

WW2 bomb found at wind farm exploded

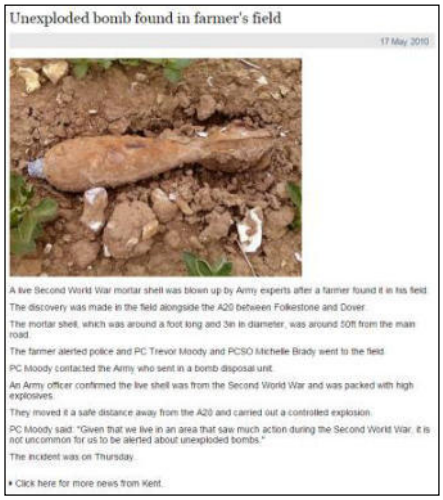
WWII bomb found in kitchen cupboard



Mortar thought to be from WWII found on Oshawa's Camp-X grounds

August 24, 2018 | 5:42 am

What is believed to be a World War II mortar has been discovered in south Oshawa. A man out in Intrepid Park, the site of the Camp-X Second World War training grounds, discovered the round with his metal detector on Tuesday evening. Durham police are held the scene overnight awaiting military officials from Trenton to come and properly detonate the mortar.



Unexploded bomb found in farmer's field

17 May 2010

A live Second World War mortar shell was blown up by Army experts after a farmer found it in his field.

The discovery was made in the field alongside the A20 between Folkestone and Dover.

The mortar shell, which was around a foot long and 3in in diameter, was around 50ft from the main road.

The farmer alerted police and PC Trevor Moody and PCSO Michelle Brady went to the field.

PC Moody contacted the Army who sent in a bomb disposal unit.

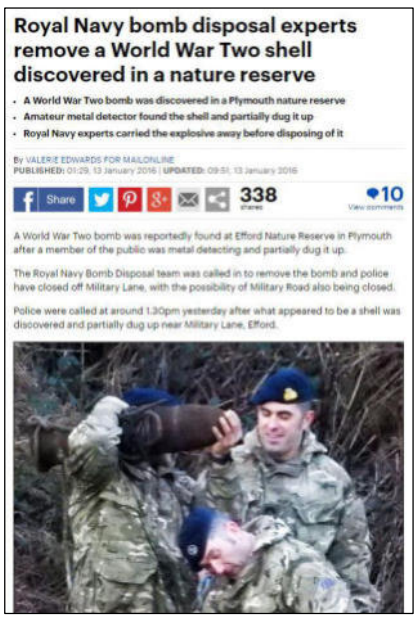
An Army officer confirmed the live shell was from the Second World War and was packed with high explosives.

They moved it a safe distance away from the A20 and carried out a controlled explosion.

PC Moody said: "Given that we live in an area that saw much action during the Second World War, it is not uncommon for us to be alerted about unexploded bombs."

The incident was on Thursday.

• Click here for more news from Kent



Royal Navy bomb disposal experts remove a World War Two shell discovered in a nature reserve

- A World War Two bomb was discovered in a Plymouth nature reserve
- Amateur metal detector found the shell and partially dug it up
- Royal Navy experts carried the explosive away before disposing of it

By VALERIE EDWARDS FOR MAILONLINE

PUBLISHED: 01:29, 13 January 2016 | UPDATED: 09:51, 13 January 2016

Share 338 shares 10 View comments

A World War Two bomb was reportedly found at Efford Nature Reserve in Plymouth after a member of the public was metal detecting and partially dug it up.

The Royal Navy Bomb Disposal team was called in to remove the bomb and police have closed off Military Lane, with the possibility of Military Road also being closed.

Police were called at around 1.30pm yesterday after what appeared to be a shell was discovered and partially dug up near Military Lane, Efford.



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

© Jonathan Pow

Bomb Beach Alley: Rockets were found after a landslide on Mappleton beach in 2012



Army bomb disposal team called to Blacksole Bridge in Herne Bay

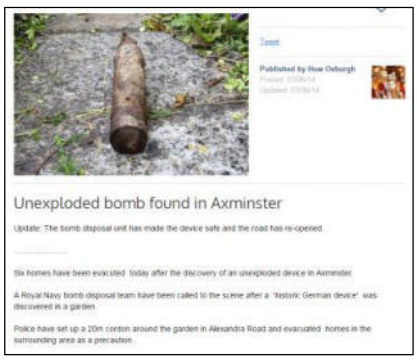
by Aiden Barlow abarlow@thekmgroup.co.uk 08 July 2015

It was like a scene from Dad's Army when Army bomb disposal experts found wartime explosives made by the Home Guard in makeshift bottles.

A team was called to the Blacksole Bridge in Herne Bay after the wartime bombs were found.

The team from the Royal Logistics Corps set up a 30 metre exclusion zone for pedestrians around the railway embankment after the suspected homemade phosphorous bombs were found.

The scene at Blacksole Bridge after wartime explosives were found in the railway cutting



Unexploded bomb found in Axminster

Update: The bomb disposal unit has made the device safe and the road has re-opened.

Six homes have been evacuated today after the discovery of an unexploded device in Axminster.

A Royal Navy bomb disposal team have been called to the scene after a 'historic German device' was discovered in a garden.

Police have set up a 20m cordon around the garden in Alexandra Road and evacuated homes in the surrounding area as a precaution.



Storms and floods unearth unexploded wartime bombs

By Claire Marshall

BBC environment correspondent

There has been a dramatic increase in the number of wartime bombs unearthed because of the winter storms and flooding.

Bomb disposal teams in the South West have dealt with double the number of unexploded ordnance than in the same period last year.

Since mid December, the Royal Navy's Southern Dive Unit has recovered or disposed of 244 items of ordnance.

During the same period last year, they dealt with just 108 items.

The storms have uncovered a lethal past

Almost 70 years after the end of WWII, one legacy of that conflict continues to turn up on beaches and harbours around Britain.

Unexploded shells, bombs and mines continue to be discovered every year, and the Royal Navy's Southern Dive Unit is tasked with making these devices safe.

Its area of responsibility stretches for some 2,250km (1,400 miles). It begins from the highwater mark in Hull and proceeds seaward to the territorial limit, and then runs clockwise around the British Isles - including the Isle of Wight, Channel Islands, and Isles of Scilly - to finish in Liverpool.

Related Stories

Ancient trees revealed by storms

Land Service Ammunition (LSA) resulting from historic military activity is commonly encountered across the UK by the public and construction industry alike. Such finds are much more common in rural areas than in urban environments, and can often be anticipated in areas such as former RAF stations or ranges. However, many such items are encountered entirely by surprise where the landowner or developer has no knowledge of any previous military use of the land.

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Project: **Plot 1, Park Works, Manchester**

Ref: **DA12562-00**

Source: Various news sources

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Manchester 'World War 2 bomb' fears: Hotel on LOCKDOWN as bomb squad probes WW2 device

POLICE cordoned off a street in Manchester and placed the Lowry Hotel on lockdown after a suspected World War 2 bomb was discovered nearby.

Chapel Street in Salford, Greater Manchester were cordoned off between Blackfriars Road and Bailey Street as police as investigated a device found at a construction site.

The bomb squad arrived on scene and residents of The Edge building opposite the construction site were told to evacuate.

Lowry Hotel has reportedly not been evacuated; however, Greater Manchester Police (GMP) had set up a 100m cordon which surrounds the area.

The GMP in a statement on Twitter said: "Police were called to reports of a suspicious item on a building site by Clowes Street and Chapel Street in Ordsall.

"Bomb disposal experts are making their way to the scene and a 100m cordon has been put in place which includes areas around the Lowry Hotel. It is believed the item could be a device from WW2."

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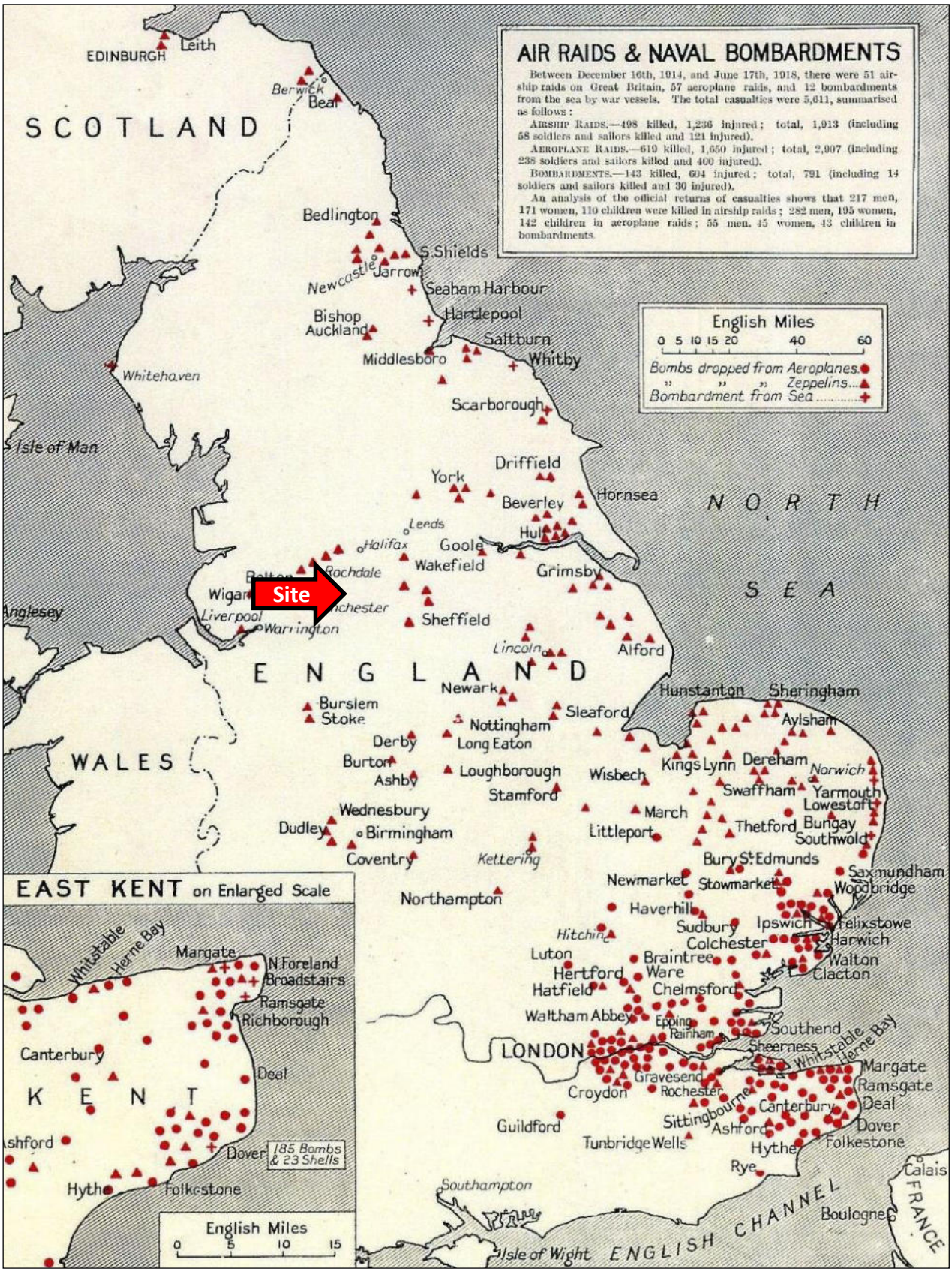
WWI Map of Air Raids and Naval Bombardments

Annex: I



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Source: J. Morris, *German Air Raids on Britain*

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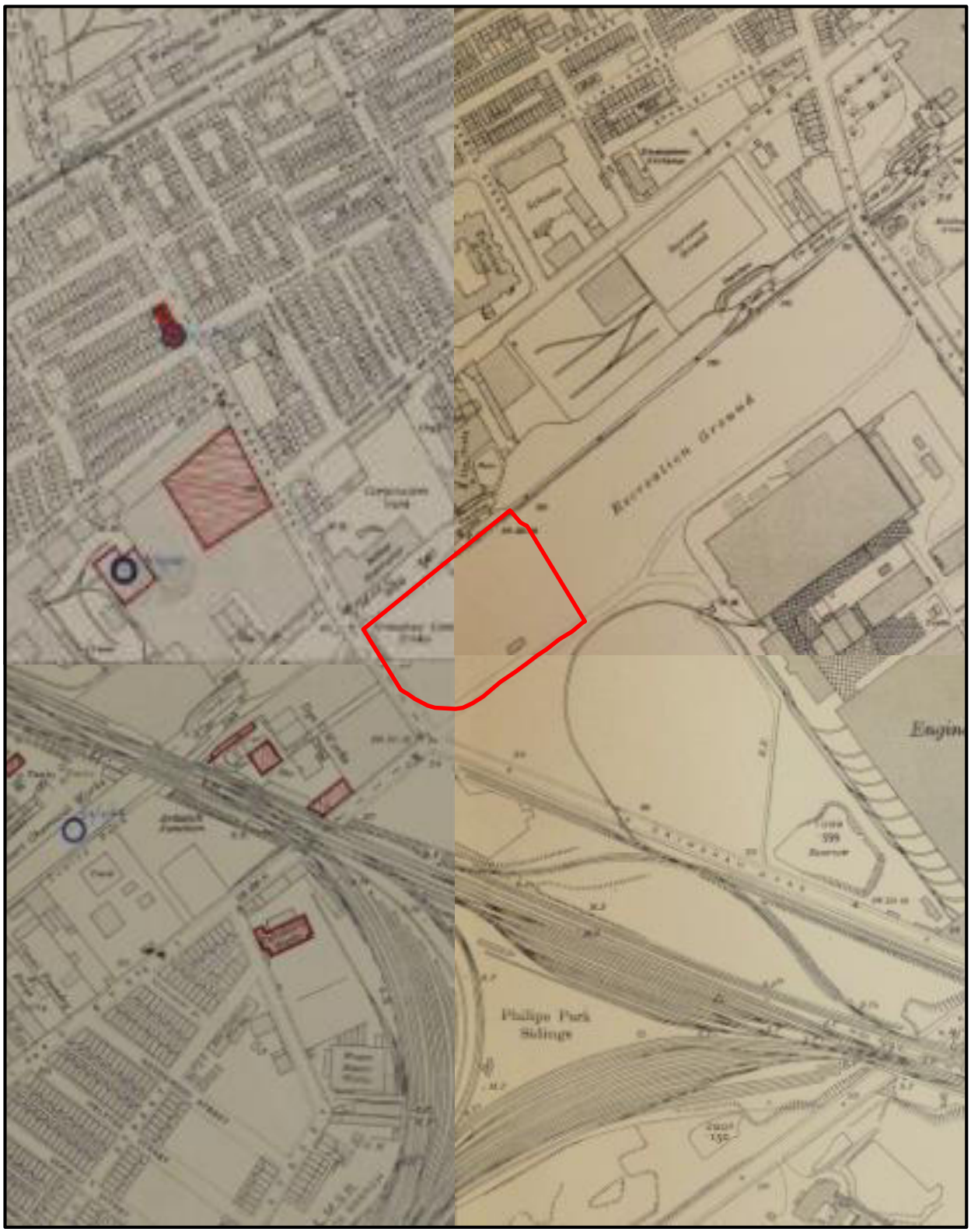
Manchester Bomb Plot & Damage Map

Annex: J



Recorded HE bomb Recorded incendiary bomb Damaged building

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Approximate site boundary

N

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Source: The University of Manchester Library

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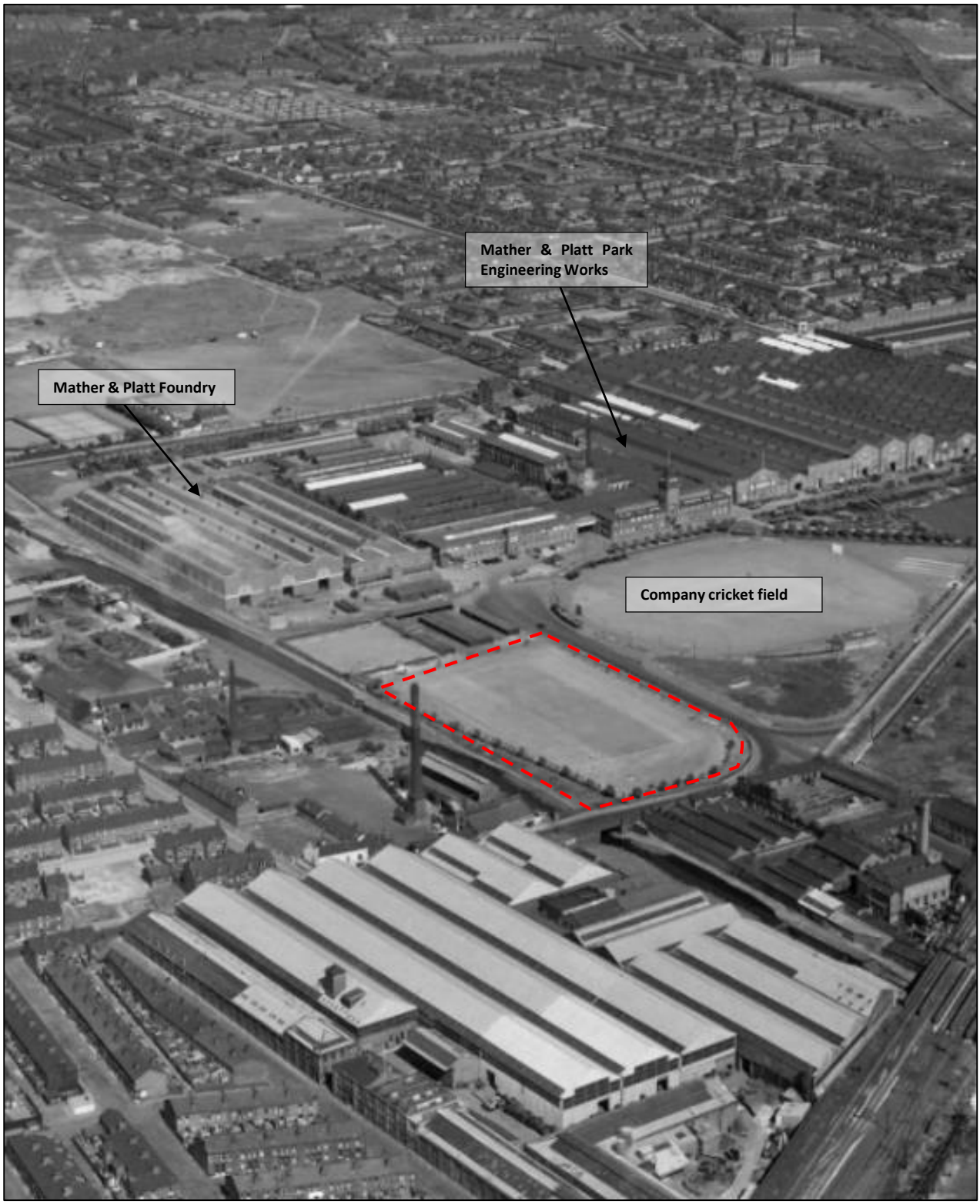
1953 Post-WWII Oblique Photography

Annex: **K**

The R & J Dempster Ltd Gas Plant Works and environs, Newton Heath, 1953



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Approximate site boundary

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Source: Britain From Above

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An example of WWI era Avro aeroplanes manufactured at Park Works, and the Avro Factory which was located south of the site, on the south side of Briscoe Road.



