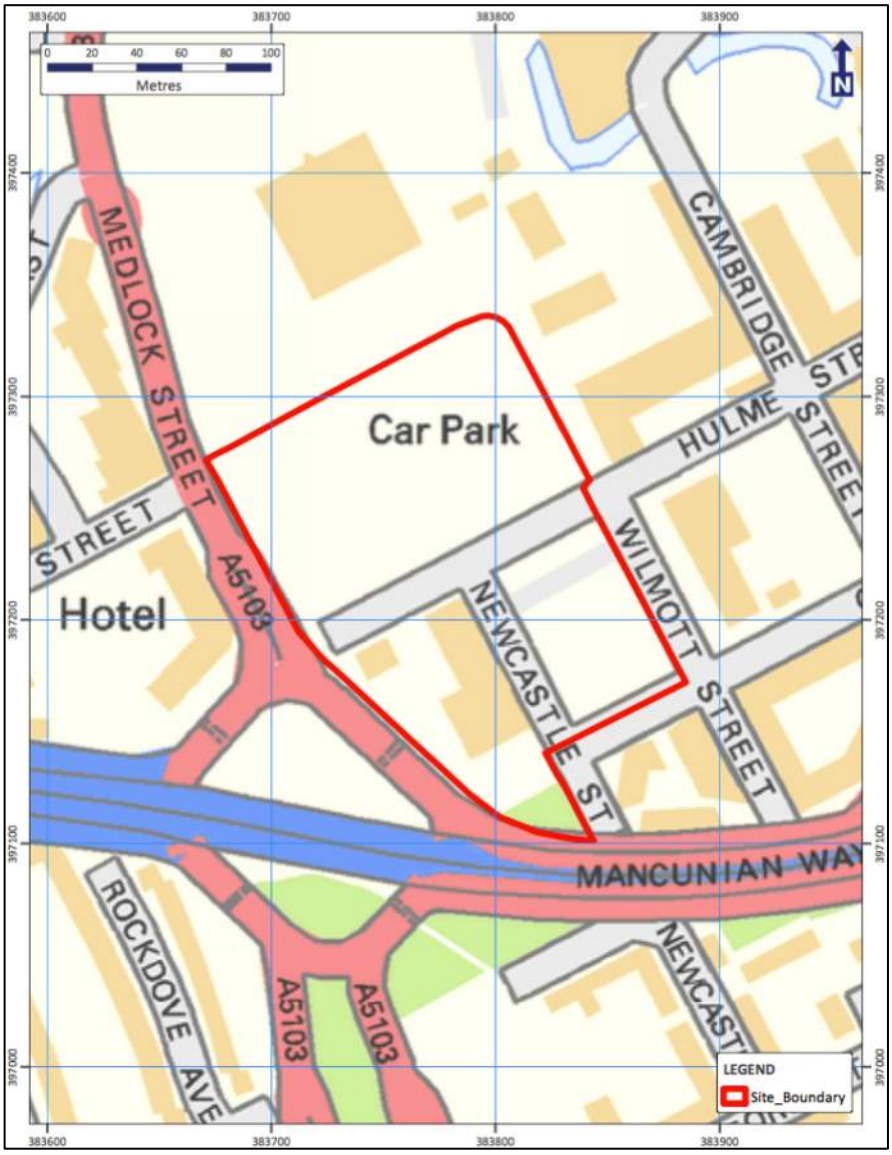
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Detailed Unexploded Ordnance (UXO) Threat & Risk Assessment

Meeting the requirements of CIRIA C681 "Unexploded Ordnance (UXO) – A guide for the Construction Industry" Risk Management Framework



6 Alpha Project Number: P4938
Landmark Order Number: 74907346_1
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Site: Plots 6, 7 & 8., First Street, Manchester

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Acronyms and Abbreviations

AA	Anti-Aircraft
AAA	Anti-Aircraft Ammunition
AAC	Army Air Corps
AFS	Advanced Flying School
ALARP	As Low As Reasonably Practicable
AOD	Above Ordnance Datum
ARP	Air Raid Precaution
ATS	Auxiliary Territorial Service
AXO	Abandoned Explosive Ordnance
BD	Bomb Disposal
BDO	Bomb Disposal Officer
bgl	Below Ground Level
BGS	British Geological Survey
BH	Borehole
BPD	Bomb Penetration Depth
CDP	Cast Driven Piles
CFA	Continuous Flight Auger
CIRIA	Construction Industry Research and Information Association
CPT	Cone Penetration Testing
CS	County Series
EFTS	Elementary Flying Training School
ELG	Emergency Landing Ground
EO	Explosive Ordnance
EOC	Explosive Ordnance Clearance
EOD	Explosive Ordnance Disposal
ERW	Explosive Remnants of War
FAA	Fleet Air Arm
FPP	Flight Pilot Pool
FTS	Flight Training School
GI	Ground Investigation
GIS	Geographic Information Systems
GL	Ground Level
GP	General Purpose
GPS	Global Positioning Systems
HAA	Heavy Anti-Aircraft
HE	High Explosive
HO	Home Office
HSE	Health and Safety Executive
IB	Incendiary Bomb
IED	Improvised Explosive Device
JSEODOC	Joint Service Explosive Ordnance Disposal Operations Centre
kg	Kilograms
km	Kilometres
LAA	Light Anti-Aircraft
lb	Pounds
LCC	London County Council
LDV	Local Defence Volunteers
LE	Low Explosive
LSA	Land Service Ammunition
m	Metres
MACP	Military Aid to the Civil Power
MoD	Ministry of Defence
mm	Millimetres
NATO	North Atlantic Treaty Organisation
NEQ	Net Explosive Quantity
NFF	National Filling Factory
NGR	National Grid Reference
OD	Ordnance Datum
OS	Ordnance Survey
OTU	Operational Training Unit
PBG	Polar Blasting Gelignite
PM	Parachute Mine
PoW	Prisoner of War
RADAR	Radio Detection And Ranging
RAF	Royal Air Force
RBL	Rifle Breach Loaded
RDX	Research Department Explosives
RFC	Royal Flying Corps
RML	Rifle Muzzle Loaded
RN	Royal Navy
RNAS	Royal Naval Air Service
ROF	Royal Ordnance Factory
SAA	Small Arms Ammunition
Sqn	Squadron
TA	Territorial Army
TNT	Trinitrotoluene
UK	United Kingdom
UN	United Nations
USAAF	United States Army Air Force
UXB	Unexploded Bomb
UXO	Unexploded Ordnance
V Weapons	*Vergeltungswaffe* – Vengeance Weapons
WAAF	Women's Auxiliary Air Force
WD	War Department
WWI	World War One
WWII	World War Two

EXECUTIVE SUMMARY

Study Site

The Client has described the Study Site as "Plots 6, 7 & 8., First Street, Manchester". The Site is located at NGR 383780, 397220.

Risk Level

MED/HIGH

Potential Threat Sources

The most probable UXO threat is posed by WWII *German* HE bombs and IBs, whilst *British* AAA projectiles (which were used to defend against *German* bombing raids) pose a residual threat.

Risk Pathway

Given the types of UXO that might be present on Site, all types of aggressive intrusive engineering activities may generate a significant risk pathway.

