

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. The nearest recorded is approximately 4.7km north-east of the site, near Brownswood Park.

13.10. Bomb Disposal Tasks

The information service from the Explosive Ordnance Disposal (EOD) Archive Information Office at 33 Engineer Regiment (EOD) is currently facing considerable delay. It has therefore not been possible to include any updated official information regarding bomb disposal/clearance tasks with regards to this site. A database of known disposal / clearance tasks has been referred to which does not make reference to such instances occurring within the site of proposed works. If any relevant information is received at a later date Rydon will be advised.

13.11. Evaluation of Bombing Records

Item	Conclusion
<p>Density of Bombing</p> <p><i>It is important to consider the bombing density when assessing the possibility that UXBs remain in an area. High levels of bombing density could allow for error in record keeping due to extreme damage caused to the area.</i></p>	<p>The Metropolitan Borough of St. Pancras was subject to a Moderate density of bombing with 258 bombs recorded per 1,000 acres. However, this borough was of a particularly large size (2,694 acres) and as can be seen in the consolidated bomb census mapping of 7th October 1940 to 28th July 1941 (see Annex K), the area surrounding the site received a relatively high concentration of bombing. Strikes can be attributed to its proximity to key railway infrastructure, as well as the indiscriminate bombing of London’s civilian population.</p>
<p>Ground Cover</p> <p><i>The type & amount of ground cover existing during WWII would have a substantial influence on any visual indication that may indicate UXO being present.</i></p>	<p>The site was occupied exclusively by dense terraced residential housing and roads during WWII. Where these structures and tarmacked ground was present, it is likely that evidence of UXB entry holes would have initially been highly visible due to the resulting disruption in infrastructure - however, UXBs falling on areas of rubble or debris could easily go unnoticed. In the attached garden areas it is possible that ground cover was poor from the outset, depending on the quality of its maintenance – often with more vegetated, softer ground there is the potential for dropped UXO to go undetected. The quality of RAF aerial imagery does not allow for the exact nature of ground cover to be determined.</p>



<p>Access Frequency</p> <p><i>UXO in locations where access was irregular would have a greater chance of passing unnoticed than at those that were regularly occupied. The importance of a site to the war effort is also an important consideration as such sites are likely to have been both frequently visited and are also likely to have been subject to post-raid checks for evidence of UXO.</i></p>	<p>Due to the residential nature of the area as well as its proximity to a roundabout, a railway line, a school and a church, it is anticipated that the site received a relatively high degree of access, at least for the initial part of WWII. However, following bombing of the site, it is possible that access significantly decreased to individual properties. This may have meant that further strikes on structures were unrecorded, or that those on more withdrawn areas with a poorer condition of ground cover, such as in the gardens, UXO may have been missed.</p>
<p>Damage</p> <p><i>If buildings or structures on a site suffered bomb or fire damage any resulting rubble and debris could have obscured the entry holes of unexploded bombs dropped during the same, or later, raids. Similarly a High Explosive bomb strike in an area of open agricultural land will have caused soil disturbance, increasing the risk that a UXB entry hole would be overlooked</i></p>	<p>Historical mapping, RAF aerial photography and bomb damage mapping all show that a large amount of damage was inflicted on structures on the site. These confirm several large areas of clearance both within and outside the site in the immediate post-war period, as well as a patch used for prefabricated homes – these are usually assembled to replace destroyed housing. Damage mapping indicates that all structures on site were affected to some extent, and the OS map edition of 1953-1954 shows that in some cases ruins remained for several years after.</p> <p>This makes it difficult to identify any part of the site that would not have either received a direct strike, or have been in close enough proximity to a strike to avoid having potential contamination from the ‘J-curve’ effect.</p>
<p>Bomb Failure Rate</p>	<p>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.</p>
<p>Abandoned Bombs</p>	<p>1st Line Defence holds no records of abandoned bombs within the site vicinity. The closest is recorded 4.7km to the north-east, on the West Reservoir of Brownswood Park.</p>
<p>Bombing Decoy sites</p>	<p>1st Line Defence could find no evidence of bombing decoy sites within the site vicinity.</p>
<p>Bomb Disposal Tasks</p>	<p>1st Line Defence could find no evidence of Bomb Disposal Tasks within the site boundary and immediate area.</p>