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Source: https://www.baesystems.com/en/heritage/brownsfield-mill--newton-heath--alexandra-park--yeandon--hamble--trafford-park--failsworth-and-ashton-under-lyne

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Women working at the Mather and Platt works to assist the War effort.





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Source: https://gm1914.wordpress.com/2016/10/13/manchesters-industrial-war-a-view-from-the-factories/

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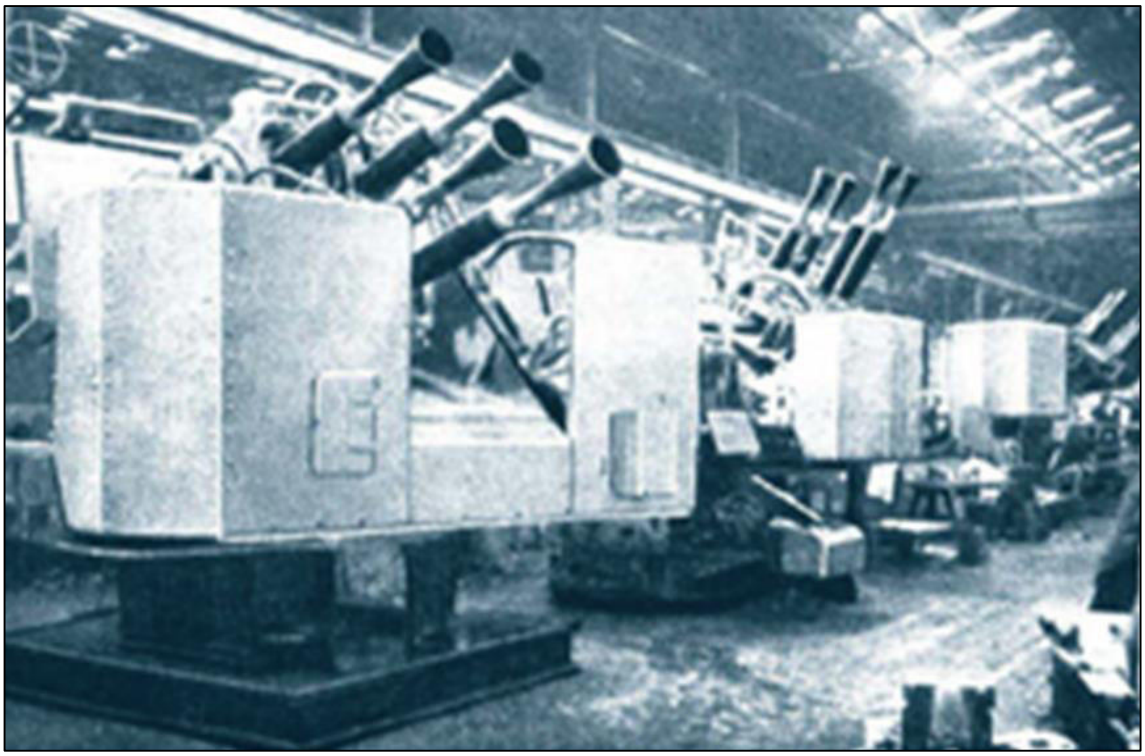
Barrage balloons produced by Mather and Platt



Mather and Platt Ack Ack gun mounting for ships



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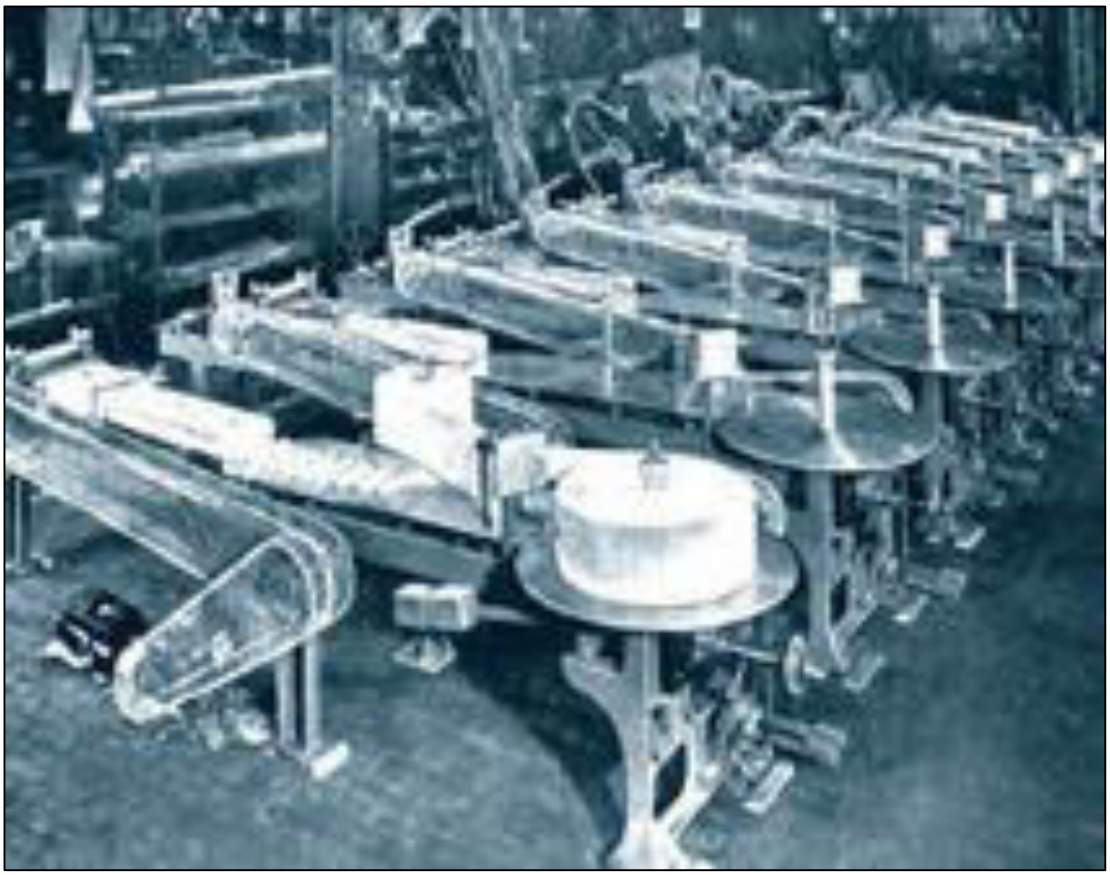
Batch of paper corrugating and scrolling machines ready for delivery to munitions filling factories



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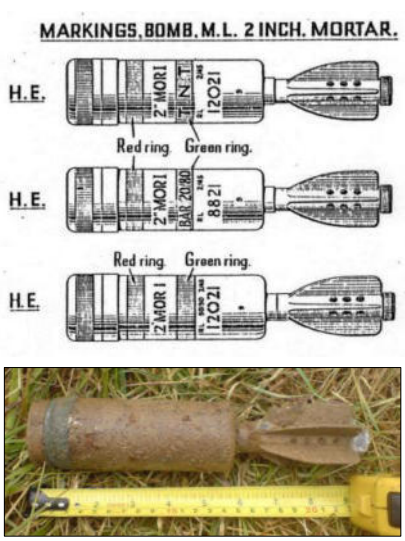
Examples of Land Service Ammunition – Mortars

Annex: **M1**

2 inch Mortar High Explosive

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





2 inch Mortar Smoke

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

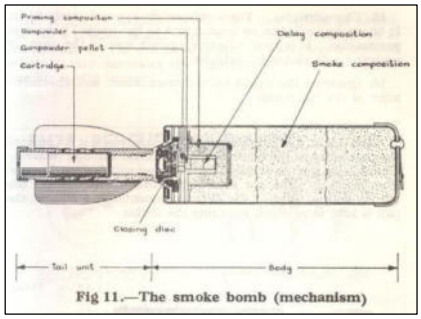
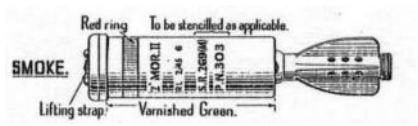


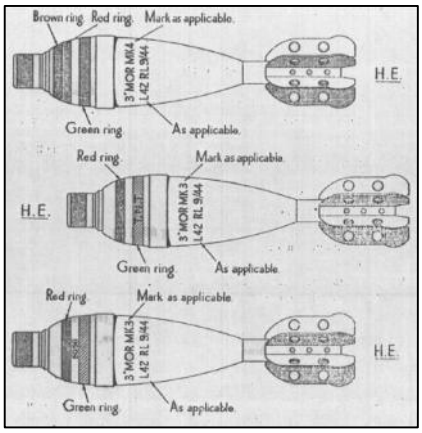
Fig 11.—The smoke bomb (mechanism)



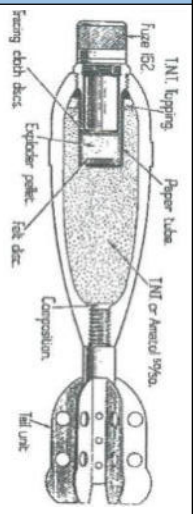


3 inch Mortar High Explosive

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







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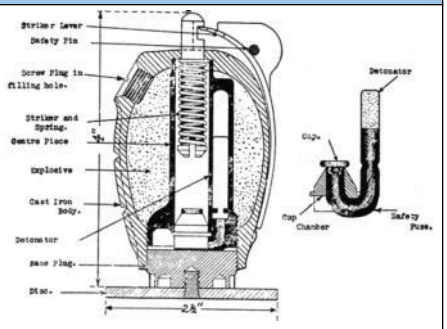
Examples of Land Service Ammunition – Grenades

Annex: **M2**

No. 36 'Mills' Grenade

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





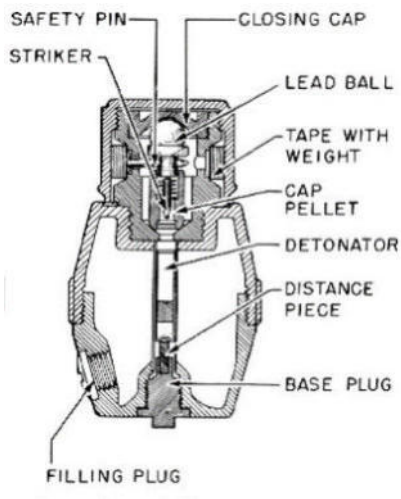


Left: baseplate and detonator removed

No. 69 Grenade

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

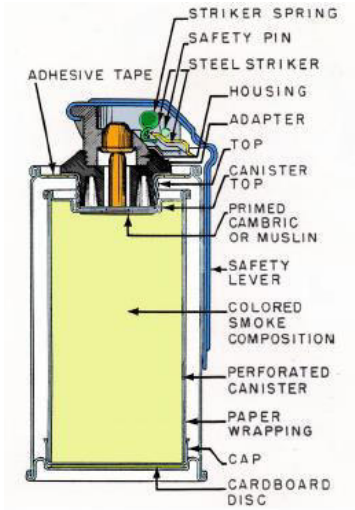




No. 83 Smoke Grenade

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





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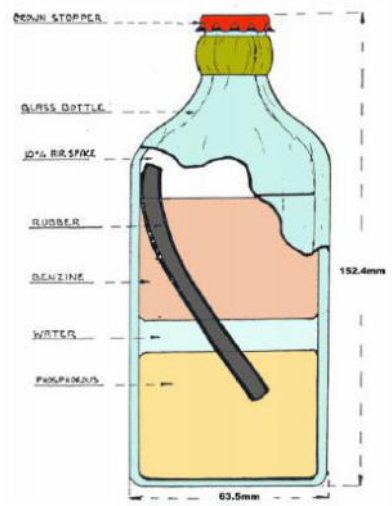
No. 76 Self Igniting Phosphorous (SIP) Grenade

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



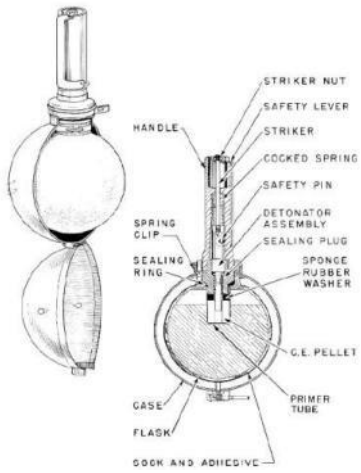


No. 74 Grenade ("Sticky Bomb") Mk1

Weight	Approx. 1.1kg (2.25lb)
Filling	Approx. 600g Nobel's No.283 (Nitro-glycerine) (1.33lb)
Design	A glass ball on the end of a Bakelite (plastic) handle. The inside of the ball would contain the explosive filling and the outside a very sticky adhesive coating.
Use	An anti-tank grenade primarily issued to the home guard. It required the user to come in very close proximity with the target and smash the glass explosive container against it.
Remarks	Timer fuze was located in the handle. This would explode after 3-6 secs. 9.5in Long 4.5in Diameter







Flame Fougasse Bomb

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





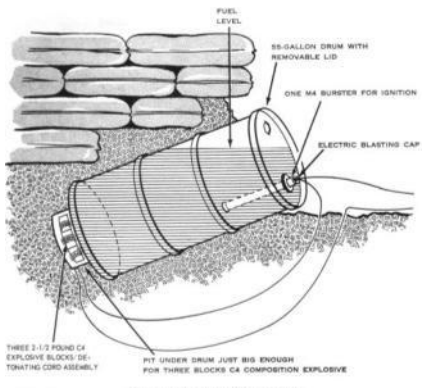


Figure 11. Flame fougasse (55-gallon drum).

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Examples of Small Arms Ammunition

Examples of British Small Arms Ammunition

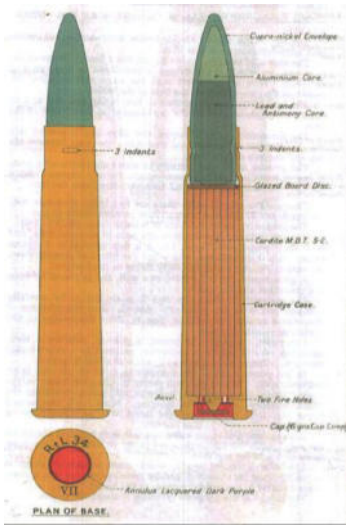


.303 Rifle

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

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





Buried and Decayed Ammunition





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Examples of Anti-Aircraft Projectiles

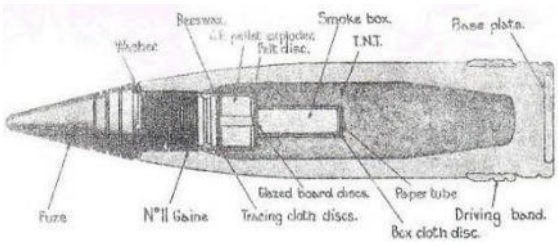
Annex: O

3.7 Inch QF Anti-Aircraft Projectile

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





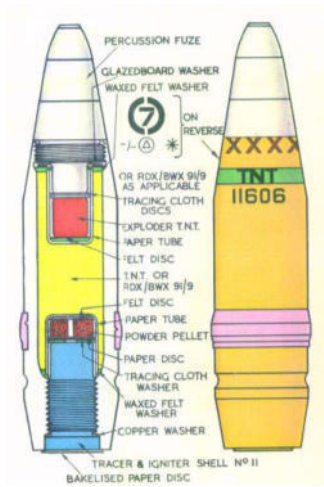


40mm Bofors Projectile

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



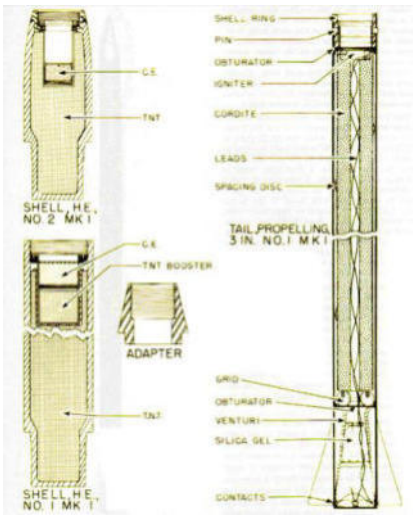




3in Unrotated Projectile (UP) Anti-Aircraft Rocket ("Z" Battery)

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





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Coal Mining Risk Assessment

Mather's Foundry and Grimshaw Lane Plots 1 & 2
Manchester
M40 2BA

January 2021

423207.0000.0000

Prepared For:
Canmoor (Manchester) Limited
34 Dover Street
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W1S 4NG

Prepared By:
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20 Red Lion Street
London
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Registered office: 150 Minories, London EC3N 1LS | Company number: 06749633

Quality Control

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Project Name:	Mather's Foundry, Manchester
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Document Title:	Coal Mining Risk Assessment
Date:	19th January 2020

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Approved by:	 PP.			
	P Welburn	A Sokolowski		

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Executive Summary

TRC Companies Limited (TRC) was commissioned by Canmoor (Manchester) Limited to prepare a Coal Mining Risk Assessment (CMRA) at Mather's Foundry, Manchester, M40 2BA (hereafter referred to as the 'Site').