Key Findings

During WWII, the Study Site was situated within the *Manchester County Borough,* which recorded 26 HE bomb strikes per 1,000 acres, a relatively low level of bombing. However, given that the Site was situated partially within a primary bombing target and industrial area during WWII, the localised bombing density may in fact have been much greater.

Luftwaffe aerial reconnaissance photography associated with the Site identified a gas works located partially on Site and immediately to the north as a primary bombing target. In addition, numerous manufacturing industries and railway stations in the vicinity may have been considered secondary bombing targets.

ARP records associated with the Site did not note any HE bomb strikes within it however seven were recorded within 190m of the Site. Furthermore, whilst IBs may have fallen within the Study Site, they fell in such large numbers they were considered ubiquitous and accurate record keeping was either non-existent or perfunctory. Despite this, ARP records associated with the Site registered one IB within the Site's north-eastern section. In addition, eight were recorded within 272m of the Site.

Official bomb damage maps associated with the Site could not be located. Nonetheless, an analysis of pre and post war mapping has identified several 'missing houses', which could be attributed to bomb damage. However, the validity of these 'missing houses' being definitively associated with bomb damage is compromised as further research suggests that the area underwent mass slum clearance during the late 1930s into the 1950s. As such, the areas of 'missing houses' may in fact represent an amalgamation of both bomb damage and slum clearance.

Pre-WWII mapping (1938) associated with the Study Site shows that it was located to the south of *Gaythorn Gas Works* within a dense residential and industrial area. It also shows mass clearance in the Site and to the west, which was identified to be slum clearance. Located in the northeast of the Site and surrounding vicinity is the *Dunlop Rubber Works,* which made barrage balloons during WWII. As a result, it is plausible that *Dunlop Rubber Works* was inspected for UXB entry holes following any raids. However, due to the recent slum clearance in the remaining areas of the Site, a UXB entry hole would likely not have been noticed.

The Site has undergone extensive redevelopment since WWII though the majority of this involved the demolition of structures with little replacing them. Consequently, it is considered unlikely that any UXO within the Site would have been discovered and removed; suggesting that the risk of UXO is equal across the Site. The exception of this is the post-WWII construction seen at *Medlock House* and *Church Works*. Nonetheless, the potential for buried UXO may still be present within these areas of recent development. As such, pro-active risk mitigation measures are recommended during any intrusive works within the Site's boundary.

EXECUTIVE SUMMARY (…continued)

Recommended Risk Mitigation

All Groundworks in All Areas:

1. Operational UXO Risk Management Plan; appropriate Site Management documentation should be held on Site to guide and plan for the actions which should be undertaken in the event of a suspected or real UXO discovery, (this plan can be supplied by 6 Alpha);

2. UXO Safety & Awareness Briefings; the briefings are essential when there is a possibility of explosive ordnance encounter and are a vital part of the general safety requirement. All personnel working on the Site should receive a briefing on the identification of a UXB, what actions they should take to keep people and equipment away from such a hazard and to alert Site management. Information concerning the nature of the UXB threat should be held in the Site office and displayed for general information on notice boards, both for reference and as a reminder for ground workers. The safety and awareness briefing is an essential part of the Health & Safety Plan for the Site and helps to evidence conformity with the principles laid down in the CDM regulations 2015, (this briefing can be supplied by 6 Alpha).

Excavations in All Areas:

3. EOD Banksman Support; An EOD Engineer in the Banksman role will supervise and/or survey the site during any open excavations and identify all suspicious items that might be associated with UXO. This is considered the best course of action due to the high presence of made/mineralised ground and the perceived shallow depth of UXO contamination, (this service can be provided by 6 Alpha).

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ASSESSMENT METHODOLOGY

Approach

6 Alpha Associates is an independent, specialist risk management consultancy practice, which has assessed the risk of encountering UXO (as well as buried bulk high explosives) at this Site, by employing a process advocated for this purpose by CIRIA. The CIRIA guide for managing UXO risks (C681) not only represents best practice but has also been endorsed by the HSE. Any risk mitigation solution is recommended *only* because it delivers the Client a risk reduced to ALARP at best value.

UXO hazards can be identified through the investigation of Local and National archives associated with the Site, MoD archives, local historical sources, historical mapping as well as contemporaneous aerial photography (if it is available). Hazards will have only been recorded if there is specific information that could reasonably place them within the boundaries of the Site. The amalgamation of information is then assessed to enable the researcher to provide relevant and accurate risk mitigation practices.

The assessment of UXO risk is a measure of *probability of encounter* and *consequence of encounter*; the former being a function of the identified hazard and proposed development methodology; the latter being a function of the type of hazard and the proximity of personnel (and/or other 'sensitive receptors', such as equipment) to the hazard, at the moment of encounter.

If UXO risks are identified, the methods of mitigation we have recommended are considered reasonably and sufficiently robust to reduce them to ALARP. We advocate the adoption of the legal ALARP principle because it is a key factor in efficiently and effectively ameliorating UXO risks. It also provides a ready means for assessing the Client's tolerability of UXO risk. In essence, the principle states that if the cost of reducing a risk significantly outweighs the benefit, then the risk may be considered tolerable. This does not mean that there is never a requirement for UXO risk mitigation, but that any mitigation must demonstrate that it is beneficial. Any additional mitigation that delivers diminishing benefits and that consume disproportionate time, money and effort are considered *de minimis* and thus unnecessary. Because of this principle, UXB and UXO risks will rarely be reduced to zero (nor need they be).

Important Notes

Key source material is referenced within this document, whilst secondary/anecdotal information may be available upon request.

Although this report is up to date and accurate at the time of writing, our databases are continually being populated as and when additional information becomes available. Nonetheless, 6 Alpha have exercised all reasonable care, skill and due diligence in providing this service and producing this report.

The assessment levels are based upon our professional opinion and have been supported by our interpretation of historical records and third party data sources. Wherever possible, 6 Alpha has sought to corroborate and to verify the accuracy of all data we have employed, but we are not accountable for any inherent errors that may be contained in third party data sets (e.g. National Archive or other library sources), and over which 6 Alpha cannot exercise control.

STAGE ONE – SITE LOCATION AND DESCRIPTION

Study Site

The Client has described the Study Site as ""Plots 6, 7 & 8., First Street, Manchester". The Site is located at NGR 383780, 397220. The Site location and Site boundary are presented at *Figures 1* and *2* respectively.

Location Description

The Study Site is situated within *Manchester County Borough* and covers an area of 2.65 hectares (ha).

Furthermore, the Site is bounded by:

- Northwest: An area of hardstanding and construction activities with *First Street* running through the centre*;*
- Northeast: Commercial properties to the north and *Wilmott Street* to the south*;*
- Southwest: *Medlock Street* leading to a roundabout*;*
- South: Three commercial properties on an area of hard standing. Behind this is the A5103 and the A57 (M) flyover.

Aerial Photography (2009) (*Figure 3*)

Current aerial photography corroborates with the information above and shows that the Site is situated within a densely developed urban area. .