14. The Threat from Allied Military Ordnance

14.1. General

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

14.2. Land Service Ammunition

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

Mortars	A bomb, normally nosed-fused and fitted with its own propelling charge. Its flight is stabilised by the use of a fin. They are usually tear-dropped shape (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. They are either High Explosive or Carrier (i.e. smoke, incendiary or pyrotechnic).
Grenades	A short range weapon (explosive range 15-20m) which can be thrown by hand or alternatively fired from the end of a rifle or a purposely designed grenade launcher. They can either be High Explosive or Carrier (usually smoke) and common variants have a classic 'pineapple' shape.
Projectiles	A projectile (or shell) is defined as an object which can be propelled by force, normally from a gun, and continues in motion by virtue of its kinetic energy. It contains a fuzing mechanism and a filling. Projectiles can be High Explosive, Carrier or Shot (a solid projectile).
Rockets	A rocket is defined as a missile that obtains thrust from a rocket engine. Military rockets are used to propel warheads to an intended target. This warhead will contain an explosive charge normally initiated on contact or at a predetermined height / proximity from target.
Landmines	A landmine is a munition designed to be placed under, on, or near the ground or other surface and to be exploded by the presence, proximity or contact of a person or vehicle.

Unexploded or partially unexploded Mortars and Grenades are among the most common items of LSA encountered in the UK as they could be transported and utilised anywhere. They are commonly encountered in areas used by the military for training and are often found discarded on or near historic military bases.

As with UXBs, items of LSA 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.

14.3. Defending London from Aerial Attack

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

Passive Defences	Active Defences
These included defence tactics such as: <ul style="list-style-type: none"> To hinder the identification of targets, by using lighting blackouts at night and camouflaging strategic installations. To mislead bomber pilots into attacking decoy sites located away from the city with the use of dummy buildings or lighting to replicate that of the city under attack. To force attacking aircraft to higher altitudes with the use of barrage balloons. 	These relied on a coordinated combination of a number of installations in order to actively engage and oppose attacking aircraft. Some of these installations were: <ul style="list-style-type: none"> Fighter aircraft to act as interceptors. Anti-aircraft gun batteries. The use of rockets and missiles (later during WWII).

14.4. Anti-Aircraft Artillery (AAA) and Projectiles

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

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

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

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

Gun type	Calibre	Shell Weight	Shell Dimensions
3.0 Inch	76mm	7.3kg	76mm x 356mm
3.7 Inch	94mm	12.7kg	94mm x 438mm
4.5 Inch	114mm	24.7kg	114mm x 578mm
40mm	40mm	0.9kg	40mm x 311mm

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

Numerous unexploded AAA shells were recovered during and following WWII and are still occasionally encountered on sites today.

The closest recorded HAA battery to the site was situated approximately 1km to the north-west of the site, on Primrose Hill.

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

14.5. Evaluation of Allied Military Ordnance Risk

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

Item	Conclusion
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Military Camps	1 st Line Defence could find no evidence of a Military Camp within the site.
Anti-Aircraft Defences	The closest anti-aircraft defence to the site was a HAA (heavy anti-artillery) battery, approximated 1km to the north-west of the site.
Home Guard Activity	Evidence of Home Guard training areas and activities is difficult to obtain. 1 st Line Defence has no evidence of any Home Guard activities on the site.
Defensive Positions	There is no evidence of any defensive structures in the vicinity of the site.
Training or firing ranges	No evidence of these could be found.
Defensive Minefields	No evidence of these could be found.
Ordnance Manufacture	No evidence of ordnance manufacture could be found.
Military Related Airfields	The site was not situated within the vicinity of a military airfield. The nearest was RAF Hendon, located roughly 8km north-west of the site.
Explosive Ordnance Clearance Tasks	1 st Line Defence holds no records of EOD operations on the site.

15. Ordnance Clearance and Post-WWII Ground Works

15.1. General

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

15.2. UXO Clearance

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

15.3. Post war Redevelopment

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

In the late 1960's / early 1970's, all remaining properties on site were removed, as well as the contained roads. This was replaced by the Bacton housing estate, as is present in the current-day. This contains a complex of low-rise flat buildings, as well as associated areas of grass (for recreational use) and paving / tarmac (for parking, roads or pathways).