After issue of Version 1 of this CMRA, the Site boundary was extended to include two further plots of land. Plot 1 is located immediately to the west of the original Mather's Foundry site, fronting onto Grimshaw Lane and Plot 2 was located to the south east, adjacent to Ten Acres Lane. Version 2 of this CMRA has been updated to include these additional plots of land.

This Executive Summary is part of the complete report; and findings, opinions or conclusions in this Executive Summary are made in context with the complete report. TRC recommends that the user reads the entire report for all supporting information related to findings opinions and conclusions.

Executive Summary	
Site Details	
Client	Canmoor (Manchester) Limited
Site Address & Grid Reference	Mather's Foundry, Manchester, M40 2BA SJ 87040, 99980
Site Area	10.24 ha
Proposed Development	TRC understands that the Client is proposing to redevelop the Site for an industrial / commercial end use. The proposed development plan indicates that this will comprise a number of units, ranging in size from 5,100ft^2 to 146,500ft^2, along with associated infrastructure, parking and loading bays.
Site Setting	
Current Site Use	At the time of report the Mather's Foundry Site was derelict, occupied by various disused interlinking foundry buildings, areas of hardstanding and soft landscaping. The main buildings were located across a vast majority of the Site, with car parking / loading area in the western and southern sections of the Site. Plots 1 and 2 on Grimshaw Lane are both vacant plots of land which are covered by grassland and vegetation. An access roadway also formed part of the Site, providing access from Grimshaw Lane, located to the southwest.
Site History	The earliest OS map available for study was from 1848, which indicated that the Site comprised open agricultural fields with a number of small ponds. In 1893 a football ground was recorded in the north of the Site. By 1908 the football ground was no longer present, and an excavation was recorded in the western section of the Site. A mineral railway also encroached onto the southern part of the Site, adjacent to the excavation, and led to Park Engineering Works that was partially located within Plot 2. An excavation was noted on the Site between 1908 to 1938, which was later infilled. A slope is also indicated along the north-eastern boundary of the Site, adjacent to Ten Acres Lane and it is feasible that more extensive excavations had already occurred across the Site. Within the Plot 2 area there were a number of large ponds present suggesting that this area had also been excavated. Further excavations were present to the northeast of the Site that were situated adjacent to a brick works. Located to on the far side of Ten Acres Lane. By 1932 the Park Engineering Works had extended onto the main part of the Site and a new building was present within the Plot 2 area. The ponds in Plot 2 and the excavation in the western section of the Site were then no longer recorded. Along the north eastern edge of the new Park Engineering Works building a slope was indicated with a tank also indicated. Between 1938 and

	1999 Park Engineering Works expanded further to include two buildings in the central and northern section of the Site. Between 1999 and 2019 the works at the Site were no longer in use. The aerial photograph from 2000 indicated that the former engineering works within Plot 2 area had been demolished. The following coal mining features were indicated to be present in the surrounding area (<250m): • 1848 – several coal pits were located >600m southwest, south and west of the Site; • 1848 – Gleden Coal Pit No 1 and No 2 were located approximately 800 to the southwest. From the features on the map these may have included shafts for underground mining and not just surface coal mining.
Expected Geology	Made Ground – the BGS does not indicate artificial ground, however, the Curtin's previous investigation encountered Made Ground ranging in thickness from 0.2m to 8.0m. The investigation of Plot 1 by WYG Environment indicated that Made Ground extended to depths of between 0.4 and 3.3m bgl. Historical maps indicated that an excavation and ponds were present on the Site which was later infilled. Also, a slope was shown along the northeastern side of the Site and significant reprofiling was undertaken when the Site was redeveloped, which is likely to account for the variability in the Made Ground thickness. Superficial Deposits – Glacial Till across the Site, with localised granular Glacial Deposits. The BGS maps and historical borehole logs indicate that the superficial deposits are likely to be in excess of 20m thick. Bedrock Geology –A northwest to southeast orientated fault (named the Bradford Fault) is indicated to cross the Site. Plot 1 is located to the southwest of the fault and the main site area and Plot 2 is located to the northeast. To the south of the fault line the Pennine Middle Coal Measures Formation is indicated to be present with a named sandstone unit (Newton Heath Sandstone) present immediately to the southwest of the fault. The Chester Formation is indicated to be present to the northeast of the fault, across the remainder of the Site.
Coal Mining Risk Assessment	
Known Workings	The findings of the desktop review indicate that one coal seam was worked beneath the Site. The worked coal seam was located to the southwest of the fault and therefore is only likely to be present beneath Plot 1. The coal mining assessment has indicated that there should be sufficient thickness of intact rock above this coal seam to minimize the risk of voids migrating to surface.
Potential Shallow Workings	The Coal Authority website indicates that the western edge of Plot 1 is located within a development high risk area due to the presence of a coal seam which is indicate to subcrop beneath the superficial deposits. The Coal Authority Consultants Report identifies this as the Doctor Coal. It is noted that the Consultant's report indicates that the seam was not workable. The BGS map indicates that the Site is underlain by Chester Formation across much of the Site. The Newton Heath Sandstone is located across the centre of the Site, which is a named sandstone unit within the Pennine Middle Coal Measures Formation. The Chester Formation and Newton Heath Sandstone is separated by a fault line. It is noted that the 1:50,000 Series BGS map does not record the presence of the Doctor Coal suggesting that this is not a significant seam. In addition, there is likely to be superficial deposits overlying the Doctor Coal seam which could be in excess of 20m thick. If present, the Doctor Coal is likely to dip to the southwest (i.e. off-site) and therefore is only likely to be

	present beneath the southwestern part of Plot 1 and the existing Site access road. Given that the Consultants report indicates that the Doctor Coal was not workable and given the considerable thickness of overlying superficial deposits it is considered that the coal seam was unlikely to have been worked. The proposed redevelopment includes the construction of new buildings in the main part of the site, located predominantly to the northeast of the fault line and to the northeast of the Doctor Coal Seam subcrop. The Doctor Coal subcrops at the western end of Plot 1 with the coal seam dipping away from the main part of the Site. As such while there remains a potential risk that the coal seam had been worked, the proportion of the site affected is considered to be small (limited to the southwestern edge of the site).
Other Mining Risks	A fault line is indicated to be present at the Site. Fault lines can act as preferential pathways for the migration of mine gas. The Consultants Coal Mining Report indicates that the Parker Mine was likely to extend up to the fault and therefore there is a potential risk that mine gas could migrate upwards through the broken ground caused by the faulting. It is anticipated that there is likely to be in excess of 20m of superficial deposits overlying the bedrock. The superficial deposits would have been deposited after the fault movement and as such the fault is unlikely to extend to surface. The superficial deposits predominantly comprised Glacial Till that would prevent the upwards migration of mine gas. However, the BGS 1:50,000 scale maps indicated that there was the potential for granular materials to be present within the Glacial Till. The previous investigation at the Site identified that the majority of the superficial deposits comprised Glacial Till and therefore it is considered that the risk of mine gas migrating to surface is considered to be low. However, it is recommended that if granular materials are encountered in the vicinity of the fault line, that monitoring wells are installed with the screened sections installed to coincide with the granular layers. Subsequent permanent ground gas monitoring should be undertaken to ensure that the granular layers do not provide a pathway through the Glacial Till for gas migration.

Recommendations

The presence of a coal seam subcropping beneath the Glacial Till in the western part of the site has resulted in the Coal Authority classifying this area of the site as a development high risk area. This means that further investigation of this area will be required in order to determine if this coal seam has been worked.

The Consultants Coal Mining Report provided contradictory information regarding whether the coal seam had been worked and therefore intrusive site investigation will be required in order to provide further information. It is recommended that a minimum of three deep boreholes are drilled at the western end of the site. The boreholes should fully penetrate the superficial deposits and extend at least 10m into the Pennine Middle Coal Measures to determine whether there is a coal seam present and, if present to determine if it had been worked.

In addition, TRC consider that there is also a potential risk to the proposed development from the fault line. Based upon the information collected by Curtins it is likely that this will be masked by the presence of significant thickness Glacial Till. However, should the Glacial Till be granular in nature this could act as a preferential pathway for mine gas. The proposed development includes new commercial units in the vicinity of the fault. It is recommended that the thickness of the superficial deposits are proved in the vicinity of the fault line, so that future foundations are contained within the superficial deposits and do not overstress potential broken ground associated with the fault. However, proving the depth of the bedrock geology will only be required if a deep piled foundation solution is adopted. It is assumed that

a shallow foundation solution, shallow piled foundation solution or ground improvement methodology will be appropriate for the scheme, subject to the findings of the Phase II Geo-environmental Site Assessment.

In addition, it is recommended that should granular deposits be encountered within the Glacial Till that monitoring wells are installed with the screened sections installed to coincide with the granular layers. Subsequent permanent ground gas monitoring should be undertaken to ensure that the granular layers do not provide a pathway through the Glacial Till for gas migration.

1.0 Introduction

1.1 Purpose

TRC Companies Limited (TRC) was commissioned by Canmoor (Manchester) Limited (the 'Client) to undertake a Coal Mining Risk Assessment (CMRA) for Mather's Foundry, Manchester, M40 2BA (hereafter referred to as the 'Site').

Version 1 of this CMRA comprised the consideration of the former Mather's Foundry site along with an access road leading from Grimshaw Lane. After issue of Version 1 of this CMRA, the site boundary was extended to include two further plots of land. Plot 1 was located immediately to the west of the original Mather's Foundry site, located to the north of the access road and fronting onto Grimshaw Lane. Plot 2 was located to the southeast of the main site, adjacent to Ten Acres Lane and extending as far as Briscoe Lane. Version 2 of this CMRA has been updated to include these additional plots of land.

A Site Location Plan is presented as Figure 1 in Annex A.

According to the Coal Authority website, the Site is located within a Coal Mining Reporting Area and in addition, the southern edge of the Site is located within a high-risk development area with respect to coal mining activity. The purpose of this CMRA is to obtain further information relating to the potential coal workings beneath the Site and provide an assessment of the implications to the proposed development.

1.2 Proposed Development

TRC understands that the Client is proposing to redevelop the Site for an industrial / commercial end use. The proposed development plan indicates that this will comprise a number of units, ranging in size from 5,100ft^2 to 146,500ft^2, along with associated infrastructure, parking and loading bays.

The Proposed Development Plan is presented as Figure 2 in Annex A.

1.3 Scope of Services

This report presents the findings of a desk based CMRA based on review of the following information:

- Coal Authority website;
- British Geological Survey website;
- Historical Ordnance Survey maps;
- Consultants Coal Mining report;
- Curtins Due Diligence Geo-Environmental Site Assessment (covers main site area);
- WYG Environment Geo-Environmental Desk Study and Ground Investigation Report (covers Plot 1); and
- TRC Phase II Geo-environmental and Geotechnical Ground Investigation Report (385367)

The CMRA was conducted with due regard to the following guidance:

- The National Planning Policy Framework;
- BS5930 (2015) Code of Practice for Ground Investigations; and
- CIRIA C758D Abandoned Mine Workings Manual.

1.4 Significant Assumptions

This report presents TRC's observations, findings, and conclusions as they existed on the date that this report was issued. This report is subject to modification if TRC becomes aware of additional information after the date of this report that is material to its findings and conclusions.

The reliability of information provided by others to TRC cannot be guaranteed to be accurate or complete. Performance of this CMRA is intended to reduce, but not eliminate, uncertainty of coal mining risks

associated with the subject Site; therefore, the findings and conclusions made in this report should not be construed to warrant or guarantee the subject Site, or express or imply, including without limitation, warranties as to its marketability for a particular use. TRC found no reason to question the validity of information received unless explicitly noted elsewhere in this report.

1.5 User Reliance

This report was prepared for Canmoor (Manchester) Limited. Reliance on the Report by any other third party is subject to requesting and fully executing a reliance letter between TRC and the third party that acknowledges the TRC Standard Terms and Conditions with the Client, to the same extent as if they were the Client thereunder.

TRC has been provided with information from third parties for information purposes only and without representation or warranty, express or implied as to its accuracy or completeness and without any liability on such third parties part to revise or update the information. Where reliance has been provided by third parties to potential purchasers this is noted in our report.

2.0 Site Setting

2.1 Site Description

The main part of the Site, which is included within the current planning site boundary comprises an approximate 5.74ha plot of land centred on National Grid Reference SJ 87040, 99980, which is approximately 3.5km to the northeast of Manchester City Centre. In addition, two further plots measuring an additional 4.5ha are also being considered for redevelopment and area also included within the overall site boundary.

The main part of the site Site was an irregular shape which measured a maximum length of approximately 380m north to south and approximately 180m east to west. The main part of the site included an access road from Grimshaw Lane. Plot 1 was located immediately to the west of the main site, located to the north of the access road and fronting onto Grimshaw Lane. Plot 2 was located to the southeast of the main site, adjacent to Ten Acres Lane and extending as far as Briscoe Lane.

At the time of report the main part of the Site was derelict, occupied by various disused interlinking foundry buildings, areas of hardstanding and soft landscaping. The main buildings were located across a vast majority of the Mather's Foundry Site. Both Plots 1 and 2 are currently vacant and are covered by grassland and vegetation. An access roadway also formed part of the Site, providing access from Grimshaw Lane to the southwest.

A bakery is located to the south of Plot 2. Ten Acres Lane was located to the east of the Site, with a sports complex beyond this. Field space was located to the north of the Site with residential dwellings beyond. Grimshaw Lane was located southwest of the Site, with commercial facilities beyond. TRC had not undertaken a Site walkover at the time of preparing this report. Therefore, the above information is based on anecdotal evidence only. The findings of the Site walkover will be detailed in TRCs Phase II Geo-environmental Site Assessment, which will be detailed under a separate cover.

The Site has an average elevation of approximately 64m Above Ordnance Datum (AOD) in western section of the Site, adjacent to Grimshaw Lane. This increases to approximately 77mAOD adjacent to the northern corner of the Site, within Ten Acres Lane.

2.2 Site History

The following provides a summary of the historical use of the Site and surrounding area with specific emphasis on activities relating to coal mining. Full details of the Site history are provided in the Due Diligence Geo-Environmental Site Assessment written by Curtins (ref: 070588-CUR-XX-RP-GE-001, dated - 3rd February 2020). The site history has been updated to include the two additional plots of land.

Table 1: Summary of Historical Mapping

Aspect	Map Dates	Location	Description
General Site Features	1848 - 2019	On-Site	The earliest OS map available for study was from 1848, which indicated that the Site comprised open agricultural fields with a number of small ponds. In 1893 a football ground was recorded in the north of the Site. By 1908 the football ground was no longer present, and an excavation was recorded in the western section of the Site. A mineral railway also encroached onto the southern part of the Site, adjacent to the excavation, and led to Park Engineering Works that was partially located within Plot 2. On the 1932 mapping a building was recorded in the south of the Site which formed part of the Park Engineering Works. The excavation in the western section of the Site was no longer recorded and a recreation ground is present. Between 1938 and 1999 Park Engineering Works expanded further to include two buildings in the central and northern section of the Site. Two tanks were recorded in the northeast of the Site and a further tank to the east of the Park Engineering Works on Plot 2. A bowling green was present in the northwest of the Site. Travelling cranes were identified at the Site in the northeast section post 1971. Numerous slopes are indicated to be present suggesting that significant reprofiling of the Site had occurred to produce level building platforms. Between 1999 and 2019 the bowling green was no longer in use and overgrown. Also, the works at the Site were no longer in use. The aerial photograph from 2000 indicated that the former engineering works within Plot 2 area had been demolished.
Excavations	1908 - 1938	On-Site	An excavation was noted on the Site during the period, which was later infilled. A slope is also indicated along the north eastern boundary of the Site, adjacent to Ten Acres Lane and it is feasible that furthermore extensive excavations had already occurred across the Site. Within the Plot 2 area there were a number of large ponds present suggesting that this area had also been excavated. Further excavations were present to the northeast of the Site that were situated adjacent to a brick works. Located to on the far side of Ten Acres Lane..