Proposed Works

The Client has described the following: *'Construction of numerous high rise apartments (some greater than 20 stories).'* Furthermore, the Client has also stated that the works will involve '*piled foundations to depths greater than 15 m bgl. Removal of sub-surface obstructions in the made ground (anticipated excavations of up to 3 m bgl) re-engineering of the existing made ground to between 2 and 3 m bgl for floor slabs and pavement. Limited open / space and soft landscaping.'*

As a result, 6 Alpha will assume that a number of construction investigative methodologies will be undertaken, including piling and excavations.

Ground Conditions

The Client has described the ground conditions as follows: *'Ground Conditions: The ground conditions generally are indicated to comprise a sequence including Made Ground, Glaciofluvial Deposits (sand and gravel), Till (clay, sand, gravel, cobbles and boulders) rested on the Chester Pebble Beds (sandstone).'*

In addition, BGS borehole log ***'SJ89NW4197 — Manchester Metropolitan University BH 3'*** (located 200m to the southwest), recorded the following strata:

- 0m to 2m – Hardcore backfill;
- 2m to 4.5m – Sand and gravel;
- 4.5m to 11.7m – Brown clay;
- 11.7m to 13m – Weathered red sandstone;
- 13m to 29m – Red sandstone;
- 29m to 36.5m – Darker red sandstone very fractured with mixed gravel pieces;
- 36.5m to 46m – Red mudstone and red sandstone layers;
- 46m to 64m – Dark red mudstone with grey mudstone traces.

It is important to establish the specific ground conditions in order to determine the maximum *German* UXB penetration depth as well as the potential for other types of munitions to be buried.

STAGE ONE – SITE LOCATION AND DESCRIPTION (…continued)

Ground Conditions (…continued)

If the Site investigations and/or construction methodologies change, and/or if a specific methodology is to be employed, and/or if the scope of work is focused upon a specific part of the Site, then 6 Alpha are to be informed so that the prospective UXO risks and the associated risk mitigation methodology might be re-assessed. Certain ground conditions may also constrain certain types of UXO risk mitigative works e.g. magnetometer survey is adversely affected in mineralised and made ground.

STAGE TWO – REVIEW OF HISTORICAL DATASETS

Sources of Information Consulted

The following primary information sources have been used in order to establish the background UXO threat:

1. 6 Alpha's Azimuth Database;
2. Home Office WWII Bomb Census Maps;
3. WWII and post-WWII Aerial Photography;
4. Official Abandoned Bomb Register;
5. Information gathered from the National Archives at Kew;
6. Historic UXO information provided by 33 Engineer Regiment (Explosive Ordnance Disposal) at Carver Barracks, Wimbish.

Potential Sources of UXO Contamination

In general there are several activities that can contaminate a site with UXO but the three most common ways are: legacy munitions from military training/exercises; deliberate or accidental dumping (AXO) and ordnance resulting from war fighting activities (ERW).

During WWII, the *Luftwaffe* undertook bombing campaigns all over the UK. The most common UXO discovered today is the aerially delivered HE bomb, which are comparatively thick-skinned and dropped from enemy aircraft. If the bomb did not detonate, the force of impact allowed the UXO to penetrate the ground, leaving behind it a UXB entry hole. These entry holes were not always apparent and some went unreported, leaving the bomb buried and unrecorded. More rarely, additional forms of *German* UXO are occasionally discovered including *inter alia* 'V1' and 'V2' rockets, IBs and Anti-personnel (AP) bomblets.

Although the *Luftwaffe* had designated primary bombing targets across the UK, they jettisoned unused HE bombs over opportunistic targets and residential areas. As a result, thousands of buildings were damaged and civilian fatalities were common.

As the threat of invasion lingered over *Britain* during WWII, defensive actions were undertaken. The *British* and *Allied Forces* requisitioned large areas of land for military training and bomb storage (including HE bombs, naval shells, artillery and tank projectiles, explosives, LSA and SAA). Thousands of tonnes of these munitions were used for the *Allied Forces* weapon testing and military training alone. It has been estimated that at least 20 per cent of the UK's land has been used for military training at some point.

CIRIA C681 suggests that approximately 10 per cent of all munitions deployed failed to function as designed, ERW are therefore, still occasionally found whist undertaking construction and civil engineering groundwork.

Furthermore, in exceptional circumstances, UXO is discovered unexpectedly and without apparent rational explanation. There are several ways this may occur:

- When *Luftwaffe* aircraft wanted to swiftly escape e.g. from an attack they would jettison all of their bombs and flee. This is commonly referred to as *'tip and run'* and has resulted in bombs being found in unexpected locations;
- Transportation of sediment containing munitions to an area that was previously free of UXO, usually related to construction activities such as aggregate that may have contaminated whilst dredged offshore;
- Poor precision during targeting (due to high altitude bombing/poor visibility) resulted in bombs landing within the surrounding area.

STAGE TWO – REVIEW OF HISTORICAL DATASETS (…continued)

Site History

From an analysis of the CS and OS historical mapping associated with the Site, the following Site history can be deduced:

1896 CS Map – The Study Site contained numerous residential streets and houses. A more industrial area was located to the north of the Site which included *Gaythorn Gas Works*;

1922 CS Map – The majority of buildings along *Poplar Street, Irving Street and Agnes Street*, situated in the northeast of the Site, were demolished. Additionally a school was marked out in the southeast of the Site;

1938 CS Map – Mass slum clearance within the Site resulted in the remaining residential properties being demolished. The main streets in the Site were *River Street, George street* and *Newcastle Street*. A rubber works had extended westwards into the northern section of the Site;

1948 OS Map – Structures associated with *Dunlop Rubber Works* comprised the northern half of the Site. In the southern sector, an engineering works, a coal yard, *Medlock House* (clothing), a *Church Works* (printing) and a compliance works (engineering) are present. Streets between these works located on Site include *Ebenezer Street, Jones Street, Mount Street* and *Bedale Street*;

1954 OS Map – An extension to the *Church Works* (printing) extended it as much again eastwards. Several small structures within *Dunlop Rubber Works* were demolished and constructed. A building in the southern most sector of the Site was labelled as an institute;

1969 OS Map – The southwest section of the Site was developed as the roundabout and flyover (*Mancunian Way)* were constructed immediately to the south of the Site. *Medlock House* remained untouched with the exception of two small structures, which were constructed to the southeast and northwest of the main building. However, the warehouse and adjacent streets to the west of *Medlock House* and the institute to the south were demolished;

1972 OS Map – Changes were not recorded within the Study Site;

1980 OS Map – The C*hurch Works* had extended to the northwest, enveloping the compliance works. In addition, *Medlock House* had extended into the newly opened space to the west, with additional smaller structures built adjacent to it. The *Dunlop* R*ubber Works* in the northern half of the Site had remained the same;

1992 OS Map – There were small changes to structures within *Dunlop Rubber Works* however the main two buildings remained the same. Further development to *Medlock House* was recorded;

2006 OS Map – The former *Dunlop Rubber Works*, which comprised the northern half of the Site, was demolished;

2015 OS Map – The remaining structures on Site, with the exception of a small structure located in the western section of the Site, were demolished. The northern half of the Site was labelled as a car park and two small structures were developed in the northeast of the Site.