The development of the paved or tarmacked areas will have involved minimal excavation work. Where this development has taken place, the risk of encountering shallow-buried UXO, especially 1kg incendiaries and anti-aircraft projectiles will have been partly mitigated.

Construction of the large structures on site will have most likely required some deeper foundations, however the exact extent of this intrusive work is not known. The risk of encountering deep-buried UXO / UXBs can only be considered to be mitigated at locations where post-war piling or deep foundations have taken place.

16. 1st Line Defence Risk Assessment

16.1. Risk Assessment Stages

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

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

UXO Risk Assessment	
Quality of the Historical Record	The research has located and evaluated pre- and post-WWII Ordnance Survey maps, London WWII ARP bomb plots from 1940 to 1945, Camden Bomb Damage Maps, in-house data and post-WWII era aerial photographs for the site. The record is of good quality in identifying locations of damage, however due to the lack of ARP incident records for the area it has not been possible to confirm the nature or number of strikes on the site.
The Risk that the Site was Contaminated with UXO	<p>After considering the following facts, 1st Line Defence believes that there is a Medium Risk that unexploded high explosive bombs could have fallen unnoticed and unrecorded within the site boundary.</p> <ul style="list-style-type: none"> • During WWII the Metropolitan Borough of St. Pancras was subjected a Moderate density bombing campaign, however the area surrounding the site sustained a relatively high concentration of bombing. • St. Pancras contained both St. Pancras and King's Cross Station (both approximately 3km south-east of the site) as well as other major pieces of railway infrastructure and gas / electrical works, which were targeted by the Luftwaffe. It would also have received bombing as a result of the indiscriminate bombing of the civilian population.



	<ul style="list-style-type: none"> • London bomb census mapping record at least four HE bombs within the boundaries of the site. Several more are plotted just outside of these borders, and an incendiary shower immediately the north-east. • Historical mapping indicates that the site was occupied by dense residential properties during WWII, as well as bordering roads. This, as well as its proximity to a roundabout, railway line, a school and a church, would suggest that the site received a high degree of access. However, it is likely that this dramatically decreased following damage, and further bombs may not have been recorded or detected (particularly in less visible parts such as gardens, which were projected towards the centre of the site). • Garden areas are also of a concern because of the unclear condition of groundcover – it has not been possible to precisely identify this from RAF aerial imagery from the immediate post-war period. In areas of soft, vegetated ground, as may have been present in the gardens, there is the potential for dropped UXO to go unnoticed. While the structures and roads would have explicitly displayed signs of disruption caused by heavier UXO, where bomb damage had been inflicted, the resulting debris or rubble would not have been conducive to noticing dropped ordnance during subsequent raids. • Aerial photography from immediately post-war, bomb damage mapping and alterations in historical mapping make clear the presence of significant bomb damage across the site. This resulted in several clearance areas and the erection of prefabricated homes on site. All structures on site (covering most of its premises) appear to have sustained some degree of damage. Even though this is in some instances light and perhaps not a result of direct bomb hits, its proximity to areas of major disruption would indicate potential risk of the J-curve effect (unexploded bombs falling unnoticed within damaged or open areas and coming to rest at a lateral offset from point of entry, sometimes beneath structures which survived the war intact – recent UXB finds in London have been attributed to this effect). An incident overlay is presented in Annex R to show the spread of recorded strikes and damage. • There is no evidence that the site formerly had any military occupation or usage that could have led to contamination with other items of ordnance.
<p>The Risk that UXO Remains on Site</p>	<p>There has been a significant amount of post-war development on the site of proposed work, including the construction of the multi-storey flat blocks that are present in the current-day. It is believed that these will have required deeper foundations, however the exact depth of this is unknown. Where they are present, it is possible that the risk of encountering German-dropped UXO has been mitigated to some extent. The risk of encountering shallow buried UXO (especially 1kg incendiaries or anti-personnel bombs) and anti-aircraft projectiles will have been partly mitigated in areas with occupying structures or paved ground due to the shallow excavations taken place – it is possible that this is not the case in the grass areas.</p>
<p>The Risk that UXO may be Encountered during the Works</p>	<p>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.</p> <p>Since an air-dropped bomb may come to rest at any depth between just below ground level and its maximum penetration depth, there is also a chance that such an item could be encountered during shallow excavations (for services or site investigations) into the original WWII ground level.</p>
<p>The Risk that UXO may be Initiated</p>	<p>The risk that UXO could be initiated if encountered will depend on its condition, how it is found and the energy with which it is struck. Certain construction activities such as piling</p>