Aspect	Map Dates	Location	Description
Coal Mining Features	1848 - 2019	>250m	The following coal mining features were indicated to be present in the surrounding area: • 1848 – several coal pits were located >600m southwest, south and west of the Site; • 1848 – Gleden Coal Pit No 1 and No 2 were located approximately 800 to the southwest. From the features on the map these may have included shafts for underground mining and not just surface coal mining. • 1894 to 1909 – a coal yard was located approximately 250m west of the Site. • 1909 to 1923 a Coal Wharf was located approximately 350m west of the Site.

3.0 Ground Conditions

3.1 Published Geology

The following publications of the British Geological Survey (BGS) and Coal Authority have been examined in respect of the strata underlying the Site:

- BGS Geoindex;
- BGS historical borehole records;
- BGS 1:50,000 Series Map Sheet 85, Manchester (Bedrock and Superficial Edition), 2011 and (Bedrock Edition), 2010;
- Coal Authority website; and,
- Coal Authority Consultants Coal Mining Report (ref: 51002290625001, dated 22nd July 2020).

In addition, reference has been made to the following guidance document:

- Abandoned Mine Workings Manual (CIRIA Report C758D, 2019).

3.2 Made Ground and Superficial Geology

According to the BGS Geoindex service, the Site is underlain by superficial deposits comprising Glacial Till across the entirety of the Site. The previous investigation by Curtins encountered Glacial Till from between 0.2m and 8.0m below ground level (bgl), which persisted to the base of the boreholes (maximum 12.0mbgl). According to cross section included on the 1:50,000 Series Map (Bedrock and Superficial Edition) Ice Contact Deposits (mainly sand with some gravel) are present in the surrounding area and could also be encountered at the Site.

While the BGS maps do not indicate Made Ground to be present beneath the Site, the historical OS maps indicate that there was once an excavation in the western section of the Site which was later infilled. In addition, a slope was historically present along the northeastern side of the Site and significant reprofiling of the Site occurred during the development of the Site indicating that variable thicknesses of made ground are likely to be present across the Site. This was confirmed by the investigation undertaken by both the Curtins and TRC Phase II investigations which encountered Made Ground ranging in thickness from 0.2m to 8.0mbgl. The investigation of Plot 1 by WYG Environment indicated that made ground extended to depths of between 0.4 and 3.3m bgl. The thickest Made Ground was in the western section of the Site (nearby to the historical excavation). Other areas that encountered Made Ground of significant thickness was the northern section of the Site (3.05m to 4.3m) and the eastern section of the Site (maximum of 2.7m).

The 1:50,000 scale map (bedrock and superficial edition) included a map which provided an indication of the bedrock elevation across the region. This indicated that bedrock was anticipated to be encountered at an elevation of approximately 40 to 50mAOD. The depth to bedrock generally increased to the west towards an old river system known as the Proto-Ryton. Site elevation at the Site varied from 64mAOD in the southwest to the 77mAOD at the northern end. Assuming bedrock was at an average elevation of 45mAOD this would result in depths of bedrock across the Site of between 19 and 32m across the Site. Even though the bedrock surface is indicated to slope to the west, the change in surface elevation is likely to result in an increased thickness of superficial deposits at the eastern end of the Site.

The investigations undertaken by Curtins and WYG Environmental did not encounter the bedrock geology. However, extensive Glacial Till was encountered across the Site underlying the Made Ground. The Glacial Till extended to the base of the boreholes that were drilled to a maximum depth of 12m bgl. The Glacial Till was typically cohesive with interbedded sand bands of variable thickness.

3.3 Bedrock Geology

According to the BGS Geoindex, bedrock beneath the Site is indicated to comprise the Chester Formation across the majority of the Site. The BGS describes the Chester Formation as "*The formation shows a progressive change in lithology northwards, from a coarse-grained, typically well-cemented proximal facies to fine-grained, less well-cemented facies*".

A northwest to southeast orientated fault (named the Bradford Fault) is indicated to cross the Site, to the southwest of the main Site buildings. Plot 1 is located to the southwest of the fault and the main site area and Plot 2 is located to the northeast. A fault is a discontinuity or fracture of a rock which can cause displacement due to the movement of the rock. The fault line at the Site will relate to the bedrock geology, however this could cause movement of the superficial deposits overlying this if the superficial deposits are not of a significant thickness. To the south of the fault line strata of the Pennine Middle Coal Measures Formation are indicated to be present. The Pennine Middle Coal Measures Formation is indicated to comprise interbedded grey mudstone, siltstone, pale grey sandstone and commonly coal seams, with a bed of mudstone containing marine fossils at the base, and several marine fossil-bearing mudstones in the upper half of the unit.

Immediately to the southwest of the fault the Newton Heath Sandstone is documented to be present, which is named unit within the Pennine Middle Coal Measures Formation. The 1:50,000 Series BGS map indicates that the Newton Heath Sandstone Formation is between 15 and 20m thick and underlain by mudstones and siltstones of the Pennine Middle Coal Measures and the following specific features:

- Edmondia Marine Band;
- Worsley Four Feet Coal;
- Parker Coal;
- Aegiranum Marine Band;
- Sutton Marine Band;
- Haughton Marine Band;
- Radley Coal.

The Coal Measures in the vicinity of the Site are indicated to dip to the southwest by approximately 15 degrees. Several coal seams are indicated to subcrop (located directly beneath the superficial deposits with no rock cover) to the southwest. However, these are located stratigraphically above the Newton Heath Sandstone and given the dip of the strata will not be present beneath the Site.

The Coal Authority Consultants Coal Mining Report (CAC) indicates that the Parker seam was mined beneath the Site. The CAC also indicated that a coal seam was shown to subcrop beneath the southwestern part of the Site, across the Site access road. This coal seam has been named as the Doctor Coal which is not indicated on the 1:50,000 scale map.

According to an internet search (Wikipedia) the Doctor Coal was part of the Bradford Group from the Upper Pennine Coal Measures, along with the Two Foot, New, Yard, Bradford Four Foot, Three Quarters and Charlotte. Given the source of this information this should only be treated as anecdotal. The BGS did not provide further details on the Doctors Coal. According to the 1:50,000 Scale map, the boundary between the Upper and Middle Pennine Coal Measures is marked by the Cambriense Marine Band indicated to subcrop approximately 190m to the southwest of the Site.

3.4 BGS Historical Borehole Records

Several BGS historical borehole records are located on the Site, however, all but one of the logs are restricted / confidential, as such these could not be assessed. The records each side of the fault line (off Site) and therefore may be expected to show the general sequence of the geology. The following records, that were in excess of 10m depth (excluding the onsite borehole), were reviewed and presented as Annex B.

SJ89NE52, located on Site (western edge of the Site)
This borehole log contains several boreholes that were drilled onsite to a maximum depth of 9.75mbgl. All the locations encountered Made Ground underlain by Boulder Clay to the base of the boreholes.

SJ89NE2508, located 250m to the south
Glacial Till comprising clay with occasional sand bands was noted from 1.6m (underlying the Made Ground) to the 23.2m. The was underlain by a 'large boulder' to the base of the borehole at 23.6m.

SJ89NE469, located 290m to the west
This borehole is located to the west of the fault line at the Site and provides a detailed record of the possible geological sequence, as detailed below:

- 0 – 0.2m = Concrete
- 0.2 – 0.4m = Black fill
- 0.4 – 6.4m = Black clay
- 6.4 – 9.0m = Black clay and gravel
- 9.0 – 21.8m = Sandy clay
- 21.8 – 30.2m = Red marl
- 30.2 – 32.0m = Sand
- 32.0 – 60.0m = Black coal measures

From the above descriptions it is difficult to definitively state whether Coal Measures bedrock was encountered at depth of either 21.8 or 32mbgl.

SD80SE81, located 600m to the northwest
Clay with stones was encountered to 13.71m, underlain by a gravel band to 14.02m. In turn, this was underlain by clay with stones to 24.38m, before becoming a black shale to the base of the borehole at 29.26m. This has been interpreted as Glacial Till with a layer of granular Glacial Deposits to a depth of approximately 24.4m overlying Coal Measures strata.

SD80SE76, located 1,200m to the northeast
No BGS boreholes of sufficient depth are located to the east of the Site (i.e. east of the fault), as such this borehole has been utilised. This provides detailed record of the possible geological sequence, as detailed below:

- 0 – 12.19m = Clay
- 12.19 – 19.81m = Quicksand
- 19.81 – 23.10m = Blue clay
- 23.10 – 33.52m = Yellow clay
- 33.52 – 35.05 = Clay and gravel
- 35.05 – 36.88 = Sandstone
- 36.88 – 45.72 = Red marl
- 45.72 – 107.89m = Sandstone

The historical boreholes provided an indication that the superficial deposits in the area extended to depths in excess of 20mbgl and while the superficial deposits generally comprised Glacial Till there were layers of granular Glacial Deposits also present.

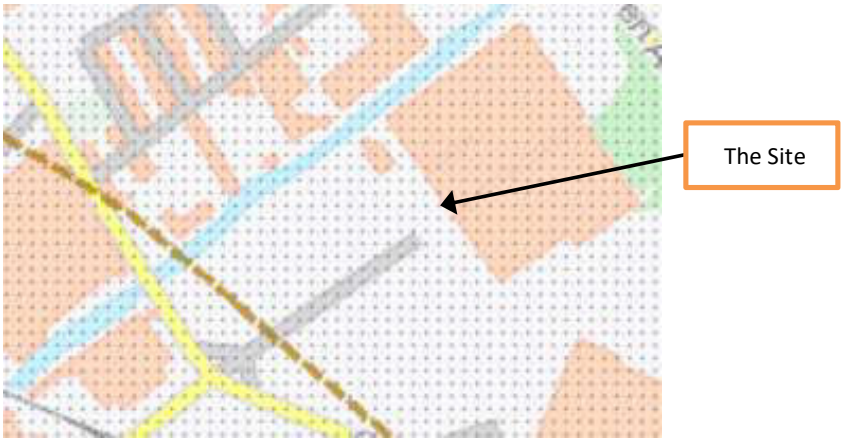
3.5 Coal Authority

According to the Coal Authority the Site is located within a coal mining reporting area and in addition the following information was obtained:

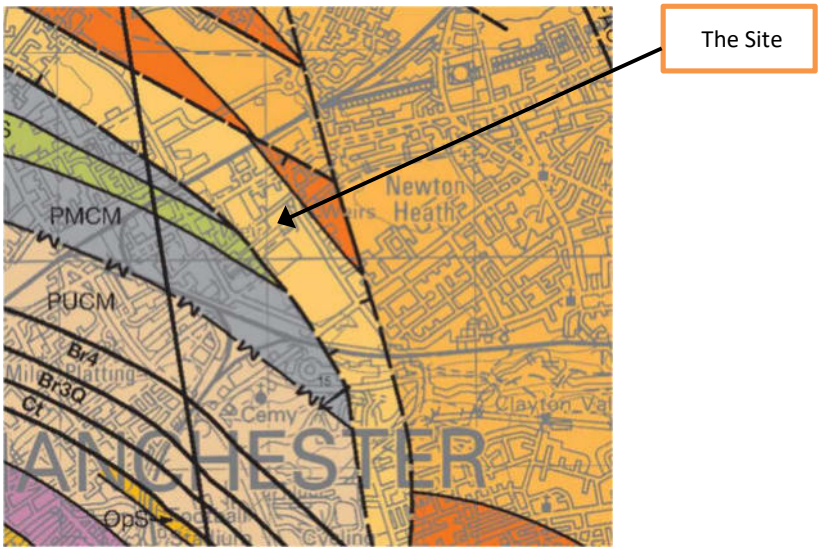
- A development high risk area is located in western edge of the Site, adjacent to Grimshaw Lane;
- An area of probable shallow coal mine workings coincides with development high risk area;

- Underground workings are indicated to be present on the western edge of the Site, adjacent to Grimshaw Lane. The coal is indicated to dip at approximately 18 degrees to the southwest of the Site. The seam thickness was approximately 0.8m and the seam was mined up to 1935.

One outcrop (assumed to subcrop due to the presence of superficial deposits) is present on the western edge of the Site, which is shown below.



Extract from Coal Authority WebSite depicting Underground Workings (purple).



Extract from BGS Geoindex depicting Newton Heath Sandstone (green), general Coal Measures (grey), coal outcrops (thick black lines) and fault lines (thin black dashed lines)

3.6 Consultants Coal Mining Report

The Consultants Coal Mining Report provided by the Coal Authority provides the following information:

- There is record of working within one coal seam at the Site. The following is an extract from the Coal Mining Report showing details of the worked seams.

Past underground mining

Colliery	Seam	Mineral	Coal Authority reference	Depth (m)	Direction to working	Dipping rate of seam worked (degrees)	Dipped direction of seam worked	Extraction thickness (cm)	Year last mined
unnamed	PARKER	Coal	35BL	127	Beneath Property	18.0	South-West	80	1935
unnamed	PARKER	Coal	35BJ	145	North	17.9	South-West	80	1935
unnamed	CROMBOUKE	Coal	359F	549	South	21.0	South-West	120	1924
unnamed	CROMBOUKE	Coal	359J	554	South	16.0	South-West	120	1933
unnamed	CROMBOUKE	Coal	3597	564	West	16.9	South-West	120	1936
unnamed	ROGER	Coal	35AN	574	West	17.2	South-West	180	1964
unnamed	ROGER	Coal	35AY	587	South-West	16.1	South-West	180	1961

In addition, the Coal Authority report indicates the following:

- Probably unrecorded shallow workings are anticipated at the Site;
- No spine roadways recorded at shallow depth;
- No mine entries recorded within 100 metres of the enquiry boundary;
- There are five abandoned mine plans available, presumably associated with the coal working indicated above;
- There is one coal outcrop within the Site boundary, named as the Doctor Seam;
- A fault is recorded at the Site, which runs northwest to southeast.
- No opencast mines recorded within 500m of the enquiry boundary;
- No Coal Authority managed tips recorded within 500m of the enquiry boundary;
- There are no records of Site investigations within 50m of the enquiry boundary;
- The Coal Authority has not received a damage notice or claim for the subject property, or any property within 50 metres of the enquiry boundary, since 31 October 1994;
- There is no current Stop Notice delaying the start of remedial works or repairs to the property;
- The Coal Authority is not aware of any request having been made to carry out preventive works before coal is worked under section 33 of the Coal Mining Subsidence Act 1991;
- No mine gas records recorded within 500m of the enquiry boundary;
- No mine water treatment schemes recorded within 500m of the enquiry boundary;
- No records of future underground mining or coal mining licensing;
- No notices have been given, under section 46 of the Coal Mining Subsidence Act 1991, stating that the land is at risk of subsidence;
- The property is not in an area where a notice to withdraw support has been given; and,
- The property is not in an area where a notice has been given under section 41 of the Coal Industry Act 1994, cancelling the entitlement to withdraw support.

The Consultants Coal Mining Report is included as Annex C.

4.0 Assessment of Coal Mining Risks

4.1 Known Workings

The findings of the desktop review indicate that one coal seam was worked beneath the Site. The worked coal seam was located to the southwest of the fault and therefore is only likely to be present beneath Plot 1. This was the Parker Coal at a depth of 127mbgl. The seam was indicated to dip southwest at a depth of 18 degrees to the southwest. The extraction thickness was 0.8m and this was last mined in 1935.

It is anticipated that the mining would have been undertaken using room and pillar techniques. CIRIA guidance document C758D 'Abandoned Mine Workings Manual' states that there are three principal modes of failure in room and pillar workings comprising roof failure, floor heave and pillar failure and that roof failure is by far the most common cause of subsidence.

In some cases when the mine was abandoned, a room may have been packed with waste rock debris (back stowing), but in other cases the room may have remained open. In these cases there is a the potential for roof collapses to be initiated leading to a collapse of rock to the floor of the workings resulting in the upwards migration of a void through the strata until it is either choke filled, arrested by overlying competent strata or appears at the surface as a crown/chimney hole.

The other two mechanisms of collapse (floor heave and pillar failure) both involve failure of the pillars, the first due to the softening of the floor material (essentially bearing capacity failure) and the second by shearing/failure of the pillar itself.

The established rule of thumb is that there needed to be approximately 10 times the seam thickness of competent strata above the workings to prevent the void migrating to surface. CIRIA C758 indicates that with respect to roof collapse this approximation still appears to hold, even though there is some evidence to suggest that the span width (i.e. the distance between two pillars or supports) is also an influencing factor. However, the way the void migrates upwards does vary according to the nature (e.g. strata dip and bulking characteristics) and thickness of the rock and soil overburden. Interbedded strata for example have a higher potential to host upwards migration of voids compared with strata comprised of a single rock type. Void migration can also be exaggerated where faults or fissures exist in the roof rock or where there are significant quantities of water.

Cases where consideration to an increase in the 10 times seam thickness rule of thumb should be applied include:

- Where strata dip is greater than approximately 20 degrees as there is a potential for collapsed material to flow down-dip into deeper areas of the workings thus reducing potential for 'choke-out' to occur;
- High groundwater flow zones where materials could be washed away or condition of floor, pillars and/or roof could deteriorate;
- Where there was a particularly high extraction rate (e.g. due to pillar robbing); or
- Where there have been multiple seam extractions.

To achieve the 10 times seam thickness rule of thumb, would require in excess of 8m of intact rock for a 0.80m thick coal seam. Given that the shallowest know worked coal seam is located 127mbgl, and that superficial deposits at the Site could potentially be between 20 and 30m thick then this rule of thumb is likely to applicable and therefore the risk of voids migration to surface is considered to be low.