WWII Site Use

The CS mapping prior to WWII (1938), shows that the Study Site was located to the south of *Gaythorn Gas Works.* It also shows mass clearance in the Site and to the west, later identified to be slum clearance. In the northeast of the Site and extending outwards is the *Dunlop Rubber Works,* which made barrage balloons during WWII.

STAGE TWO – REVIEW OF HISTORICAL DATASETS (…continued)

WWII Bombing of Manchester

Manchester's importance to the British war economy as an inland port, industrial centre and aircraft manufacturer meant the city and surrounding area represented a significant bombing target for the Luftwaffe. The first air raids occurred during August 1940 and continued until 1942. The majority of these small-scale raids were across the cities suburbs causing damage to properties and minimal casualties.

The Luftwaffe bombing campaign of Manchester peaked between the 22nd and the 24th December 1940 (Manchester Blitz), and involved over 400 enemy aircraft delivering in excess of 460 tons of HE bombs and 37,000 IBs. Following this raid, approximately 65 warehouses, 200 business premises and 150 offices were destroyed or damaged with the Manchester Cathedral, the Royal Exchange and the Free Trade Hall among the large buildings damaged. An estimated 684 people were killed and a further 2,364 people were injured.

Manchester continued to be bombed throughout the war and on the 24th December 1944 flying bombs were launched towards the city. The rockets failed to meet their intended targets with one stray bomb impacting Oldham, killing 27 civilians. The city was beyond the range of the "V2" rocket.

WWII Luftwaffe Bombing Targets (*Figure 4*)

Prior to WWII, the *Luftwaffe* conducted numerous aerial photographic reconnaissance missions over *Britain*, recording key military, industrial and commercial facilities for attack, in the event of war. In addition, logistics infrastructure and public services, such as railways, canals, power stations, reservoirs, water and gas works were also considered viable bombing targets.

Luftwaffe aerial reconnaissance photography associated with the Site identified *Gaythorn Gas Works* located partially on Site and immediately to the north as a primary bombing target. In addition, numerous works, mills, warehouses and railway stations in the vicinity may have been considered secondary bombing targets.

WWII Consolidated Bomb Strikes (*Figure 5*)

During WWII, ARP wardens compiled detailed logs of bomb strikes across their respective districts. However, ARP records associated with the Site did not register any HE bomb strikes within it, however seven were recorded; 60m to the west, 315m to the southwest and 135m, 180m, 190m, 190m and 190m to the south. Furthermore, whilst IBs may have fallen within the Study Site, they fell in such large numbers they were considered ubiquitous and accurate record keeping was either non-existent or perfunctory. Despite this, ARP records associated with the Site registered one IB within the Site's north-eastern section. In addition, eight were recorded; 60m, 115m and 155m to the east; 135m and 225m to the northeast; 240m, 250m and 275m to the south.

WWII Bomb Damage (*Figure 6*)

Official bomb damage maps associated with the Site could not be located. Nonetheless, an analysis of pre and post war mapping has identified several 'missing houses', which could be attributed to bomb damage. However, the validity of these 'missing houses' being associated with bomb damage is compromised as further research suggests that the area underwent mass slum clearance during the late 1930s into the 1950s. As such, the areas of 'missing houses' may actually represent an amalgamation of both bomb damage and slum clearance.

STAGE TWO – REVIEW OF HISTORICAL DATASETS (…continued)

WWII HE Bomb Density (*Figure 7*)

The Study Site was located within *Manchester County Borough,* which recorded 26 HE bombs per 1,000 acres, a relatively low level of bombing. However, given that the Site was situated partially within a primary bombing target during WWII, the localised bombing density may in fact have been much greater.

Abandoned Bombs

An examination of the official abandoned bomb records did not identify any abandoned bombs with 1,000m of the Site.

Records of WWII UXB Disposal Tasks

An examination of the civil defence records listing UXBs dealt within in the *Manchester County Borough* from 1940-45 did not identify any tasks within the Site's vicinity.

Records of Post-WWII UXB Disposal Tasks

An examination of the post-WWII BDO tasks associated with the area has not identified any BDO operations within the Site's vicinity.

STAGE THREE – DATA ANALYSIS

Was the ground undeveloped during WWII?

No; according to the CS mapping prior to WWII (1938), the Study Site contained several structures including *Dunlop Rubber Works*. There was also an area of mass clearance in the Site and to the west, later identified to be slum clearance. However, this undeveloped area was quickly redeveloped either during the war or shortly thereafter as OS mapping from 1948 identified numerous industrial buildings on Site.

Is there a reason to suspect that the immediate area was a bombing target during WWII?

Yes; *Luftwaffe* aerial reconnaissance photography associated with the Site identified a gas works located partially on Site and immediately to the north as a primary bombing target. In addition, numerous works, mills, warehouses and railway stations in the vicinity may have been considered secondary bombing targets

As WWII progressed, major towns and cities became targets within their own right as the *Luftwaffe* switched from specifically targeting industrial and military facilities to a more general method of *'carpet bombing'*, and as a result, suburban and residential areas were frequently bombed.

Is there firm evidence that ordnance landed on Site?

Yes; ARP records associated with the Site did not register any HE bomb strikes within it, although the closest strikes were recorded 60m to the west, 135m and 180m to the south. Despite this, ARP records registered one IB within the Sites north-eastern section. In addition, a further eight IBS were recorded; 60m, 115m and 155m to the east; 135m and 225m to the northeast; 240m, 250m and 275m to the south.

Furthermore, whilst IBs did fall within the Study Site, they fell in such large numbers they were considered ubiquitous and accurate record keeping was either non-existent or perfunctory.

Is there firm evidence of bomb damage on Site?

Possibly; official bomb damage maps associated with the Site could not be located. Nonetheless, an analysis of pre and post war mapping has identified several 'missing houses', which could be attributed to bomb damage. However, the validity of these 'missing houses' being definitively associated with bomb damage is compromised as further research suggests that the area underwent mass slum clearance during the late 1930s into the 1950s. As such, the areas of 'missing houses' may actually represent an amalgamation of both bomb damage and slum clearance.

Would a UXB entry hole have been observed and reported during WWII?

Possibly; the Site did comprise *Dunlop Rubber Works* and potentially numerous other industrial structures, which were constructed between 1938 and 1948 according to 1938 CS map, when the area underwent slum clearance. As a result, it is plausible that *Dunlop Rubber Works* was inspected for UXB entry holes following any raids. However, due to the recent slum clearance in the remaining areas of the Site, a UXB entry hole would likely not have been noticed. Pre-WWII mapping (1938) associated with the Study Site shows that it was located to the south of *Gaythorn Gas Works* within a dense residential and industrial area. It also shows mass clearance in the Site and to the west, which was identified to be slum clearance. Located in the northeast of the Site and surrounding vicinity is the *Dunlop Rubber Works,* which made barrage balloons during WWII.

Is there any reason to suspect that live firing or military training may have occurred at this location?

No; there is no supporting evidence to suggest that military training, guns or associated artillery (or other types of) munitions were ever stored, manufactured, located and/or fired from this Site during WWII nor subsequently.

STAGE THREE – DATA ANALYSIS (…continued)

What is the expected level of UXO contamination?

The most likely source of UXO contamination is from *German* aerially delivered ordnance, which ranges from small IBs through to large HE bombs (the latter forms the principal threat). Additional residual contamination may be present from *British* AAA projectiles (which were used to defend the UK against *German* bombing raids).