	<p>and percussive drilling pose a greater risk of initiating UXO than, say, machine excavation where the force of impact is generally lower and the item more likely to be observed.</p> <p>If a UXB is struck by piling or percussive drilling equipment, the force of the impact can be sufficient to detonate the main high explosive charge irrespective of the condition of the fuze or other components. Violent vibration might also impart enough energy to a chemical detonator for it to function, and there is a potential risk that clockwork fuzes could restart.</p> <p>If piling works are planned at the Gospel Oak site, there is a potential risk that a UXB, if present, could be initiated. The risk of initiation is assessed to be considerably lower for any shallow intrusive works planned.</p>
The Consequences of Encountering or Initiating Ordnance	<p>The repercussions of the inadvertent detonation of UXO during intrusive ground works are potentially profound, both in terms of human and financial cost. A serious risk to life and limb, damage to plant and total site shutdown during follow-up investigations are potential outcomes.</p> <p>If appropriate risk mitigation measures are put in place, the chances of initiating an item of UXO during ground works is comparatively low. The primary consequence of encounter of UXO will therefore be economic. This would be particularly notable in the case of a high-profile site and sites where it is necessary to evacuate the public from the surrounding area. A site may be closed for anything from a few hours to a week with potentially significant cost in lost time.</p> <p>It should be noted that even the discovery of suspected or possible item of UXO during intrusive works (if handled solely through the authorities), may also involve loss of production. Generally, the first action of the police in most cases will be to isolate the locale whilst awaiting military assistance, even if this turns out to have been unnecessary.</p>

16.2. Assessed Risk Level

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

Medium Risk

The site was occupied by dense residential housing during WWII, the majority of which sustained significant damage, having been located in an area of high bombing density and receiving several HE bomb strikes within its perimeters. Due to the extent and spread of this damage, as well as the potential for poor ground cover, it has not been possible to negate the risk of UXO encounter in any parts of the site (particularly given the chance of the J-curve effect). Note that the risk will have been mitigated at the location of and down to the depth of post-war foundations and excavations.

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

Other Allied Military Ordnance		✓		
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17. Proposed Risk Mitigation Methodology

17.1. General

The following risk mitigation measures are recommended to support the proposed works at the Gospel Oak site.

Type of Work	Recommended Mitigation Measure
All Works	<ul style="list-style-type: none"> Site Specific Unexploded Ordnance Awareness Briefings to all personnel conducting intrusive works. <p>A specialised briefing is always advisable when there is a possibility of explosive ordnance contamination. It is an essential component of the Health & Safety Plan for the site and conforms to requirements of CDM Regulations 2015. All personnel working on the site should be instructed on the identification of UXB, actions to be taken to alert site management and to keep people and equipment away from the hazard. Posters and information of a general nature on the UXB threat should be held in the site office for reference and as a reminder.</p>
Shallow Intrusive Works/Open Excavations	<ul style="list-style-type: none"> Unexploded Ordnance (UXO) Specialist Presence on Site to support shallow intrusive works: <p>When on site the role of the UXO Specialist would include; monitoring works using visual recognition and instrumentation and immediate response to reports of suspicious objects or suspected items of ordnance that have been recovered by the ground workers on site; providing UXO Awareness briefings to any staff that have not received them earlier and advise staff of the need to modify working practices to take account of the ordnance threat, and finally to aid Incident Management which would involve liaison with the local authorities and Police should ordnance be identified and present an explosive hazard.</p>
Borehole/Piles	<ul style="list-style-type: none"> Intrusive Magnetometer Survey of all Borehole and pile locations down to a maximum bomb penetration depth: <p>1st Line Defence can deploy a range of intrusive magnetometer techniques to clear ahead of all the pile locations. The appropriate technique is governed by a number of factors, but most importantly the site's ground conditions. The appropriate survey methodology would be confirmed once the enabling works have been completed.</p>