4.2 Potential Shallow Workings

The Coal Authority website indicates that the western edge of Plot 1 is located within a development high risk area due to the presence of a coal seam which is indicate to subcrop beneath the superficial deposits. The Coal Authority Consultants Report identifies this as the Doctor Coal. It is noted that the Consultants Report indicates that the seam was not workable.

The BGS map indicates that the Site is underlain by Chester Formation across much of the Site. The Newton Heath Sandstone is located across the centre of the Site, which is a named sandstone unit within the Pennine Middle Coal Measures Formation. The Chester Formation and Newton Heath Sandstone is separated by a fault line. It is noted that the 1:50,000 Series BGS map does not record the presence of the Doctor Coal indicating that this is not a significant seam. In addition, there is likely to be superficial deposits overlying the Doctor Coal seam which could be in excess of 20m thick. If present the Doctor Coal is likely to dip to the southwest (i.e. off-site) and therefore is only likely to be present beneath the southwestern part of Plot 1 and the existing Site access road.

Given that the Consultants report indicates that the Doctor Coal was not workable and given the considerable thickness of overlying superficial deposits it is considered that the coal seam was unlikely to have been worked.

The proposed redevelopment includes the construction of new buildings in the main part of the site, located predominantly to the northeast of the fault line and to the northeast of the Doctor Coal Seam subcrop. The Doctor Coal subcrops at the western end of Plot 1 with the coal seam dipping away from the main part of the Site. As such while there remains a potential risk that the coal seam had been worked, the proportion of the site affected is considered to be small (limited to the southwestern edge of the site).

4.3 Other Mining Risks

A fault line is indicated to be present at the Site. Fault lines can act as preferential pathways for the migration of mine gas. The Consultants Coal Mining Report indicates that the Parker Mine was likely to extend up to the fault and therefore there is a potential risk that mine gas could migrate upwards through the broken ground caused by the faulting. It is anticipated that there is likely to be in excess of 20m of superficial deposits overlying the bedrock. The superficial deposits would have been deposited after the fault movement and as such the fault is unlikely to extend to surface.

The superficial deposits predominantly comprised Glacial Till that would prevent the upwards migration of mine gas. However, the BGS 1:50,000 scale maps indicated that there was the potential for granular materials to be present within the Glacial Till. The previous investigation at the Site identified that the majority of the superficial deposits comprised Glacial Till and therefore it is considered that the risk of mine gas migrating to surface is considered to be low. However, it is recommended that if granular materials are encountered in the vicinity of the fault line, that monitoring wells are installed with the screened sections installed to coincide with the granular layers. Subsequent permanent ground gas monitoring should be undertaken to ensure that the granular layers do not provide a pathway through the Glacial Till for gas migration.

4.4 Proposed Development Foundations

It is considered that superficial deposits in the form of the Glacial Till will be present across the Site, with localised granular Glacial Deposits also possible. Further investigation is required to determine whether the Glacial Till can form a suitable bearing stratum for the proposed development. Deep made ground has been identified in some locations. Piled foundations or ground improvement is likely to be required in some areas. However, it is considered that piles end bearing within the Glacial Till are likely to be appropriate. If deep piled foundations are required then the foundation design will need to take into consideration the presence of the fault and the potential for broken ground. It is recommended that the depth of superficial deposits in the vicinity of the fault is determined, if deep piled foundations are adopted.

5.0 Conclusions and Recommendations

5.1 Conclusions

According to the Coal Authority there is one worked coal seam beneath the Site, at a depth of 127mbgl. The coal mining assessment has indicated that there should be sufficient thickness of intact rock above this coal seam to minimise risk of voids migrating to surface.

However, the Coal Authority does indicate that there may be shallow coal workings beneath the Site, specifically on the western edge of the Site (Plot 1 and access road). Additional information supplied by the Coal Authority indicates that this is likely to be associated with the Doctor Coal, which is shown to dip to the southwest. The Consultants report suggests that the Doctor Coal was not worked.

The proposed redevelopment includes the construction of new buildings in the main part of the Site as well as Plot 1 and Plot 2. The main part of the site and Plot 2 are both located to the northeast of the fault line and as such are not at risk from the potential underground coal workings. With respect to Plot 1 and the access road, the majority of these areas are located to the northeast of the Doctor Coal Seam subcrop. The coal seam dips to the south west away from the majority of Plot 1 and therefore it is the western edge of Plot 1 that is considered to be potentially at risk from the shallow coal seam if it had been worked. However, given the information reviewed it is considered that the risk is low.

A fault line is indicated to be present at the Site with the Parker Mine indicated to extend up to the fault line. Fault lines can act as preferential pathways for the migration of mine gas. It is anticipated that there is likely to be in excess of 20m of superficial deposits overlying the bedrock, that is likely to be predominantly cohesive limiting the upwards migration of mine gas.

5.2 Recommendations

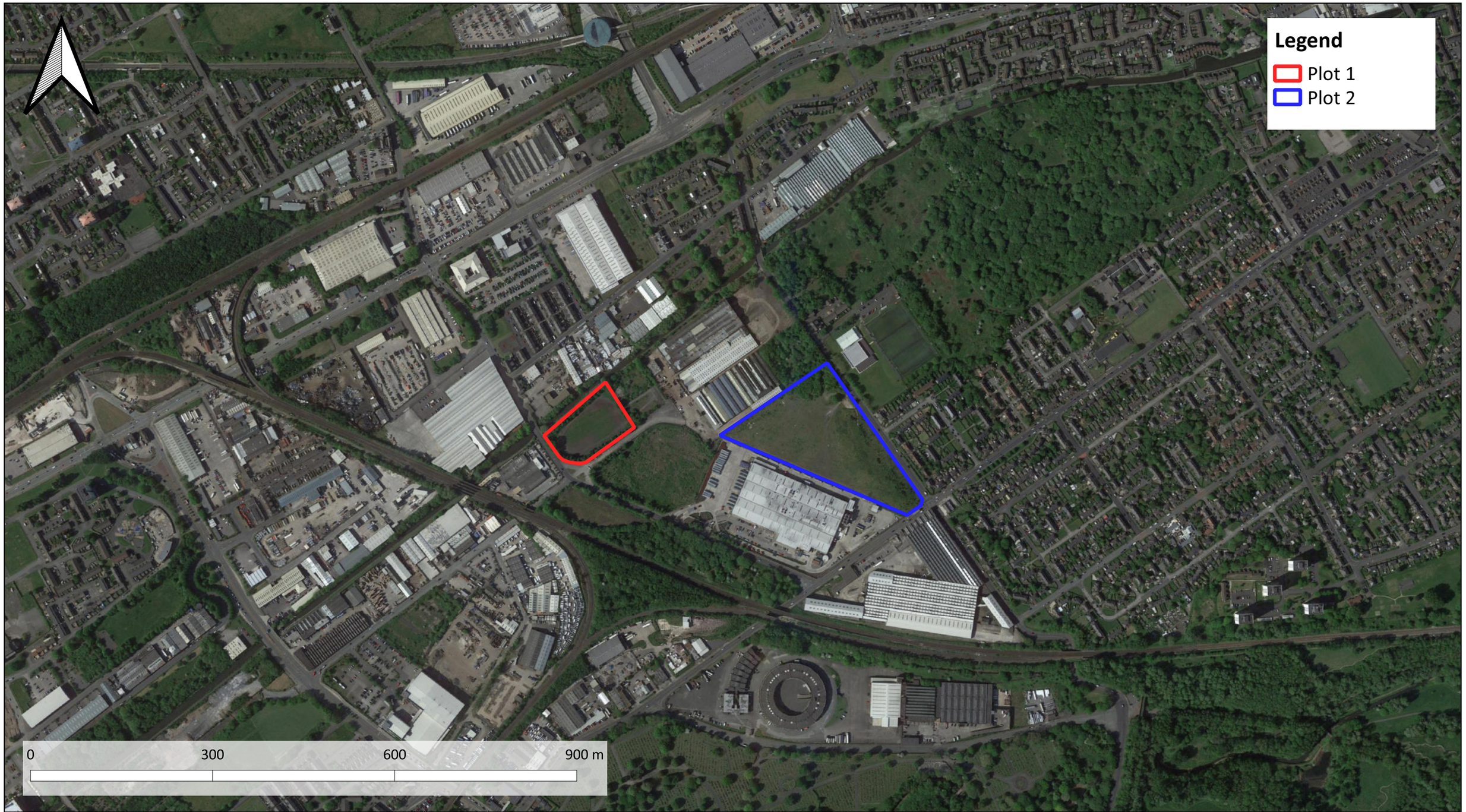
The presence of a coal seam subcropping beneath the Glacial Till in the western part of the site has resulted in the Coal Authority classifying this area of the site as a development high risk area. This means that further investigation of this area will be required in order to determine if this coal seam has been worked.

The Consultants Coal Mining Report provided contradictory information regarding whether the coal seam had been worked and therefore intrusive site investigation will be required in order to provide further information. It is recommended that a minimum of three deep boreholes are drilled at the western end of the site. The boreholes should fully penetrate the superficial deposits and extend at least 10m into the Pennine Middle Coal Measures to determine whether there is a coal seam present and, if present to determine if it had been worked.

In addition, TRC consider that there is also a potential risk to the proposed development from the fault line. Based upon the information collected by Curtins and TRC it is likely that this will be masked by the presence of significant thickness Glacial Till. However, should the Glacial Till be granular in nature this could act as a preferential pathway for mine gas. The proposed development includes new commercial units in the vicinity of the fault. It is recommended that the thickness of the superficial deposits are proved in the vicinity of the fault line, so that future foundations are contained within the superficial deposits and do not overstress potential broken ground associated with the fault. However, proving the depth of the bedrock geology will only be required if a deep piled foundation solution is adopted. It is assumed that a shallow foundation solution, shallow piled foundation solution or ground improvement methodology will be appropriate for the scheme, subject to the findings of the Phase II Geo-environmental Site Assessment.

In addition, it is recommended that should granular deposits be encountered within the Glacial Till that monitoring wells are installed with the screened sections installed to coincide with the granular layers. Subsequent permanent ground gas monitoring should be undertaken to ensure that the granular layers do not provide a pathway through the Glacial Till for gas migration.

Annex A: Figures



NOTES

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REVISIONS

REV.	REVISION NOTES/COMMENTS			
	Initials			
P01	FIRST ISSUE			
	Initials	CMD	CMD	18/01/21

TRC
Work.Life
Brown Street,
Manchester,
M2 1DH

CANMOOR

PROJECT
GRIMSHAW LANE, PLOTS 1&2

TITLE
SITE LOCATION PLAN

TRC PROJECT NO.	SCALE @ A3
423207	1:6000

PURPOSE OF ISSUE	STATUS
SUITABLE FOR INFORMATION	S2

DRAWING NO.	REVISION
FIGURE 01	P01

Annex B: Historical BGS Borehole Logs

British Geological Survey

Version 2.0.6.1

BGS ID: 27661 : BGS Reference: SD80SE76
British National Grid (27700) : 388241,400733
Report an issue with this borehole

<< < Prev Page 1 of 3 Next > >>

(621) Wt. 5990—S.33 2000 6/22 Gp. 147 M.R.Co.Ltd.

132 SD 80 SE 76 No. 24.

SECTION OF Borehole at Messrs. Rothwell & Co., Heath Brewery, Oldham Road, Newton Heath, Manchester. 10.

Maps: One-inch 85 Six-inch 104 N.E.E County Lancashire

Height above O.D. 290 feet Latitude Longitude

Communicated by Professor George Hickling 260 Date of sinking 29th Aug. 1895.

Made by Dip of Strata

Hickling's No. 38.
Trans. Inst. Min. Eng. Vol. LIV. 1918. SD 8824 0072 M/c 89.

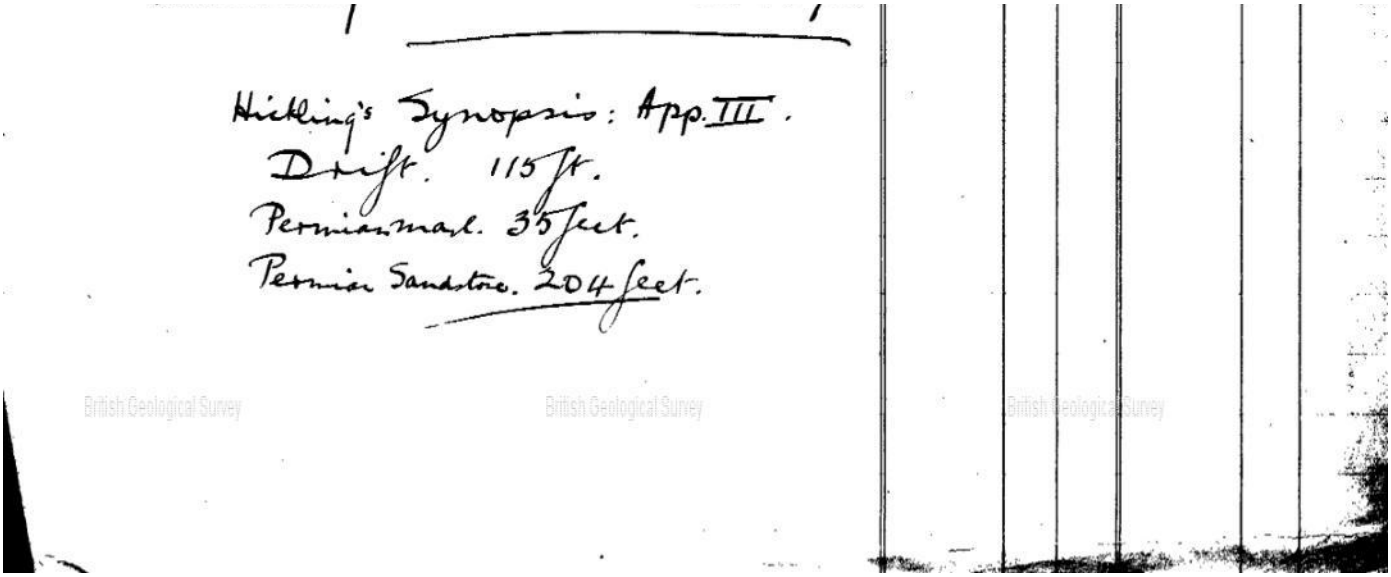
5/104 NE 12 4

	Thickness.		Depth from Surface.		
No well.			metres		
No record.	—	—	1.52	5	—
Clay	35	—	12.19	40	—
Quicksand	25	—	19.81	65	—
Blue clay	11	—	23.16	76	—
Yellow clay	34	—	33.52	110	—
Clay & gravel	5	—	35.05	115	—
? Roach. Soft red sandstone	6	—	36.88	121	—
O.D. 169+. Red marl	29	—	45.72	150	—
? Cs. Red sandstone.	204	—	107.89	354	—

Total solids in solution: 42.6.

CaO	9.0
MgO	5.0
SO_3	5.16
CO_2	1.32
Cl.	2.41
Hardness	20%
Alkalinity	24.15%.

28.6 pts/100,000



Hickling's Synopsis: App. III.
Drift. 115 ft.
Permian marl. 35 feet.
Permian Sandstone. 204 feet.

British Geological Survey
British Geological Survey
British Geological Survey

British Geological Survey

Version 2.0.6.1

BGS ID: 27661 : BGS Reference: SD80SE76
British National Grid (27700) : 388241,400733

Report an issue with this borehole

<< < Prev Page 3 of 3 Next > >>

SD8817 0070 SD 80/3 SD80SE/76 No. 124. Drawn up. W.T.

(631) Wt. 599)—S.33 2000 6 21 Gp. 147 M.R.Co.Ltd.

SECTION OF Borehole at Messrs. Rothwell & Co., Heath Brewery, Oldham Road, Newton Heath. Manchester. 10.

Maps: One-inch 85 Six-inch 104 N.W. County Lancashire

Height above O.D. 290 feet. Latitude Longitude

Communicated by Professor George Hickling 260 Date of sinking 29th Aug. 1895.

Made by Dip of Strata

Hickling's No. 38. M/c 89.

Trans. Inst. Min. Eng. Vol. LIV. 1918.

	Thickness.		Depth from Surface.	
No well.				
No record.			5	–
Clay	35	–	40	–
Quicksand	25	–	65	–
Blue clay	11	–	76	–
Yellow clay	34	–	110	–
Clay & gravel	5	–	115	–
? Road drift red sandstone	6	–	121	–
O.D. 169+. Red marl	29	–	150	–
Red sandstone.	204	–	354	–

Total solids in solution: 42.6.

CaO	9.0
MgO	5.0
SO_3	5.16
CO_2	1.32
Cl.	2.41
Hardness	20%
Alkalinity	24.15%.

28.4 grs/100 c.c.

Hickling's Synopsis: App. III.

Drift. 115 ft.
Permian marl. 35 feet.
Permian Sandstone. 204 feet.

SD 80/3.