Would previous earthwork have removed the potential for UXO to be present?

Possibly; from an analysis of the post-WWII mapping associated with the Site, the following phases of Site activity were evident:

1948 OS Map – Structures associated with *Dunlop Rubber Works* comprised the northern half of the Site. In the southern sector, an engineering works, a coal yard, *Medlock House* (clothing), a *Church Works* (printing) and a compliance works (engineering) are present. Streets between these works located on Site include *Ebenezer Street, Jones Street, Mount Street* and *Bedale Street*;

1954 OS Map – An extension to the *Church Works* (printing) eastward. Several small structures within *Dunlop Rubber Works* were demolished and constructed. A building in the southern most sector of the Site was labelled as an institute;

1969 OS Map – The southwest section of the Site was developed as the roundabout and flyover (*Mancunian Way)* were constructed immediately to the south of the Site. *Medlock House* remained untouched with the exception of two small structures, which were constructed to the southeast and northwest of the main building. However, the warehouse and adjacent streets to the west of *Medlock House* and the institute to the south were demolished;

1980 OS Map – The *Church Works* had extended to the northwest, enveloping the compliance works. In addition, *Medlock House* had extended into the newly opened space to the west, with additional smaller structures built adjacent to it. The *Dunlop Rubber Works* in the northern half of the Site had remained the same;

1992 OS Map – Some small changed to structures within *Dunlop Rubber Works* however the main two buildings remained the same. Further developed to *Medlock House* was recorded;

2006 OS Map – The former *Dunlop Rubber Works*, which comprised the northern half of the Site, was demolished;

2015 OS Map – The remaining structures on Site, with the exception of a small structure located in the western section of the Site, were demolished. The northern half of the Site was labelled as a car park and two small structures were developed in the northeast of the Site.

On this evidence, it is apparent that the Site was subjected to significant post-WWII redevelopment though the majority of this involved the demolition of structures with little replacing them. As a result, it is considered highly unlikely that any UXO within the Site would have been discovered and removed. The exception of this is the post-WWII construction seen at *Medlock House* and *Church Works*. Nonetheless, the potential for deep buried UXO may still be present within these areas of recent development.

Does the probability of a UXO discovery vary across the Site?

Yes; the probability of discovering UXO has been partially mitigated within the footprints of post-WWII construction. However, it is possible that UXO might be present below the existing foundations. The rest of the Site is considered to have equal risk across the Site.

STAGE FOUR – RISK ASSESSMENT

Threat Items

The most probable UXO threat items are *German* HE bombs and IBs, whilst *British* AAA projectiles pose a residual threat. The consequences of initiating *German* HE bombs are more severe than initiating IBs or AAA projectiles, and thus they pose the greatest prospective risk to intrusive works.

Maximum Bomb Penetration Depth

Considering the ground conditions (highlighted in Stage 1), the average BPD for a 250kg *German* HE bomb in sands, gravels, clays and sandstone is assessed to be approximately 5m bgl, with the maximum BPD considered to be approximately 14m bgl. Although it is possible that the *Luftwaffe* deployed larger bombs in the area, their deployment was infrequent, and to use such larger (or the largest) bombs for BPD calculations are not justifiable on either technical or risk management grounds.

WWII *German* bombs have a greater penetration depth when compared to IBs and AAA projectiles, which are unlikely to be encountered at depths greater than 1m bgl.

Risk Pathway

Given the types of UXO that might be present on Site, all types of aggressive intrusive engineering activities (i.e. groundworks) may generate a significant risk pathway. Whilst not all UXO encountered aggressively will initiate upon contact, such a discovery could lead to serious impact on the project especially in terms of critical injury and project delay.

Prospective Consequences

Consequences of UXO initiation include:

1. Fatally injure personnel;
2. Severe damage to plant and equipment;
3. Deliver blast and fragmentation damage to nearby buildings;
4. Rupture and damage underground utilities/services.

Consequences of UXO discovery include:

1. Delay to the project and blight;
2. Disruption to local community/infrastructure;
3. The expenditure of additional risk mitigation resources and EOD clearance;
4. Incurring additional time and cost.

UXO RISK CALCULATION

Site Activities

Although there is some variation in the probability of encountering and initiating items of UXO when conducting different types of intrusive activities, construction methodologies have been described for analysis at this Site. The consequences of initiating UXO vary greatly, depending upon, *inter alia* the mass of HE in the UXO and how aggressively it might be encountered. For this reason, 6 Alpha has conducted separate risk rating calculations for each construction methodology that might be employed.

Risk Rating Calculation

6 Alpha's Semi-Quantitative Risk Assessment assesses and rates the risks posed by the most probable threat items when conducting a number of different activities on the Site. Risk Rating is determined by calculating the probability of encountering UXO and the consequences of initiating it.

STAGE FOUR - RISK ASSESSMENT (…continued)

UXO RISK CALCULATION TABLE – ALL AREAS

Activity	Threat Item	Probability (SHxEM=P)	Consequence (DxPSR=C)	Risk Rating (PxC=RR)
Excavations (<3m)	HE Bombs	1x2=2	2x3=6	2x6=12
	IBs	2x2=4	3x2=6	4x6=24
	AAA Projectiles	1x2=2	3x1=3	2x3=6
Piling (>15m)	HE Bombs	1x3=3	3x2=6	3x6=18
	IBs	2x3=6	3x1=3	6x3=18
	AAA Projectiles	1x3=3	3x1=3	3x3=9

Abbreviations – Site History (SH), Engineering Methodology (EM), Probability (P), Depth (D), Consequence (C), Proximity to Sensitive Receptors (PSR) and Risk Rating (RR).

STAGE FIVE – RECOMMENDED RISK MITIGATION MEASURES

If a geophysical survey is required are the ground conditions an issue?

Non-Intrusive Methods of Mitigation – Magnetometer results may be affected by ferro-magnetic contamination due to previous construction activities and made ground within the Site.

Intrusive Methods of Mitigation – Intrusive magnetometry may be effective on this Site, prior to piling especially. However, any ferrous metal/red brick contamination in made ground/old foundations may affect the detection capability of the UXB survey equipment, as it passes through the contaminated layer especially. Nonetheless, beyond the contaminated strata such a survey should prove effective.

MITIGATION MEASURES TO REDUCE RISK TO 'ALARP'

Activity/Area	Risk Mitigation Measures	Final Risk Rating
All Activities in All Areas	1. **Operational UXO Risk Management Plan;** appropriate Site Management documentation should be held on Site to guide and plan for the actions which should be undertaken in the event of a suspected or real UXO discovery, (this plan can be supplied by 6 Alpha); **2. UXO Safety & Awareness Briefings;** the briefings are essential when there is a possibility of explosive ordnance encounter and are a vital part of the general safety requirement. All personnel working on the Site should receive a briefing on the identification of a UXB, what actions they should take to keep people and equipment away from such a hazard and to alert Site management. Information concerning the nature of the UXB threat should be held in the Site office and displayed for general information on notice boards, both for reference and as a reminder for ground workers. The safety awareness briefing is an essential part of the Health & Safety Plan for the Site and helps to evidence conformity with the principles laid down in the CDM regulations 2015, (this brief can be supplied by 6 Alpha).	**ALARP**
Excavations in All Areas	**3. EOD Banksman** Support; An EOD Engineer in the Banksman role will supervise and/or survey the site during any open excavations and identify all suspicious items that might be associated with UXO. This is considered the best course of action due to the high presence of made/mineralised ground and the perceived shallow depth of UXO contamination, (this service can be provided by 6 Alpha).	