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

1st Line Defence Limited

19th November 2015

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

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

Site Location Maps



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

Client: **Rydon**

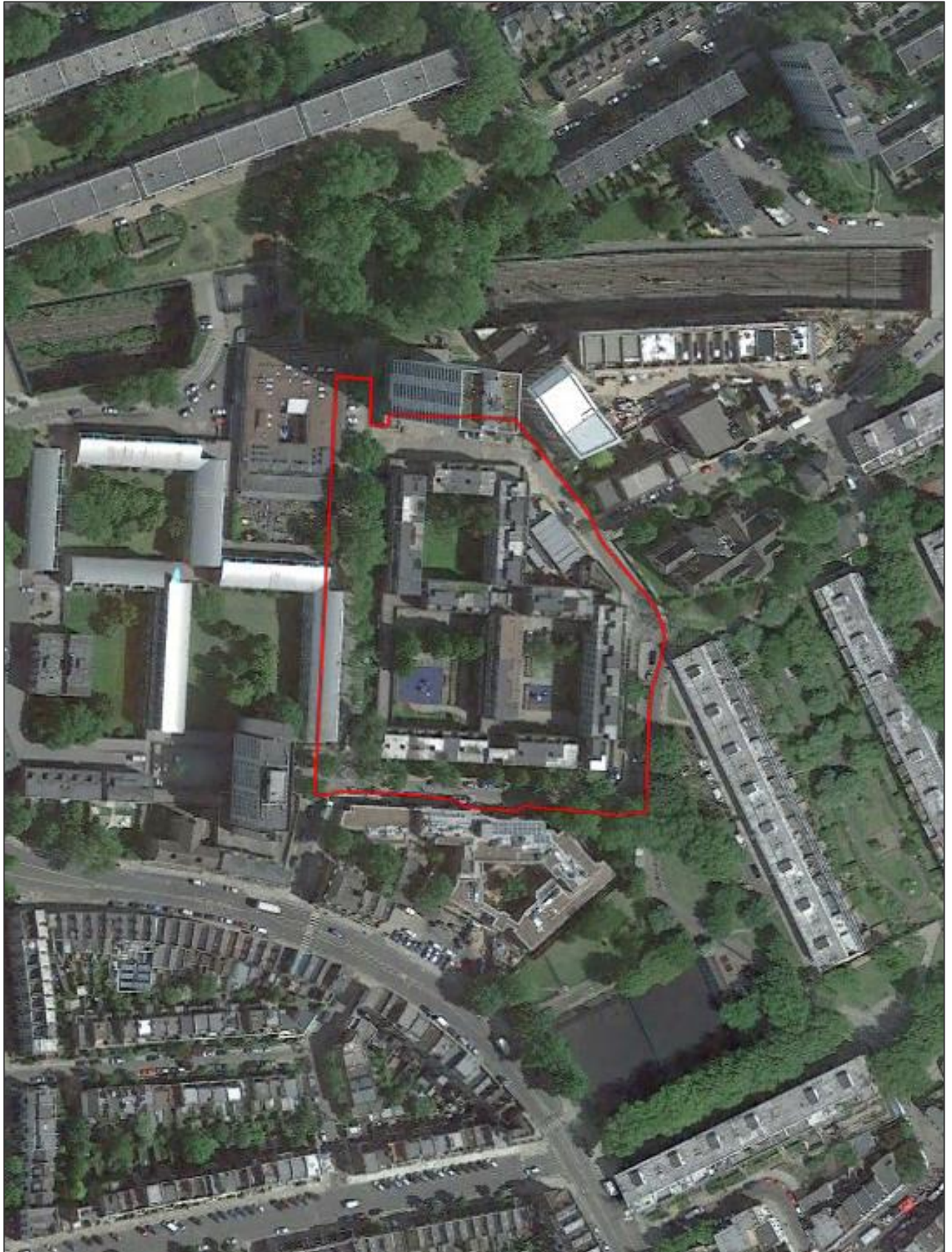
Project: **Gospel Oak Site**

Ref: **OPN2585**

Source: Google Maps


Approximate site boundary





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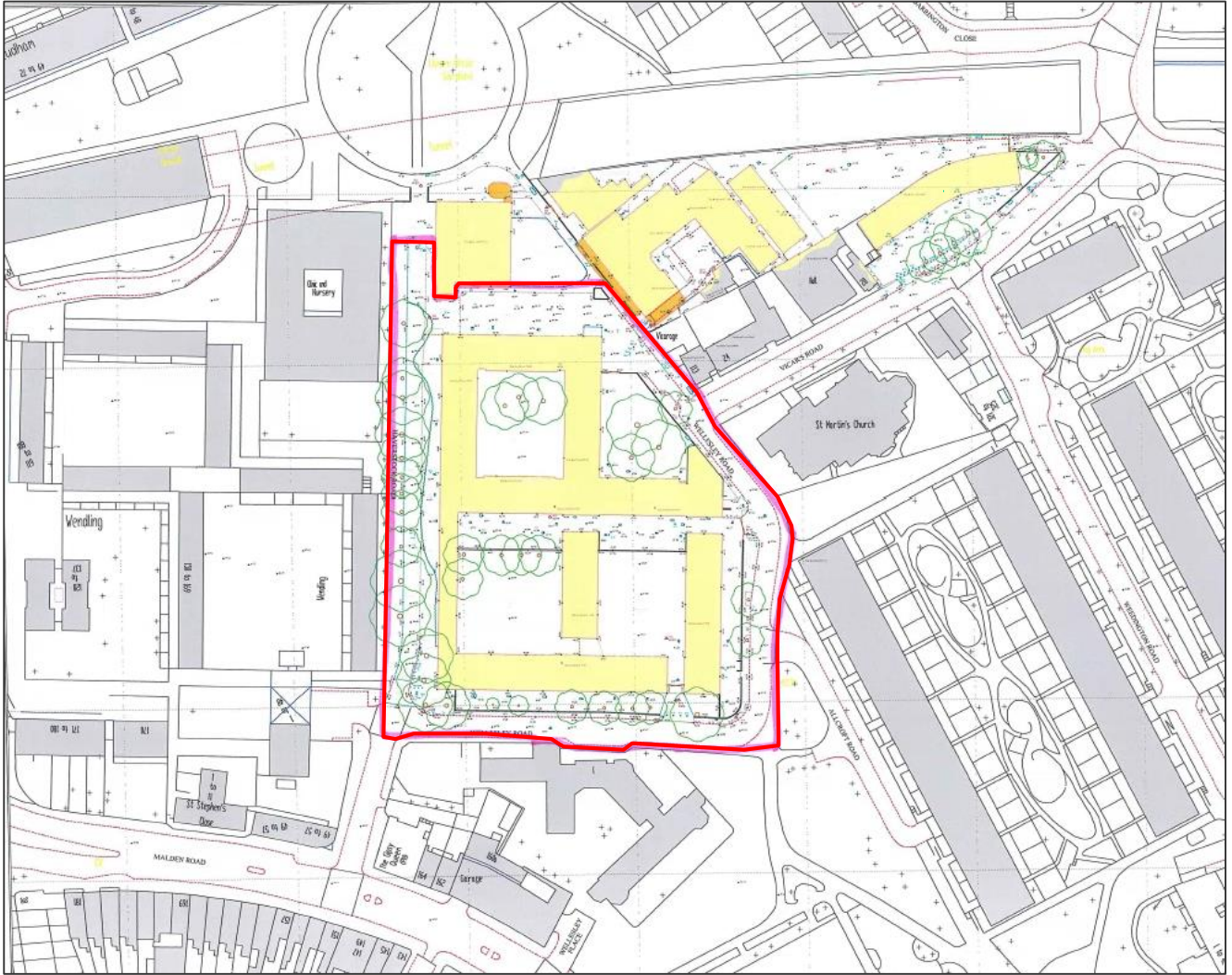