British Geological Survey British Geological Survey British Geological Survey

Annex C: Consultants Coal Mining Report

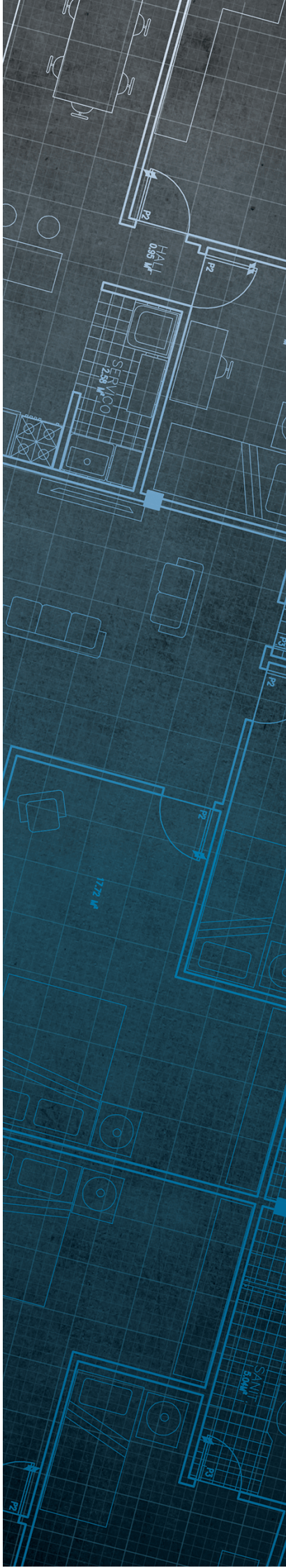
The Coal Authority

Consultants

Coal Mining Report

Park Works
Grimshaw Lane
Manchester
M40 2BA

Date of enquiry:	**22 July 2020**
Date enquiry received:	**22 July 2020**
Issue date:	**22 July 2020**
Our reference:	**51002290625001**
Your reference:	**385367**



Consultants

Coal Mining Report

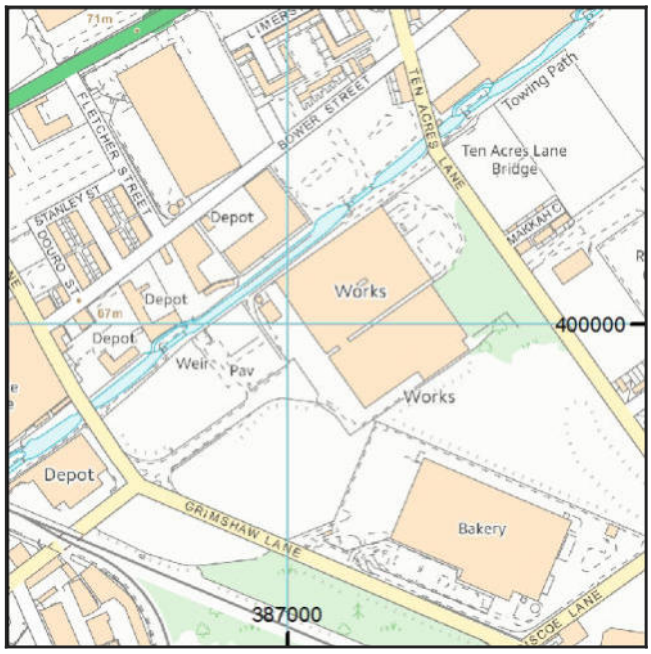
This report is based on and limited to the records held by the Coal Authority at the time the report was produced.

Client name

TRC

Enquiry address

Park Works
Grimshaw Lane
Manchester
M40 2BA



Approximate position of property

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NG18 4RG

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/thecoalauthority
/thecoalauthority

Section 1 – Mining activity and geology

Past underground mining

Colliery	Seam	Mineral	Coal Authority reference	Depth (m)	Direction to working	Dipping rate of seam worked (degrees)	Dipped direction of seam worked	Extraction thickness (cm)	Year last mined
unnamed	PARKER	Coal	35BL	127	Beneath Property	18.0	South-West	80	1935
unnamed	PARKER	Coal	35BJ	145	North	17.9	South-West	80	1935
unnamed	CROMBOUKE	Coal	359F	549	South	21.0	South-West	120	1924
unnamed	CROMBOUKE	Coal	359J	554	South	16.0	South-West	120	1933
unnamed	CROMBOUKE	Coal	3597	564	West	16.9	South-West	120	1936
unnamed	ROGER	Coal	35AN	574	West	17.2	South-West	180	1964
unnamed	ROGER	Coal	35AY	587	South-West	16.1	South-West	180	1961

Probable unrecorded shallow workings

Yes.

Spine roadways at shallow depth

No spine roadway recorded at shallow depth.

Mine entries

None recorded within 100 metres of the enquiry boundary.

Abandoned mine plan catalogue numbers

The following abandoned mine plan catalogue numbers intersect with some, or all, of the enquiry boundary:

11471	NW1172	NW437
NW645	NW644	

Please contact us on 0345 762 6848 to determine the exact abandoned mine plans you require based on your needs.

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Outcrops

Seam name	Mineral	Seam workable	Distance to outcrop (m)	Direction to outcrop	Bearing of outcrop
DOCTOR	Coal	No	Within	N/A	130
DOCTOR	Coal	No	31.6	North-West	310

Geological faults, fissures and breaklines

Please refer to the 'Summary of findings' map (on separate sheet) for details of any geological faults, fissures or breaklines either within or intersecting the enquiry boundary.

Faults under or close to the property recorded.

Opencast mines

None recorded within 500 metres of the enquiry boundary.

Coal Authority managed tips

None recorded within 500 metres of the enquiry boundary.

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Section 2 – Investigative or remedial activity

Please refer to the 'Summary of findings' map (on separate sheet) for details of any activity within the area of the site boundary.

Site investigations
None recorded within 50 metres of the enquiry boundary.

Remediated sites
None recorded within 50 metres of the enquiry boundary.

Coal mining subsidence
The Coal Authority has not received a damage notice or claim for the subject property, or any property within 50 metres of the enquiry boundary, since 31 October 1994.

There is no current Stop Notice delaying the start of remedial works or repairs to the property.

The Coal Authority is not aware of any request having been made to carry out preventive works before coal is worked under section 33 of the Coal Mining Subsidence Act 1991.

Mine gas
None recorded within 500 metres of the enquiry boundary.

Mine water treatment schemes
None recorded within 500 metres of the enquiry boundary.

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Section 3 – Licensing and future mining activity

Future underground mining
None recorded.

Coal mining licensing
None recorded within 200 metres of the enquiry boundary.

Court orders
None recorded.

Section 46 notices
No notices have been given, under section 46 of the Coal Mining Subsidence Act 1991, stating that the land is at risk of subsidence.

Withdrawal of support notices
The property is in an area where notices to withdraw support were given in 1955 and 1963.

The property is not in an area where a notice has been given under section 41 of the Coal Industry Act 1994, cancelling the entitlement to withdraw support.

Payments to owners of former copyhold land
The property is not in an area where a relevant notice has been published under the Coal Industry Act 1975/Coal Industry Act 1994.

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Section 4 – Further information

The following potential risks have been identified and as part of your risk assessment should be investigated further.

Development advice

The site is within an area of historical coal mining activity. Should you require advice and/or support on understanding the mining legacy, its risks to your development or what next steps you need to take, please contact us.

For further information on specific site or ground investigations in relation to any issues raised in Section 4, please call us on 0345 762 6848 or email us at groundstability@coal.gov.uk.

Section 5 – Data definitions

The datasets used in this report have limitations and assumptions within their results. For more guidance on the data and the results specific to the enquiry boundary, please **call us on 0345 762 6848** or **email us at groundstability@coal.gov.uk.**

Past underground coal mining

Details of all recorded underground mining relative to the enquiry boundary. Only past underground workings where the enquiry boundary is within 0.7 times the depth of the workings (zone of likely physical influence) allowing for seam inclination, will be included.

Probable unrecorded shallow workings

Areas where the Coal Authority believes there to be unrecorded coal workings that exist at or close to the surface (less than 30 metres deep).

Spine roadways at shallow depth

Connecting roadways either, working to working, or, surface to working, both in-seam and cross measures that exist at or close to the surface (less than 30 metres deep), either within or within 10 metres of the enquiry boundary.

Mine entries

Details of any shaft or adit either within, or within 100 metres of the enquiry boundary including approximate location, brief treatment details where known, the mineral worked from the mine entry and conveyance details where the mine entry has previously been sold by the Authority or its predecessors British Coal or the National Coal Board.

Abandoned mine plan catalogue numbers

Plan numbers extracted from the abandoned mines catalogue containing details of coal and other mineral abandonment plans deposited via the Mines Inspectorate in accordance with the Coal Mines Regulation Act and Metalliferous Mines Regulation Act 1872. A maximum of 9 plan extents that intersect with the enquiry boundary will be included. This does not infer that the workings and/or mine entries shown on the abandonment plan will be relevant to the site/property boundary.

Outcrops

Details of seam outcrops will be included where the enquiry boundary intersects with a conjectured or actual seam outcrop location (derived by either the British Geological Survey or the Coal Authority) or intersects with a defined 50 metres buffer on the coal (dip) side of the outcrop. An indication of whether the Coal Authority believes the seam to be of sufficient thickness and/or quality to have been worked will also be included.

Geological faults, fissures and breaklines

Geological disturbances or fractures in the bedrock. Surface fault lines (British Geological Survey derived data) and fissures and breaklines (Coal Authority derived data) intersecting with the enquiry boundary will be included. In some circumstances faults, fissures or breaklines have been known to contribute to surface subsidence damage as a consequence of underground coal mining.

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Opencast mines
Opencast coal sites from which coal has been removed in the past by opencast (surface) methods and where the enquiry boundary is within 500 metres of either the licence area, site boundary, excavation area (high wall) or coaling area.

Coal Authority managed tips
Locations of disused colliery tip sites owned and managed by the Coal Authority, located within 500 metres of the enquiry boundary.

Site investigations
Details of site investigations within 50 metres of the enquiry boundary where the Coal Authority has received information relating to coal mining risk investigation and/or remediation by third parties.

Remediated sites
Sites where the Coal Authority has undertaken remedial works either within or within 50 metres of the enquiry boundary following report of a hazard relating to coal mining under the Coal Authority's Emergency Surface Hazard Call Out procedures.

Coal mining subsidence
Details of alleged coal mining subsidence claims made since 31 October 1994 either within or within 50 metres of the enquiry boundary. Where the claim relates to the enquiry boundary confirmation of whether the claim was accepted, rejected or whether liability is still being determined will be given. Where the claim has been discharged, whether this was by repair, payment of compensation or a combination of both, the value of the claim, where known, will also be given.

Details of any current 'Stop Notice' deferring remedial works or repairs affecting the property/site, and if so the date of the notice.

Details of any request made to execute preventative works before coal is worked under section 33 of the Coal Mining Subsidence Act 1991. If yes, whether any person withheld consent or failed to comply with any request to execute preventative works.

Mine gas
Reports of alleged mine gas emissions received by the Coal Authority, either within or within 500 metres of the enquiry boundary that subsequently required investigation and action by the Coal Authority to mitigate the effects of the mine gas emission.

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Mine water treatment schemes
Locations where the Coal Authority has constructed or operates assets that remove pollutants from mine water prior to the treated mine water being discharged into the receiving water body.

These schemes are part of the UK's strategy to meet the requirements of the Water Framework Directive. Schemes fall into 2 basic categories: Remedial – mitigating the impact of existing pollution or Preventative – preventing a future pollution incident.

Mine water treatment schemes generally consist of one or more primary settlement lagoons and one or more reed beds for secondary treatment. A small number are more specialised process treatment plants.

Future underground mining
Details of all planned underground mining relative to the enquiry boundary. Only those future workings where the enquiry boundary is within 0.7 times the depth of the workings (zone of likely physical influence) allowing for seam inclination will be included.

Coal mining licensing
Details of all licenses issued by the Coal Authority either within or within 200 metres of the enquiry boundary in relation to the under taking of surface coal mining, underground coal mining or underground coal gasification.

Court orders
Orders in respect of the working of coal under the Mines (Working Facilities and Support) Acts of 1923 and 1966 or any statutory modification or amendment thereof.

Section 46 notices
Notice of proposals relating to underground coal mining operations that have been given under section 46 of the Coal Mining Subsidence Act 1991.

Withdrawal of support notices
Published notices of entitlement to withdraw support and the date of the notice. Details of any revocation notice withdrawing the entitlement to withdraw support given under Section 41 of the Coal Industry Act 1994.

Payment to owners of former copyhold land
Relevant notices which may affect the property and any subsequent notice of retained interests in coal and coal mines, acceptance or rejection notices and whether any compensation has been paid to a claimant.

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VAT receipt

Issued by	The Coal Authority 200 Lichfield Lane Mansfield Nottinghamshire NG18 4RG
Tax point date	22 July 2020
Issued to	TRC 20 RED LION STREET LONDON CAMDEN WC1R 4PQ
Property search for	PARK WORKS GRIMSHAW LANE MANCHESTER M40 2BA
Reference number	51002290625001
Date of issue	22 July 2020
Cost	£112.13
VAT @ 20%	£22.43
Total received	£134.56
VAT registration	598 5850 68

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Summary of findings

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Map data

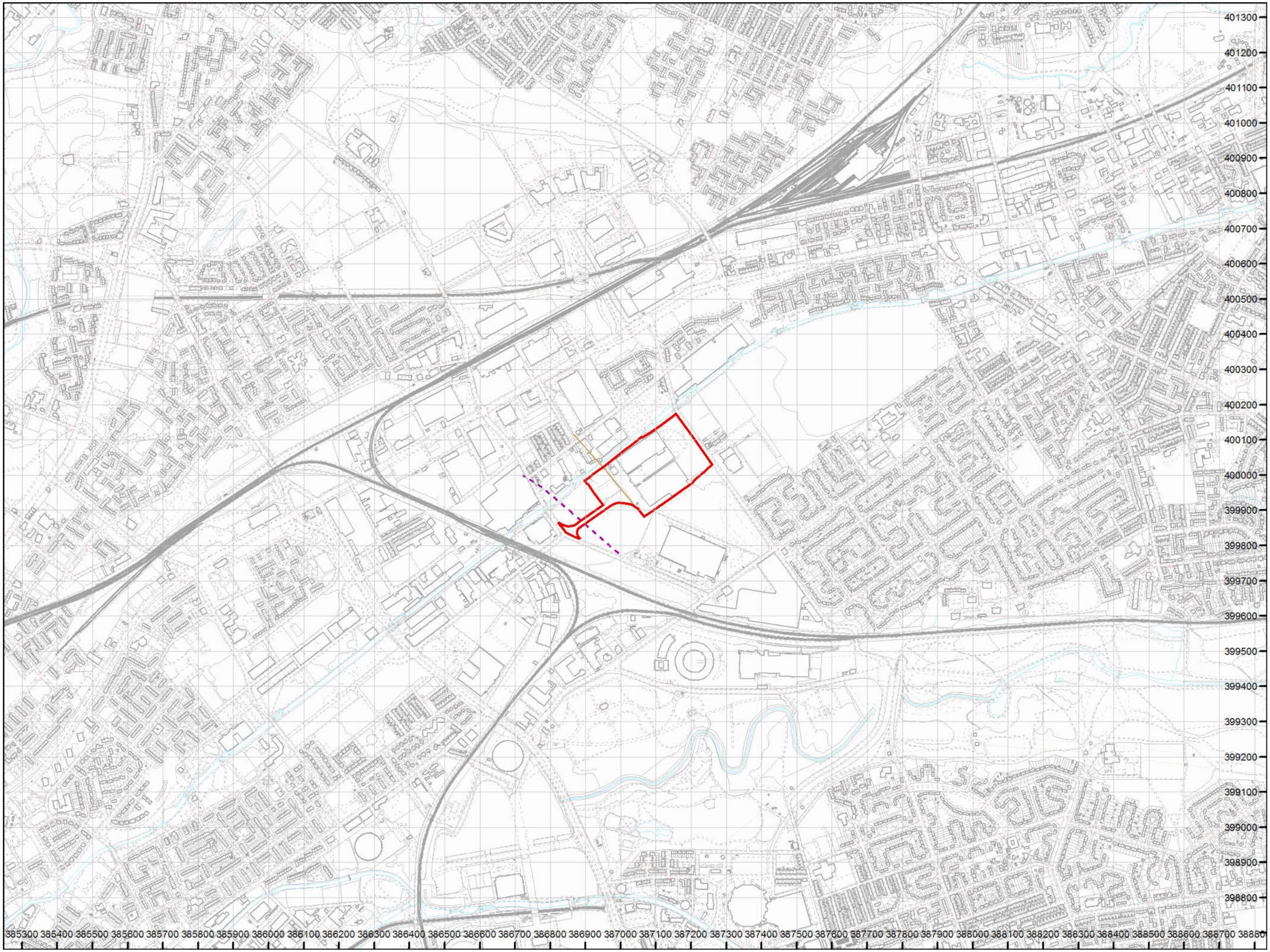
The map highlights any specific surface or subsurface features within or near to the boundary of the site.

Key

Approximate position of the enquiry boundary shown

Outcrop (Conjectured)

Geological faults



How to contact us
0345 762 6848 (UK)
+44 (0)1623 637 000 (International)
www.groundstability.com



Phase II Geo-environmental Site Assessment

Mathers Foundry
Grimshaw Lane
Manchester
M40 2BA

September 2020

385367.0000.0000

Prepared For:
Canmoor (Manchester) Limited
34 Dover Street
London
W1S 4NG

Prepared By:
TRC Companies Limited
20 Red Lion Street
London
WC1R 4PQ

Registered office: 150 Minories, London EC3N 1LS | Company number: 06749633

Quality Control

Client Name:	Canmoor (Manchester) Limited
Project Name:	Mathers Foundry
Project No.:	385367.0000.0000
Document Title:	Phase II Geo-environmental Site Assessment
Date:	September 2020

Version:	Draft	Final		
Prepared by:				
	Abigail Li	Abigail Li		
Reviewed by:				
	Jonathon Sander	Jonathon Sander		
Approved by:				
	Adam Sokolowski	Adam Sokolowski		

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Executive Summary

TRC Companies Limited (TRC) was commissioned by Canmoor (Manchester) Limited to under a Phase II Geo-environmental and Geotechnical Site Assessment at Mathers Foundry, Grimshaw Lane, Manchester, M40 2BA (hereafter referred to as the 'Site'). The purpose of the assessment was to appraise geo-environmental and geotechnical ground conditions at the Site to aid the proposed acquisition and development for commercial / light industrial end use comprising warehouse type buildings with associated yards and car parking.