This assessment has been conducted based on the information provided by the Client, should the proposed works change then 6 Alpha should be re-engaged to refine this risk assessment

Report Figures

Figure One

Site Location

PLOTS 6, 7 & 8., FIRST STREET, MANCHESTER

Site Location

BRITISH NATIONAL GRID

BOMB SEARCH
WWW.6ALPHA.COM



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P4938	1	RG	RR	16 November 2015	Contains Ordnance Survey data © Crown copyright and database right 2015	Produced by and Copyright to 6 Alpha Associates Ltd. Users noting any errors please notify 6 Alpha.

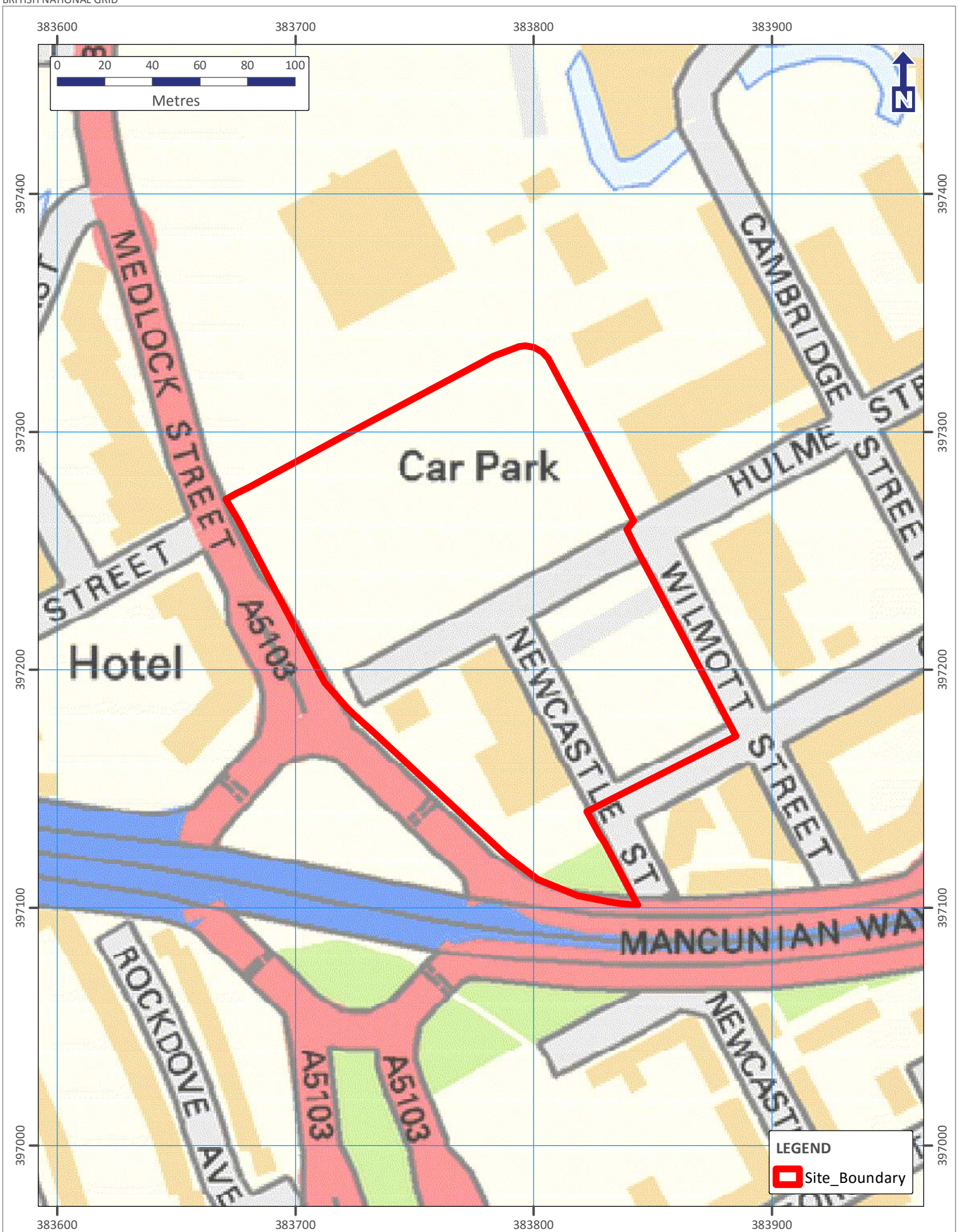
Figure Two

Site Boundary

PLOTS 6, 7 & 8., FIRST STREET, MANCHESTER

Site Boundary

BRITISH NATIONAL GRID



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Figure Three

Aerial Photography (2009)