Project: **Gospel Oak Site**

Ref: **OPN2585**

Source: Google Earth™ Mapping Services

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Source: The Client

 **Approximate site boundary**





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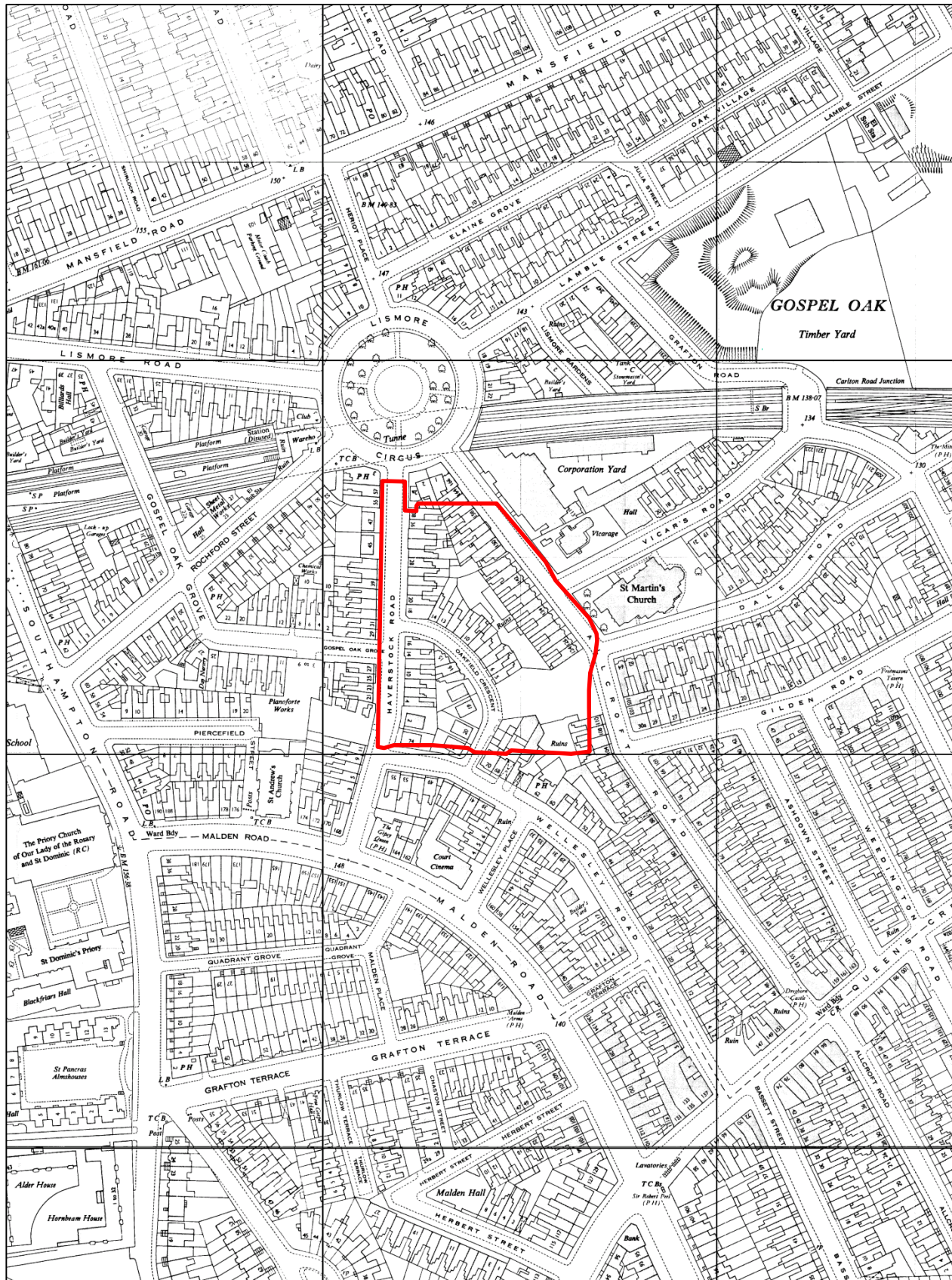
Project: **Gospel Oak Site**

Ref: **OPN2585**

Source: Landmark Maps

 **Approximate site boundary**






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Project: **Gospel Oak Site**

Ref: **OPN2585**

 **Approximate site boundary**



Source: Landmark Maps