This Executive Summary is part of the complete report; and findings, opinions or conclusions in this Executive Summary are made in context with the complete report. TRC recommends that the user reads the entire report for all supporting information related to findings opinions and conclusions.

Executive Summary	
Site Details	
Client	Canmoor (Manchester) Limited
Site Address & Grid Reference	Mathers Foundry, Grimshaw Lane, Manchester, M40 2BA Northing (400002) & Easting (387039)
Site Area	5.63 ha
Current Site Use	The Site is currently an inactive plot of land, occupied by various disused interlinking foundry buildings, areas of hardstanding and soft landscaping.
Proposed Development	The proposed development will comprise nine industrial units with associated car parking/yard space. A topographic survey was not available at the time of writing, however based upon the boreholes drilled current Site levels are estimated to be between 70.6mAOD and 74.5mAOD. The Client provided TRC with a draft cut and fill volume drawing (ref: GLM-PTA-SW-XX-GA-C-8020, dated July 2020). The drawing advised that a cut and fill scheme is proposed for the Site, with lowest levels proposed to be filled by up to 2.0m and highest levels with a maximum cut of up to 4.0m. The cut and fill scheme will be necessary to level the Site in order to create a suitable building platform in order to achieve the desired Site elevation for construction.
Phase I Summary	
Site History	The Site appeared undeveloped until the 1890s when football ground/pitches were recorded on the north of the Site. The football ground no longer appeared on maps by the early 1900s. A large excavation was present on the west of the Site and a mineral railway on the south associated with 'Park Engineering Works' which extended on the south of the Site. The excavation on the west was no longer recorded by the 1930s and Park Engineering Works/Mathers Foundry expanded across the Site throughout the 20th century. The works and foundry became disused in 2017. Numerous slopes are indicated to be present suggesting that significant reprofiling of the Site had occurred to produce level building platforms.
Initial Conceptual Site Model	On Site: The historical land uses at the Site, namely Park Engineering Works and Mathers Foundry are a potential Source of contamination. Uncontrolled Made Ground has been deposited across the Site, which is considered as a source of contamination. An area at the west of the Site has been infilled with Made Ground, as shown on Figure 04 in annex A. The following sources are considered: asbestos fibres in soil, heavy metals, polycyclic aromatic hydrocarbons (PAH), total petroleum hydrocarbons and ground gases. The sources at the Site are considered to present a medium risk to future Site users.

	Off Site: The current and historical surrounding industrial land uses are a potential source of asbestos fibres in soil, heavy metals, polycyclic aromatic hydrocarbons (PAH), total petroleum hydrocarbons, polychlorinated biphenyls and ground gases. The sources off Site are considered to pose a low to medium risk to the Site.
Investigation Findings	
Ground Conditions	Made Ground was encountered between ground level and 4.5mbgl, recording a thickness range of 0.3m to 4.5m. Made Ground refusals were encountered at the Site due to obstructions including WS201 (0.6mbgl), WS212 (0.6mbgl) and WS212A (0.6mbgl). The deepest Made Ground was recorded in the west of the Site, which corresponds with a previous assessment provided by the Client for review. Superficial deposits comprising Glacial Till was encountered 0.3m and 4.5mbgl, recording a maximum unproven thickness of 11.0mbgl. Ice Contact Deposits (granular layers) were also encountered in localised areas of the Site, recording a maximum unproven thickness of 2.0m.
Groundwater Conditions	Groundwater was encountered during the Phase II investigation between 0.3m and 4.0mbgl. During subsequent monitoring rounds resting groundwater levels of 0.93m to 2.2mbgl were recorded. Water soluble sulphate contents ranged between 1.55mg/l and 1010mg/l. The pH of groundwater samples obtained within the Site ranged from 6.9 to 10.7.
Contaminated Land Risk Assessment	
Human Health	Elevated levels of inorganic and organic compounds were detected within the soils underlying the Site, which exceeded the GAC for commercial end use. Based upon the proposed development plan it is assumed that there will be a presence of hardstanding within the building footprint providing a physical barrier against contact with potential contaminants. With the Site in its current state ground gas protection measures will be required in the floor slab of the proposed structures.
Controlled Waters	Groundwater samples obtained identified exceedances of the EQS and SoBRA guidelines values for heavy metals, petroleum hydrocarbons and speciated hydrocarbons. Exceedances of the EQS for heavy metals occurred at the majority of sampling locations within the Site. The elevated levels of petroleum hydrocarbons and suspected Light Non-Aqueous Liquid was identified in WS202 and WS204. Exceedances of the EQS for speciated Polycyclic aromatic hydrocarbons (PAH) occurred at WS202, WS204, WS205, CP06 and WS214. This indicates that speciated PAHs are present in the backfilled pit at the west of the Site and the suspected contaminant zone surrounding WS202. Figure 03, Annex A shows the areas of the Site where elevated concentrations of petroleum hydrocarbons are present. The Site is not located within a Source Protection Zone. The nearest surface water receptor is the Rochdale Canal. The Site is underlain by sensitive aquifers (Bedrock deposits are indicated to comprise Chester Formation, across much of the Site, Newton Heath Sandstone across the centre and Pennine Lower Coal Measures across the west, designated as Principal and Secondary A aquifers. The aquifers within the bedrock are overlain by low permeability Glacial Till which is expected to act as an aquiclude.

	Localized targeted remediation of the two areas of hydrocarbon contamination (shown on Figure 03, annex A) is recommended. This may include some localized soil excavation and removal with groundwater / oil recovery to reduce the contaminant mass and provide environmental betterment. Given the type of contamination (lubricating oil) it may be that residual contamination is encountered during demolition and clearance. Contamination may be found beneath former plant or drainage features that have not been detected to date. This type of contamination could be addressed through localized removal. Due to the impermeable nature of the Glacial Till present across the Site it is unlikely that the contamination has migrated far from its original source. It is considered likely that remediation would include decommissioning existing drainage, removal of all underground tanks, pumping and removal of contaminated water and petroleum hydrocarbons from underground tanks and chambers.
Ground Gas Risk Assessment	Gas monitoring indicates that the Site would be classified as Characteristic Situation 2 (low risk). However, significant concentrations of carbon dioxide and methane have been detected in areas of deep Made Ground. Speciated PAH and petroleum hydrocarbons have been identified at levels above the Society of Brownfield Risk Assessment (SoBRA) vapour intrusion guidelines. It is possible that elevated levels of petroleum hydrocarbons are causing the elevated methane readings. If remediation of petroleum hydrocarbons is carried out additional gas monitoring could be carried out post remediation. Post remediation gas monitoring may mitigate the requirement for ground gas protection measures. The Site currently corresponds with a CS2 classification - requiring gas protection measures. However, due to the high concentrations of methane recorded, it is considered necessary to allow for CS3 gas protection measures where building footprints are within the backfilled pit.
Geotechnical Assessment	
Foundation Design	In order to achieve finished levels a programme of earthworks will be required. Initial indications are that Site levels will be cut from the northern and eastern Site areas, with localised cutting in the centre and southwestern section of the Site. The excavated materials are likely to comprise Made Ground and cohesive Glacial Till. Some granular Ice Contact Deposits may also be excavated. Early indications are that while the materials may be suitable for use as general fill they are unlikely to be suitable as a selected structural fill. It should be noted that resting groundwater levels have been recorded above the cut level. It should be noted that the southeastern part of the Site has not been investigated due to the presence of a number of semi mature and mature trees. Therefore, the depth and nature of the Made Ground overlying the natural deposits is not known. It should also be noted that there is the potential that the Glacial Till may be desiccated due to the presence of the trees. It is important that materials that moved around the Site are not classified as a waste (as defined by Waste Framework Directive) on completion of the works. Given the quantity of Made Ground that will need to be reused and also the range of contaminants present it is considered that the CL:AIRE DoWCoP is likely to be the most appropriate regulatory option for the Site. It should also be noted that asbestos has been encountered in WS213. The earthworks will need to be undertaken in accordance with the Control of Asbestos Regulations.

	While shallow foundations may be feasible for some of the buildings where there are areas of cut, shallow foundations will not be feasible across the entire Site due to: • Significant depths of Made Ground associated with the backfilled pit in the northwestern section of the Site; • Areas of where Site levels will be raised as part of the earthworks; In these areas foundations will need to be extended to found on competent strata located beneath the Made Ground / fill material. It should also be noted that peat was recorded in WS202 between 3.3m and 3.7mbgl, and an SPT 'N' value of 1 was recorded in WS206. The peat and softened materials appeared to be of limited thickness and limited extent, but will need to be taken into consideration during foundation design. It is recommended that further probing is undertaken around this location to delineate the peat. Preliminary calculations indicate that for a traditional strip foundation (up to 1.0m width) at a minimum of 1.0mbgl, bearing with the Glacial Till, extending beneath current Made Ground deposit, peat deposits and future placed materials, a design bearing resistance of 100kN/m^2 will be appropriate in order to satisfy the ultimate and serviceable limit states in accordance with Eurocode 7 – Geotechnical Design.
Ground Improvement Appraisal	In areas of deep Made Ground / fill material or where water softened clays and peat have been encountered consideration could be given to utilising a ground improvement or piled foundation solution. Ground bearing floor slabs are likely to be feasible in areas where the floor is resting directly upon Glacial Till or where ground improvement has been undertaken. If this is not undertaken then a suspended floor slab will need to be utilised in areas where made ground or fill material is present. Further assessment for potentially desiccated clays should be undertaken in the area of trees that has not been investigated to date. If desiccation is identified then precautionary measures to allow for future heave will need to be undertaken. The investigation has identified that there were elevated concentrations of permanent ground gas (methane and carbon dioxide) and volatile organic compounds (naphthalene) in various areas of the Site. Precautionary measures will need to be included within the floor slab to prevent the ingress of gas into the buildings. In the area where elevated concentrations of naphthalene have been identified the membrane should prevent the ingress of VOCs as well as permanent gases. TRC recommends that the developer adopts Design Sulphate Class DS-2 and ACEC class of AC-2 for foundations.
Recommendations / Conclusion	
TRC recommends the following prior to development: • Continued groundwater monitoring during winter months. This is due to the high groundwater table recorded at the Site. It is unknown at this stage whether this represents a perched water body. • Further geotechnical laboratory testing will be required to support earthworks design and to check the geotechnical suitability and performance of selected fill. • Dynamic probing to delineate the peat recorded in WS202.	

- Intrusive investigation to support pavement design in areas of existing hard surfacing and proposed carriageways. Testing for coal tars should be carried out if tar bound macadam is to be excavated for disposal purposes.

1.0 Introduction

1.1 Purpose

TRC Companies Limited (TRC) was commissioned by Canmoor (Manchester) Limited (the 'Client') to undertake a Phase II Geo-environmental and Geotechnical Site Investigation at Park Works, Grimshaw Ln, Manchester (hereafter referred to as the 'Site').

A Site location plan is presented as Figure 1 in annex A.

The purpose of this Phase II assessment is to undertake necessary environmental and geotechnical investigations to support the proposed industrial/distribution end use. This Phase II assessment will use intrusive investigation methodologies to aid Site characterisation and to inform the Client of potential environmental liabilities and geotechnical parameters.

It is expected that this report will support the Client with future planning application for redevelopment of the Site for a proposed industrial/distribution end use.

1.2 Proposed Development

The proposed development will comprise nine industrial units with associated car parking/yard space. A topographic survey wasn't available at the time of writing, however based upon the boreholes drilled current Site levels are estimated to be between 70.6mAOD and 74.5mAOD. The Client provided TRC with a draft cut and fill volume drawing (ref: GLM-PTA-SW-XX-GA-C-8020, dated July 2020). The drawing advised that a cut and fill scheme is proposed for the Site, with lowest levels proposed to be filled by up to 2.0m and highest levels with a maximum cut of up to 4.0m. The cut and fill scheme will be necessary to level the Site in order to create a suitable building platform in order to achieve the desired Site elevation for construction.

A Proposed Development Plan is presented as Figure 6 in annex A.

1.3 Scope of Services

This report presents the findings of a Phase II Geo-environmental Site Assessment (ESA), based on the following information:

- Historical uses of the Site and surroundings;
- Current use and condition of the Site;
- Environmental setting in terms of geology, hydrogeology, hydrology and surrounding land uses;
- Relevant publicly available environmental records;
- Coal Mining Risk Assessment prepared by TRC, ref.385367.0000.0000. (July 2020); and,
- Intrusive investigation including environmental and geotechnical sampling and testing.

The Phase II ESA was conducted with due regard to the following guidance:

- The National Planning Policy Framework;
- BS10175 (2017) Investigation of Potentially Contaminated Sites – Code of Practice;
- BS5930 (2015) & A1 (2020) Code of Practice for Ground Investigations;
- Land Contamination: Risk Management (LCRM)
- BS8485 (2019) Code of Practice for the Design of Protective Measures for Methane and Carbon Dioxide Ground Gases for New Buildings; and
- BS8676:2013 'Guidance on Investigations for Ground Gas – Permanent Gases and Volatile Organic Compounds (VOCs).

1.4 Significant Assumptions

This report presents TRC's observations, findings, and conclusions as they existed on the date that this report was issued. This report is subject to modification if TRC becomes aware of additional information after the date of this report that is material to its findings and conclusions.

The reliability of information provided by others to TRC cannot be guaranteed to be accurate or complete. Performance of this Phase II Geo-environmental Site Assessment is intended to reduce, but not eliminate, uncertainty of environmental conditions associated with the subject Site; therefore, the findings and conclusions made in this report should not be construed to warrant or guarantee the subject Site, or express or imply, including without limitation, warranties as to its marketability for a particular use. TRC found no reason to question the validity of information received unless explicitly noted elsewhere in this report.

1.5 User Reliance

This report was prepared for Canmoor (Manchester) Limited. Reliance on the Report by any other third party is subject to requesting and fully executing a reliance letter between TRC and the third party that acknowledges the TRC Standard Terms and Conditions with the Client, to the same extent as if they were the Client thereunder.

TRC has been provided with information from third parties for information purposes only and without representation or warranty, express or implied as to its accuracy or completeness and without any liability on such third parties part to revise or update the information. Where reliance has been provided by third parties to potential purchasers this is noted in our report.

2.0 Site Description

2.1 Location

The Site comprises an approximate 5.63 ha plot of land centred on National Grid Reference 87040 99980, approximately 3.5km to the northeast of Manchester City Centre. The Site is an irregular shape which measures a maximum length of approximately 380m north to south and approximately 180m east to west.

The Site is located to the west of Ten Acres Lane. The Site is currently derelict land, occupied by various disused interlinking foundry buildings, areas of hardstanding and soft landscaping. The main buildings are located across a vast majority of the Site, with car parking / loading in the western and southern sections of the Site. An access roadway also formed part of the Site, providing access from Grimshaw Lane to the southwest. Disused field space was located in the northern / western sections of the Site.

The Site has an average elevation of approximately 64m above Ordnance Datum (aOD) in the western section of the Site, adjacent to Grimshaw Lane. This increases to approximately 77mAOD adjacent to the northern corner of the Site, within Ten Acres Lane.

A Site location plan is presented as Figure 1 in Annex A.

2.2 Subject and Surrounding Area

The Site is located within an area of mixed industrial, commercial and residential land use. Land uses in the immediate vicinity include the following principal features:

Table 1: Summary of Surrounding Land Use

Direction	Land Use
North	The Site is bound to the north by a canal with a manufacturer, steel stockholder and supplier, and undeveloped land beyond.
East	The Site is bound to the east by Ten Acres Lane with undeveloped grassland and a leisure centre beyond.
South	The Site is bound to the south by undeveloped grassland and a large bakery.
West	The Site is bound to the west by undeveloped land with Grimshaw Lane beyond.

2.3 Previous Environmental Assessment, Investigations or Remediation

Table 2: Summary of Previous Site Assessments

Report Title	Summary of Findings
Due Diligence Geo-Environmental Site Assessment	The report was prepared by Curtains Consulting Limited in February 2020 (report ref. 070588-CUR-00-XX-RP-GE-001) and found: • The Site remained undeveloped until the 1890s at which point football ground/pitches were recorded on the north of the Site. The football ground was no longer recorded by the early 1900s, a large excavation was present on the west of the Site which was later infilled and a mineral railway on the south associated with 'Park Engineering Works' which extended on the south of the Site. The excavation on the west was no longer recorded by the 1930s and Park Engineering Works/Mathers Foundry expanded across the Site throughout the 20th century and become disused in 2017. A slope was historically present along the north eastern side of the Site and significant reprofiling of the Site occurred during the development of the Site indicating that a variable thickness of Made Ground is likely to be present across the Site.