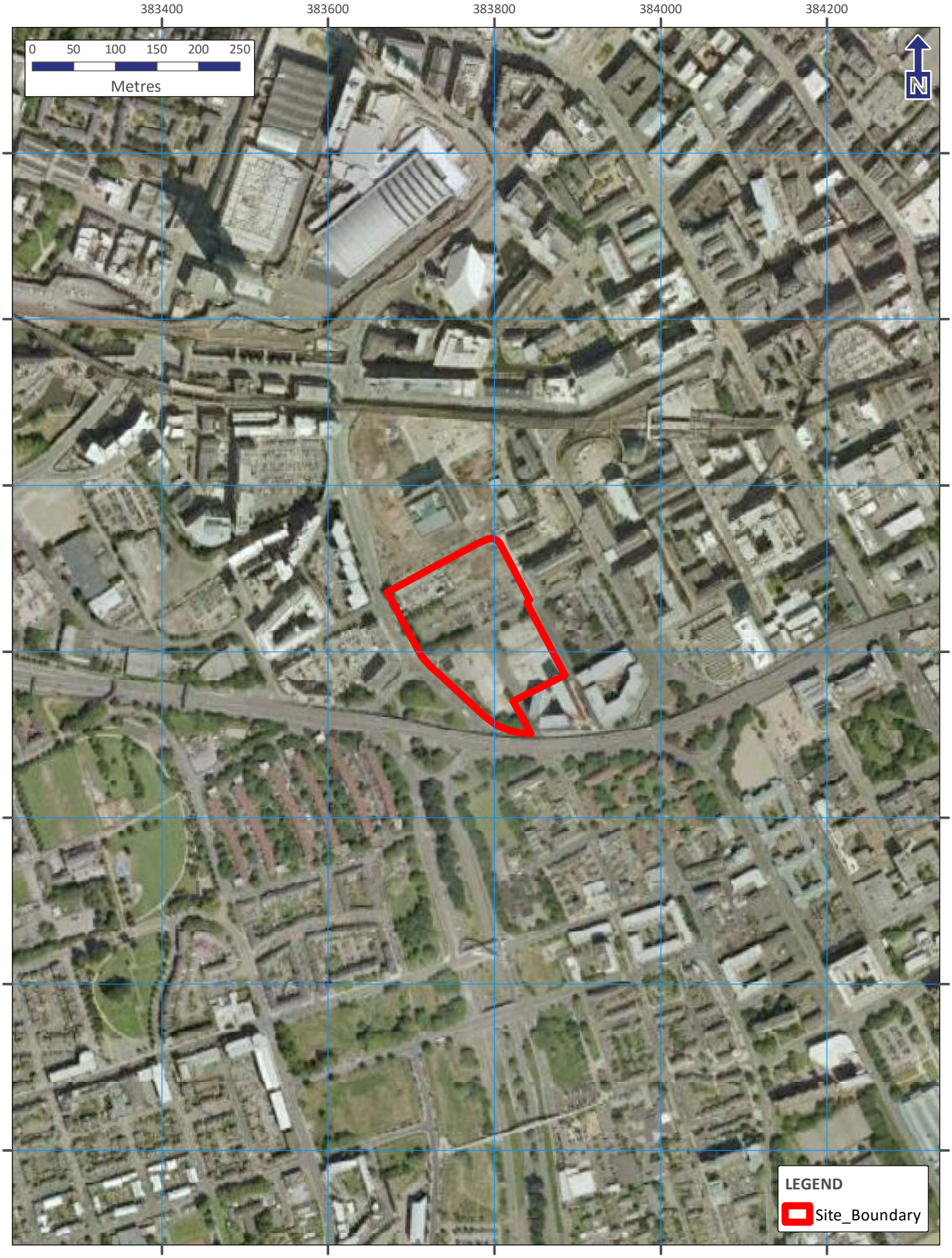


BRITISH NATIONAL GRID

PLOTS 6, 7 & 8., FIRST STREET, MANCHESTER

Aerial Photography (2009)

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P4938	3	RG	RR	16 November 2015	Map data: Google, Infoterra Ltd & Bluesky	Produced by and Copyright to 6 Alpha Associates Ltd. Users noting any errors please notify 6 Alpha.

Figure Four

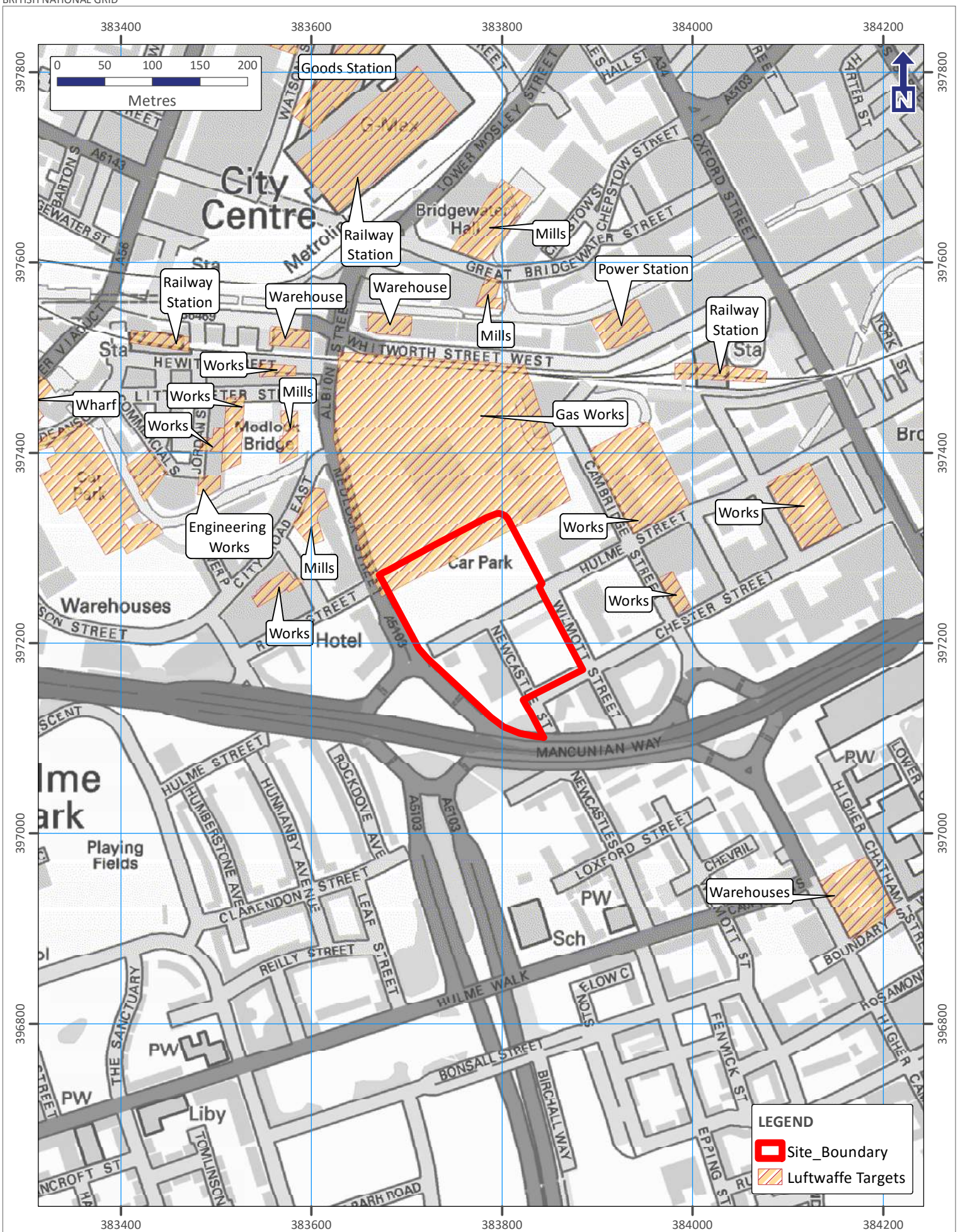
WWII Luftwaffe Bombing Targets

BRITISH NATIONAL GRID

PLOTS 6, 7 & 8., FIRST STREET, MANCHESTER

WWII Luftwaffe Bombing Targets

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Figure Five

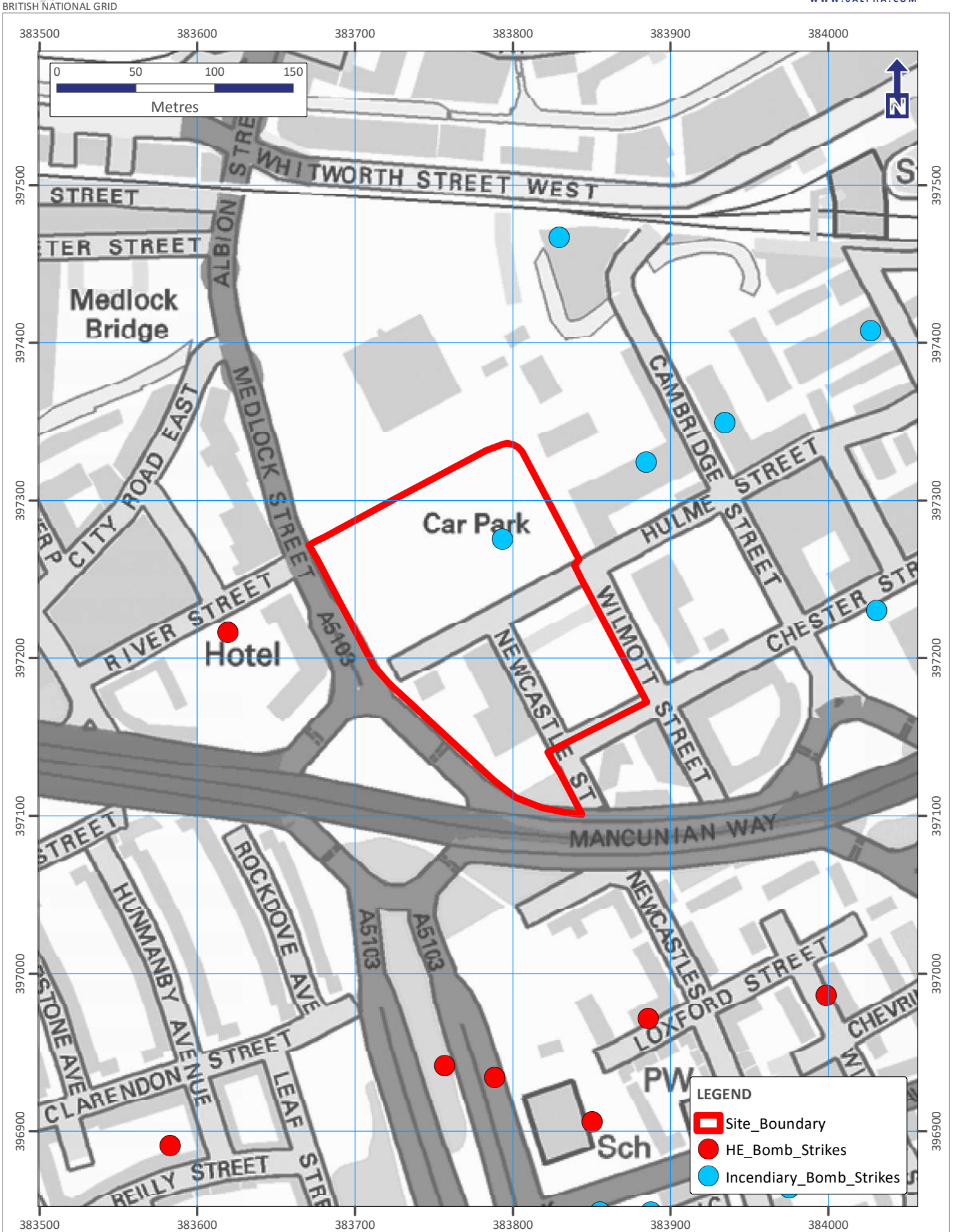
WWII Consolidated Bomb Strikes

BRITISH NATIONAL GRID

PLOTS 6, 7 & 8., FIRST STREET, MANCHESTER

WWII Consolidated Bomb Strikes

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Figure Six

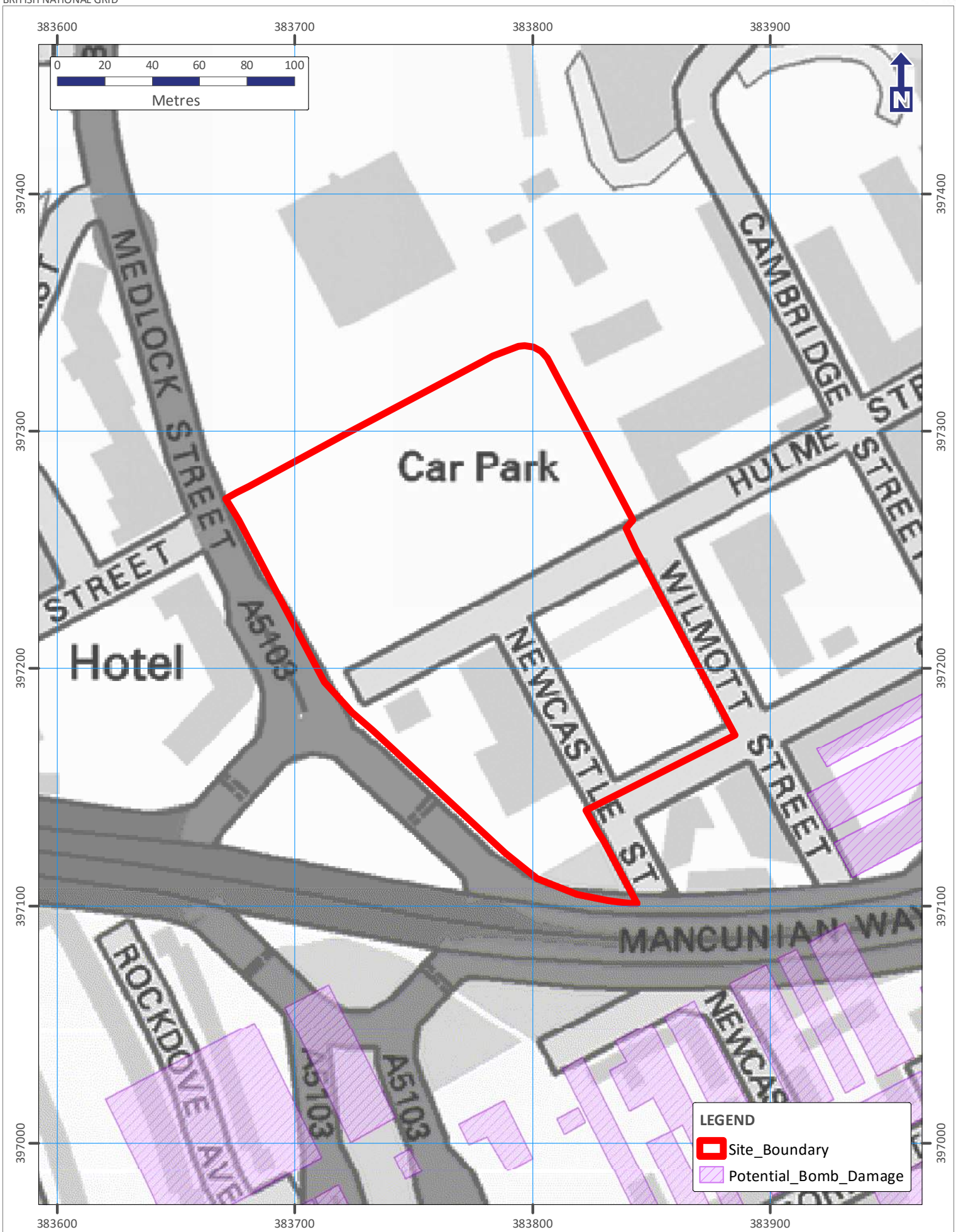
WWII Potential Bomb Damage

BRITISH NATIONAL GRID

PLOTS 6, 7 & 8., FIRST STREET, MANCHESTER

WWII Potential Bomb Damage

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Figure Seven

WWII High Explosive Bomb Density

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PLOTS 6, 7 & 8., FIRST STREET, MANCHESTER

WWII High Explosive Bomb Density

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