Report Title	Summary of Findings
	• The superficial Glacial Till is classified as a Secondary Undifferentiated Aquifer, the bedrock Chester Formation and Newton Heath Sandstone Formation are both classified as Principal Aquifers, and the Pennine Middle Coal Measures is classified as a Secondary A Aquifer. • Made Ground was encountered to a maximum depth of 8.0mbgl in one location associated with the area of infilled ground on the west of the Site. Outside of this area, Made Ground was encountered to a maximum depth of 4.30mbgl. Glacial Till was encountered underlying the Made Ground and was found to extend to a maximum proved depth of 12mbgl. It should be noted that the base of the Glacial Till was not encountered. The Glacial Till was typically cohesive with interbedded sand bands of variable thickness. • Elevated concentrations of PAHs, hydrocarbon impacted soils and asbestos fibres/ACM identified on Site. • Volatile contamination in groundwater. The interface probe recorded free phase LNAPL of up to 50mm thickness in WS08 on visit 5, visual verification revealed only a thin veneer of free phase separated liquid. • Leachable contamination; exceedances of GACs for arsenic, PAHs and TPHs recorded in groundwater samples and visual hotspots of contamination identified in soils and groundwater. • Rochdale Canal is located 3m north of the Site. Leachable contamination is considered a risk through vertical and horizontal migration due to exceedances of GACs for heavy metals, PAHs and TPHs recorded in groundwater samples. Visual hotspots of contamination identified in soils and groundwater particularly within WS08 in relatively close proximity to the canal. • Ground gas arising from Made Ground and natural soils migrating into buildings and subsequent inhalation. The infilled land on the west of Site represents a significant source of ground gas with high methane concentrations. • A historical landfill Site is located 185m northeast of the Site. The landfill was operational between 1973 and 1984 and was licensed to accept inert, industrial, commercial and household waste. • Review of freely available unexploded ordnance (UXO) mapping suggests the Site presents a moderate risk of intrusive works encountering UXO. TRC consider that further UXO assessment would be required to satisfy future intrusive investigation and construction phase works.
Coal Mining Risk Assessment	The report was prepared by TRC Companies Limited in July 2020 (report ref. 385367.0000.0000) and found: • One coal seam was worked beneath the Site, albeit on the western edge of the Site, to the southwest of a northwest to southeast orientated fault. The coal mining assessment has indicated that there should be sufficient thickness of intact rock above this coal seam to minimize the risk of voids migrating to surface. • The Coal Authority website indicates that the western edge of the Site is located within a development high risk area and that a coal seam is indicated to outcrop in the southwest of the Site, identified from the Coal Authority

Report Title	Summary of Findings
	Consultants Report as the Doctor Coal. Given that the Consultants report indicates that the Doctor Coal was not workable and given the considerable thickness of overlying superficial deposits, it is considered that the coal seam was unlikely to have been worked. • The proposed redevelopment includes the construction of new buildings in the main part of the Site, located predominantly to the northeast of the fault line and to the northeast of the Doctor Coal Seam subcrop. The Doctor Coal subcrops within the Site access road with the coal seam dipping away from the main part of the Site. As such while there remains a potential risk that the coal seam had been worked, the fact that this area of the Site unlikely to support new buildings it is considered that the risk to the proposed redevelopment will be low. If redevelopment includes the construction of new buildings in the southwestern part of the Site, it is recommended that the risk is reviewed. • The biggest risk for the Site is the fault line. Based upon the information collected by Curtins it is likely that this will be masked by the presence of significant thickness of Glacial Till. However, should the Glacial Till be granular in nature this could act as a preferential pathway for mine gas. It is recommended that should granular deposits be encountered within the Glacial Till that monitoring wells are installed with the screened sections installed to coincide with the granular layers. Subsequent permanent ground gas monitoring should be undertaken to ensure that the granular layers do not provide a pathway through the Glacial Till for gas migration.

3.0 Ground Investigation Scope of Works

3.1 Scope

The TRC Phase II Geo-environmental and Geotechnical investigation was conducted at the Site between the 10th and 21st August 2020. The purpose of the investigation was to characterise underlying ground conditions and investigate the potential presence of contamination that may present a risk to the proposed development at the Site. Additionally, a geotechnical investigation was undertaken to aid future foundation design.

The scope of works comprised:

- Supervision of drilling contractors during the advancement of three cable percussive boreholes (CP201, 202 and 203) to a maximum depth of 10.0mbgl, 15 window sample boreholes (WS201 to 214 including WS212A) to a maximum depth of 5.0mbgl with in-situ geotechnical testing (Standard Penetration Test (SPT)), and two days of cone penetration testing (CPT) to a maximum depth of 15.0mbgl using a 15-tonne wide track crawler unit delivered to Site by low-loader;
- Inspection of soils within boreholes to facilitate geological logging;
- Collection of soil samples for third party environmental and geotechnical laboratory testing;
- Field monitoring for permanent ground gases and groundwater levels on four occasions; and,
- Collection of groundwater samples on one occasion.

3.2 Investigation Rationale

The ground investigation was designed by TRC on behalf of the Client to gather information on the environmental and geotechnical ground conditions, groundwater and ground-borne gas conditions at the Site. The TRC investigation aimed to gain good general coverage of the Site.

The Exploratory Hole Location Plan is presented as Figure 2 in Annex A.

Table 3: Summary of Exploratory Hole Locations

Exploratory Hole	Site Location
CP201	Located in the eastern section of the Site to the east of the buildings.
CP202	Located adjacent to the southern boundary of the Site to the south of the buildings.
CP203	Located in the northern building to the north of WS209.
WS201	Located in the southern building to the north of WS202.
WS202	Located in the southern building to the south of WS201.
WS203	Located in front of the entrance to the southern building.
WS204	Located in front of the entrance to the northern building to the northeast of WS205.
WS205	Located in the yard area to the southwest of WS204.
WS206	Located in the soft landscaped area in the western corner of the Site. Located within the former backfilled pit.
WS207	Located towards the centre of the northern building.
WS208	Located in the soft landscaped area in the western corner of the Site. Located within the former backfilled pit.
WS209	Located in the northern building.
WS210	Located in the northern building next to the entrance of the building/
WS211	Located in the yard area near the entrance to the Site.
WS212	Located in the undeveloped land to the north of the Site to the northwest of WS212A.

WS212A	Located in the undeveloped land to the north of the Site to the southeast of WS212.
WS213	Located in the undeveloped northern corner of the Site.
WS214	Located next to the eastern corner of the southern building in the soft landscaped area.
CPT01	Located in the undeveloped northern corner of the Site next to the north eastern boundary of the Site.
CPT02	Located in the undeveloped northern corner of the Site.
CPT02A	Located in the undeveloped northern corner of the Site.
CPT03	Located in the undeveloped northern corner of the Site next to the north eastern boundary of the Site.
CPT04	Located in the undeveloped northern central of the Site.
CPT05	Located in the undeveloped northern central of the Site.
CPT06	Located in the undeveloped northern corner of the Site next to the north eastern boundary of the Site.
CPT07	Located in the undeveloped central area of the Site to the east of the building.
CPT09	Located in the building along the southern boundary of the Site.
CPT11	Located in the northern building near the north western boundary of the Site.
CPT12	Located in the northern building of the Site.
CPT13	Located to the front of the building near the north western boundary of the Site.
CPT14	Located in front of the building in the southern corner of the Site.
CPT15	Located in the undeveloped southern corner of the Site.
CPT16	Located in the undeveloped western corner of the Site. Located within the former backfilled pit.
CPT17	Located in the undeveloped western corner of the Site.
CPT18	Located in the undeveloped western central area of the Site next to the entrance of the Site.
CPT19	Located in the undeveloped western corner of the Site. Located within the former backfilled pit.
CPT20	Located next to the south western boundary next to the entrance of the Site. Located within the former backfilled pit.

3.3 Methodology

3.3.1 Ground Investigation

TRC commissioned DMW Drilling Limited (drilling contractor) to undertake the drilling works at the Site. Each borehole was advanced using either a cable percussive rig with a target depth of 10.0mbgl or a tracked windowless sampling rig with a target depth of 5.0mbgl. The drilling works were overseen by a TRC engineer who performed field assessment and logging of soil arisings.

The works included the following key actions:

- Each of the proposed exploratory hole locations was cleared using a Cable Avoidance Tool (CAT) and ground penetrating radar (GPR);
- Cable percussive drilling or windowless sampling was performed at each location by the drilling contractor, including in-situ geotechnical testing (Standard / Cone Penetration Testing);
- On-Site field assessment and recording of soil type and potential indicators of contamination. Field screening using a PID;
- Collection of soil samples for environmental and geotechnical laboratory analysis;
- Construction of gas and groundwater monitoring wells in nine borehole locations, CP201, CP202, CP203, WS202, WS204, WS205, WS209, WS211 and WS2014; and,
- WS201, WS203, WS206, WS207, WS208, WS210, WS212, WS212A an WS213 was backfilled with arisings.

3.3.2 Groundwater and Ground Gas Monitoring

Groundwater and ground gas monitoring was conducted by a TRC technician on four occasions. The dates of the monitoring visits were between the 1st September and 20th September 2020.

During each visit, groundwater elevation and potential presence of any free phase oils was measured using an oil/water interface probe. Gas monitoring was undertaken using a portable gas analyser at each monitoring well head. The field assessment gathered data relating to the concentrations of permanent ground gases (e.g. methane, carbon dioxide, carbon monoxide and oxygen).

Groundwater sampling was also undertaken in the boreholes that detected groundwater (CP201, CP202, CP203, WS204, WS205, WS214, WS02, CP01, CP04 and CP06).

3.3.3 Surface Water Sampling

Surface water sampling was conducted by a TRC technician on the 20th August 2020. Two samples were collected along the Rochdale Canal, one upstream (US01) and one downstream (DS01) of the canal.

3.4 Environmental Laboratory Analysis

A total of 20 soil samples was collected for environmental analysis during the investigation works. All soil samples were packed in laboratory provided containers and delivered to I2 Analytical (I2) for chemical analysis.

All soil samples were collected in order to provide environmental data on the quality of near surface and shallow soils beneath the Site. Representative samples of Made Ground and natural deposits were collected where feasible. The analytical suite of soils included the following parameters:

- Asbestos (Made Ground only);
- Heavy metals suite;
- Polycyclic aromatic hydrocarbons (PAH); and
- Total petroleum hydrocarbons – Criteria Working Group (TPH-CWG).

Groundwater samples were collected from 10 of the boreholes and surface water samples were collected from two locations along the adjacent canal. The samples were sent to I2 Analytical (I2) and analysed for the following:

- Heavy metals suite;
- Polycyclic aromatic hydrocarbons (PAH);
- Total petroleum hydrocarbons – Criteria Working Group (TPH-CWG);
- Volatile organic compounds (VOCs); and,
- pH and sulphate contents

The full set of chemical results are presented in Annex E.

3.5 Geotechnical Laboratory Analysis

Soil sampling for geotechnical testing was undertaken via disturbed and bulk sampling. The geotechnical testing was performed by I2 Analytical (I2) and Professional Soils Laboratory (PSL) and comprised the following:

- 12 Moisture Content;
- 10 Atterberg Limits;
- 2 PSD by wet sieve;
- 6 Quick Undrained Triaxial Tests;
- 6 BRE Full Suites;

- 1 BRE Short Suite;
- 3 Optimum Moisture Content and Maximum Dry Density; and
- 7 pH and water-soluble sulphate.

The full set of geotechnical results is presented in Annex G.

4.0 Factual Summary of Investigation Findings

4.1 Historical and Archive Information

The following publications of the British Geological (BGS) and Coal Authority have been examined in respect of the strata underlying the Site:

- BGS Geoindex;
- BGS historical borehole records;
- BGS 1:50,000 Series Map Sheet 85, Manchester (Bedrock and Superficial Edition), 2011 and (Bedrock Edition) 2010;
- Coal Authority webSite; and,
- Coal Authority Consultants Coal Mining Report (ref: 51002290625001, dated 22nd July 2020).

According to the BGS Geoindex service, the Site is underlain by superficial deposits comprising Glacial Till across the entirety of the Site. The BGS describes the Glacial Till as "unsorted and unstratified drift, generally over consolidated, depoSited directly by and underneath a glacier without subsequent reworking by water from the glacier". Also, according to cross sections included on the 1:50,000 Series Map (Bedrock and Superficial Edition) Ice Contact Deposits (mainly sand with some gravel) are present in the surrounding area and could also be encountered beneath the Site.

While the BGS maps do not indicate Made Ground to be present beneath the Site, the historical OS maps indicate that there was once an excavation in the western section of the Site which was later infilled. In addition, a slope was historically present along the north-eastern side of the Site and significant reprofiling of the Site occurred during the development of the Site indicating that variable thicknesses of made ground are likely to be present across the Site. This was confirmed by the investigation undertaken by Curtins which encountered Made Ground ranging in thickness from 0.2m to 8.0mbgl. The thickest Made Ground was in the western section of the Site (nearby to the historical excavation). Other areas that encountered Made Ground of significant thickness was the northern section of the Site (3.05m to 4.3m) and the eastern section of the Site (maximum of 2.7m).

According to the BGS Geoindex, bedrock beneath the Site is indicated to comprise the Chester Formation across the majority of the Site. The BGS describes the Chester Formation as "*a coarse-grained, typically well-cemented proximal facies to a fine-grained, less well-cemented distal facies. Red-brown, yellow, or yellow-mottled, very fine to coarse grained sandstones that are commonly cross-bedded, locally micaceous, silty or argillaceous, pebbly or conglomeratic, and generally friable*".

A northwest to southeast orientated fault (named the Bradford Fault) is indicated to cross the Site, to the southwest of the main Site buildings. A fault is a discontinuity or fracture of a rock which can cause displacement due to the movement of the rock. To the south of the fault line strata of the Pennine Middle Coal Measures Formation are indicated to be present. The Pennine Middle Coal Measures Formation is indicated to comprise interbedded grey mudstone, siltstone, pale grey sandstone and commonly coal seams, with a bed of mudstone containing marine fossils at the base, and several marine fossil-bearing mudstones in the upper half of the unit. Immediately to the southwest of the fault the Newton Heath Sandstone is documented to be present, which is named unit within the Pennine Middle Coal Measures Formation. The 1:50,000 Series BGS map indicates that the Newton Heath Sandstone Formation is between 15 and 20m thick and underlain by mudstones and siltstones of the Pennine Middle Coal Measures.

The Coal Authority Consultants Coal Mining Report (CAC) indicates that the Parker seam was mined beneath the Site. The CAC also indicated that a coal seam was shown to subcrop beneath the southwestern part of the Site, across the Site access road. This coal seam has been named as the Doctor Coal which is not indicated on the 1:50,000 scale map.

Several BGS historical borehole records are located on the Site, however, all but one of the logs are restricted / confidential, as such these could not be assessed. The records each side of the fault line (off Site) and therefore may be expected to show the general sequence of the geology. The following records, that were in excess of 10m depth (excluding the onSite borehole), were reviewed and presented below:

- Borehole SJ89NE52 is located on the western edge of the Site and encountered Made Ground underlain by Boulder Clay to the base of the borehole at 9.75m.
- Borehole SJ89NE2517 is located adjacent to the southern boundary of the Site and encountered "black, fine to coarse, clayey gravel; gravel is subangular brick (Made Ground)" to 0.7m, which in turn was underlain by "stiff orange-yellow-grey clay (Glacial Till)" to the base of the hole at 1.9mbgl.
- Several borehole records are located to the south of the Site including SJ89NE2510 which was located approximately 60m south and recorded "black, fine to coarse clayey gravel; gravel is subangular brick" to 0.4m, which was underlain by "soft, becoming firm, grey-black clay with slight alluvial odour (alluvium; Made Ground)" to 4.0m. In turn was underlain by "stiff, grey-brown clay (Glacial Till)" to the base of the hole at 5.2mbgl.
- Borehole SJ89NE2508 is located 250m south of the Site and encountered Made Ground to 1.6m, underlain by Glacial Till to 23.2m. In turn, this was underlain by a large boulder to the base of the borehole at 23.6m.
- Borehole SJ89NE469 is located 290m west of the Site and encountered concrete / Made Ground to 0.4m, which was underlain by a 'black clay' becoming a 'black clay and gravel' to 9.0m. In turn this was underlain by a sandy clay to 21.8m, then a red marl to 30.2m and a sand to 32.0m. This was underlain by black coal measures to the base of the borehole at 60.0m.
- Further from the Site borehole SD80SE81 located 600m northwest and encountered clay with stones was encountered to 13.71m, underlain by a gravel band to 14.02m. In turn, this was underlain by clay with stones to 24.38m, before becoming a black shale to the base of the borehole at 29.26m. This has been interpreted as Glacial Till with a layer of granular Glacial Deposits to a depth of approximately 24.4m overlying Coal Measures strata.

The historical boreholes in the vicinity of the Site confirm the general sequence of superficial deposits indicated on the BGS maps. The superficial deposits generally comprised Glacial Till but there were layers of granular Glacial Deposits also present. The Coal Measures were noted within the boreholes drilled to a deeper depth.

4.2 Ground Conditions

At the time of writing the report the Client provided a proposed Cut and Full Volumetric Analysis drawing (ref: GLM-PTA-SW-XX-GA-C-8020, dated July 2020). The boreholes at the Site were surveyed and the metre above ordnance datum (mAOD) displayed some variation, as detailed below:

- CP201 – 73.0 mAOD
- CP202 – 70.6 mAOD
- CP203 – 70.6 mAOD
- WS201 – WS214 (70.3 – 74.5), for full details refer to the logs in Annex C.

The investigation observed that the soils underlying the Site generally comprised the following: