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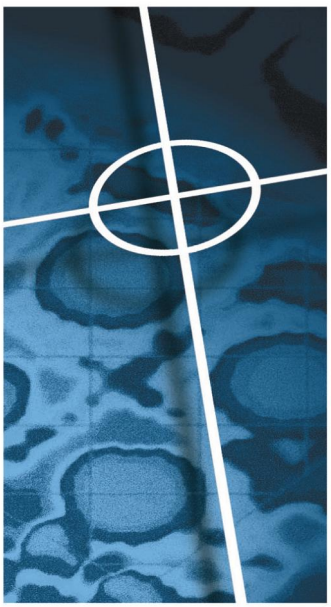

sitesafe

zetica sitesafe

Project No.	P1989-09
Project Title	SITESAFE UXB DESK STUDY
Project Location	Gravesend, Kent
Client	Gravesham Borough Council
Report Ref.	P1989-09-R1-A
Report Date	21st December 2009
Prepared by	Clark Friend
Checked by	Anne Baker
Authorised by	Mike Sainsbury

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SITESAFE UXB DESK STUDY

Town Pier, Gravesend, Kent

Executive Summary

Zetica was commissioned by Gravesham Borough Council to carry out a SiteSafe Unexploded Bomb (UXB) Desk Study for an approximately 0.1 hectare (ha) site immediately adjacent to the existing Town Pier in the tidal portion of the River Thames, Gravesend, Kent (the 'Site').

The aim of this report is to gain a fair and representative view of the UXB hazard for the Site and its immediate surrounding area in accordance with the Construction Industry Research and Information Association (CIRIA) guidance 'Unexploded Ordnance (UXO), a guide for the construction industry'. The main findings are summarised below.

- Zetica researched the bombing history for the Site and the surrounding areas. This research was based on records of bombing during both World Wars.
- Gravesend was raided on 3No. occasions during World War One (WWI), but there are no records to indicate that the Site was bombed.
- There were a number of strategic targets within 10km of the Site during World War Two (WWII). These included military airfields, docks, aircraft manufacturing, gasworks, power station and transport infrastructure. Many of these were accurately marked on Luftwaffe target maps.
- There were 5No. bombing decoy sites within 10km of the Site.
- During World War Two (WWII) Gravesend was heavily bombed. The first raid occurred on the 6th June 1940. Many of the raids were limited to Incendiary Bombs (IBs) and more than 300,000No. are estimated to have fallen on the town.
- The closest HE bombs fell within 0.5km east of the Site. There is no evidence to indicate the Site was bombed during WWII.
- During WWII, Explosive Ordnance Clearance (EOC) tasks were undertaken in the Gravesend area.
- Post-War, other EOC tasks within 3km of the Site have taken place.

Taking into consideration the available information indicating the intensity of bombing, the density of known strikes on and immediately adjacent to the Site, the distance of the Site from

strategic targets and the quality of the data, it is considered that the Site has a low risk of UXB being present.

Table 7 provides recommended actions in relation to identified UXB risk and the anticipated Site activity. The actual mitigation will depend on the detail and nature of any planned works and the clients view of acceptable risk.

1 INTRODUCTION

1.1 Project Outline

Zetica was commissioned by Gravesham Borough Council to carry out a SiteSafe Unexploded Bomb (UXB) Desk Study for an approximately 0.1 hectare (ha) site immediately adjacent to the existing Town Pier in the tidal portion of the River Thames, Gravesend, Kent (the 'Site').

The aim of this report is to gain a fair and representative view of the UXB hazard for the Site and its immediate surrounding area in accordance with the Construction Industry Research and Information Association (CIRIA) guidance 'Unexploded Ordnance (UXO), a guide for the Construction Industry'. This hazard assessment includes:

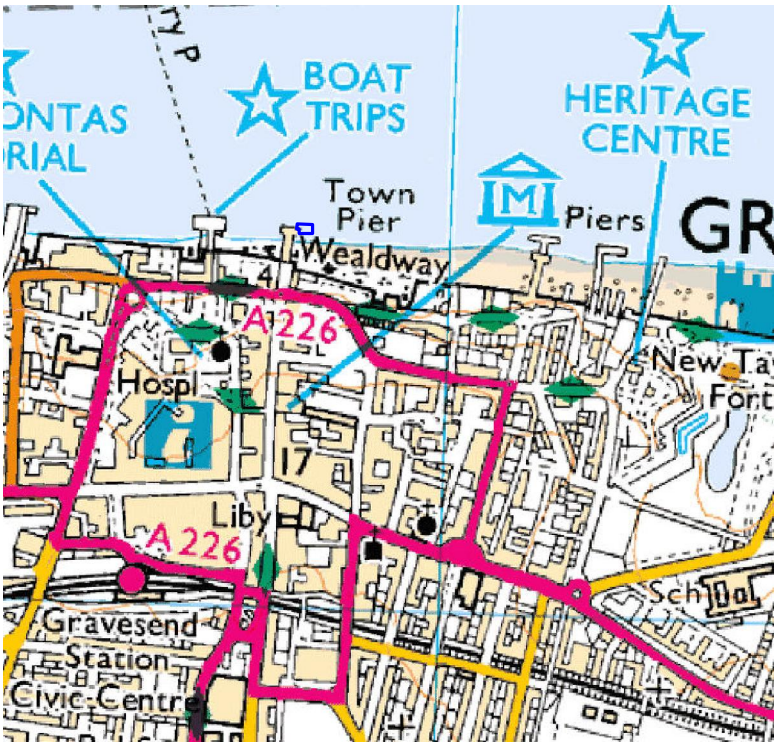
- Identifying the likely locations of UXB (if any).
- Identifying the most likely types of UXB to be present and their hazards.
- Providing input for future method statements and risk assessments.

1.2 Site Description

The Site is located at Ordnance Survey (OS) Grid Reference TQ 648745, approximately 0.3km north of Gravesend town centre on the south bank of the River Thames.

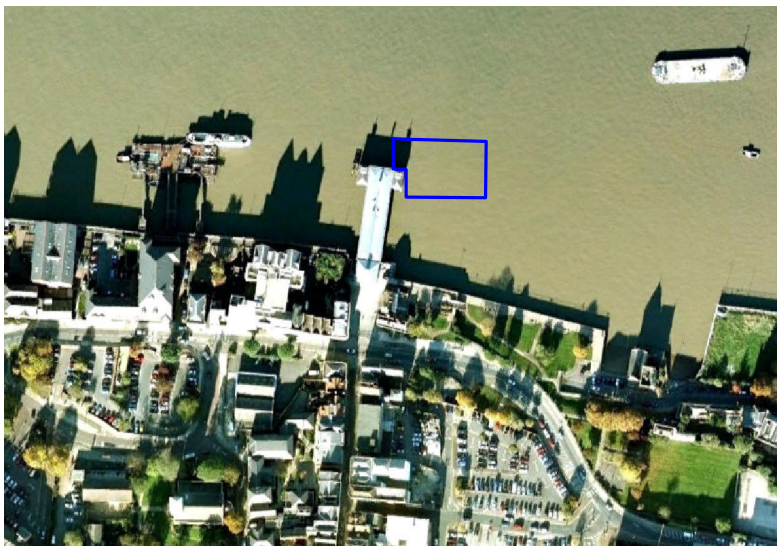
The Site comprises an area of the River Thames located immediately to the east of Town Pier, Gravesend.

A Site location plan is given in Figure 1 and a contemporary aerial photograph of the Site is shown in Plate 1.



Source: © Crown Copyright 2005. Reproduced by permission of Ordnance Survey

Figure 1	Site location plan	**Scale:** NTS



Source: Google Earth

Plate 1	Contemporary aerial photograph of the Site	**Scale:** NTS

2 SOURCES OF INFORMATION

Zetica researched the bombing history of the Site and surrounding area utilising a range of information sources. The main sources of information are detailed in the following Sections and referenced at the end of this report.

2.1 Zetica Defence Related Site Records

Zetica's in-house records were consulted, including reference books, and archived materials from past work in the region. Relevant documents have been cited within the Reference Section of this report.

2.2 Zetica Bombing Density Records and Maps

Reference has been made to the Zetica bomb risk maps located on Zetica's website (www.zetica.com/uxb_downloads.htm).

2.3 Ministry of Defence Records

The Ministry of Defence (MoD) was approached for information on Explosive Ordnance Clearance (EOC) activities and evidence of abandoned bombs.

2.4 Other Historical Records, Maps and Drawings

Numerous other reference documents, historical maps, and drawings have been consulted, including such sources from the National Archives and English Heritage. These have been referenced as appropriate within this report.

2.5 Local Authority Records

Information has been sought from the Kent Archives at the Centre for Kentish Studies and the Port of London Authority.

2.6 Local Record Offices and Libraries

The Museum of London was also consulted for relevant records.

2.7 Local Historical and Other Groups

Contact was made with various historical groups and use has been made of local history websites.

3 HISTORICAL INFORMATION

Records of air raids, bomb damage, casualties and the location of UXB are rarely released into the public domain. These records are accessible through archives which may or may not be complete. Records are only as detailed and accurate as the resources and working conditions would allow at the time. Urban records may be inaccurate due to the confusion surrounding continuous air raids.

For example, a single WWII air raid could have included 80,000No. Incendiary Bombs (IBs) mixed with High Explosive (HE) bombs. Mixed-payload raids of HE bombs and IBs were extremely difficult to record in detail and with precision in each instance.

A senior figure in charge of London's civil defence described the daily bomb reports as 'tales and fairy stories' and the person who suggested filing such reports by 9:00 a.m. every day needed 'to take the first available bed in Bedlam.' This harsh judgement of work done early in the Blitz did not wholly stand up to the procedures improved upon by Air Raid Precautions (ARP) training in later years, but it is a useful reminder that even the best contemporary records had inevitable flaws.

Strategic urban areas tended to have more comprehensive records than rural areas. It is for this and similar reasons that information for bombing both on the Site and the surrounding areas are collated from several sources. Failure to assess a site in the context of bombing in the surrounding area could lead to an underestimate of the UXB hazard.

Press records can supplement local information, although this source of information must be treated with caution, as inaccuracies do exist, either inadvertently or intentionally in order to confuse enemy intelligence. Classified official records can sometimes be considered inaccurate for the same reason.

3.1 General Site History

Town Pier is one of a number of piers in Gravesend providing berths for ferries and commercial ships. It was built in 1834 and is the world's oldest surviving cast iron pier.

Figure 2 shows Town Pier and the surrounding area in 1897. The seafront was already developed with a mixture of hotels, wharves and landing stages. Town Pier, located at the north end of the High Street, extended over the tidal mudflats so that it could still be used by shipping at all states of the tide. The pier is equipped with an extra pontoon to accommodate moorings.

Approximately 0.4km west of the Site was the Southeast & Chatham Railway Company's pier served directly by railway with adjacent marshalling yards and cattle pens for goods in transit to the moorings.

Approximately 0.6km southwest of the Site there was a 200 yard Volunteer Rifle Range with the target butts at the eastern end. This was located in a chalk quarry. This range was still in existence during WWI, but is not present on post-WWI maps.

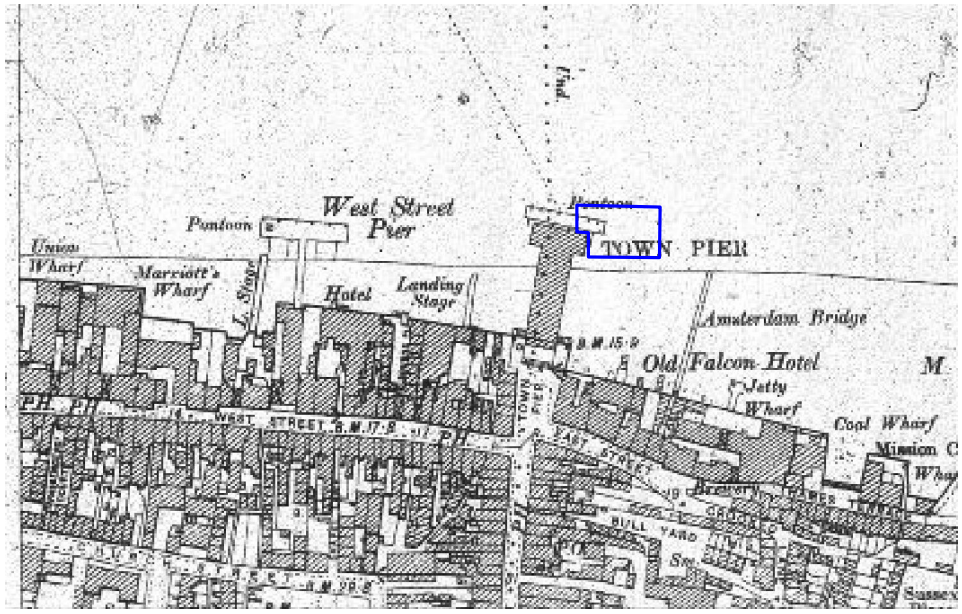


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Figure 2	Historical map, 1897	**Scale:** NTS

Figure 3 is a historical map dated 1936 which shows the Site immediately before the start of WWII. The configuration of the piers, buildings and wharves are essentially unchanged since 1897. The pontoon at the end of Town Pier has been extended eastwards to accommodate more shipping.

Source: © Crown Copyright 2005. Reproduced by permission of Ordnance Survey

Figure 3	Historical map, 1936	**Scale:** NTS

3.2 Pre-World War One (WWI)

The River Thames has always been an important strategic gateway, with important dock and industrial sites were located along the shores of the whole estuary. Consequently, there are several fortifications from many different eras along these approaches to London. The fortifications have been reused several times and some were utilised in both World Wars.

There are a number of pre-WWI installations in the vicinity of the Site. Milton Barracks TQ 657741, approximately 0.9km southeast of the Site, was constructed in 1863. It initially housed militia units until the arrival of the Duke of Cornwall's Light Infantry between 1908 and 1911. They were followed by the 2nd Battalion Royal Dublin Fusiliers.

Tilbury Fort, situated 0.9km north of the Site on the north shore of the River Thames, was first built in the 16th century and reconstructed and enlarged several times until the 18th and 19th centuries when it housed an important magazine. Plate 2 is a contemporary aerial photograph of Tilbury Fort.

Source: Microsoft Virtual Earth

Plate 2	Contemporary aerial photograph of Tilbury Fort

The Whitehill area, approximately 2.3km southeast of the Site was used as a 19th century rocket manufacturing and test site.

3.3 World War One (WWI)

During WWI an estimated 9,000No. German bombs were dropped over Britain. It was the first time that strategic aerial bombing had been used. Whilst most air raids were carried out on London and the southeast of England, targets all along the east coast were attacked.

Gravesend was an important military transferpoint. Milton Barracks, approximately 0.8km southeast of the Site, was used to house troops in transit to the Western Front.

Tilbury Fort was utilised in WWI, with both landward and seaward gun emplacements and as an Anti Aircraft (AA) battery. This initially comprised 1No. 6pounder (pdr) gun, later replaced

by 1No. 12pdr gun and was used to defend against both Zeppelin and aircraft raids. It was also equipped with searchlights as part of the outer defences of London.

Gravesend also housed some important wartime industries. It was an established centre for the manufacture of cement and paper. The Telegraph Works, an important supplier of telegraphy cable were located approximately 1.4km west of the Site.

Significant bombing incidents which occurred in the areas surrounding the Site are detailed in the following section.

4th June 1915

Naval Zeppelin L10 dropped HEs and IBs on Gravesend. Several bombs fell in the Wrotham Road, Windmill Street and Peppercroft Street area of the town, approximately 0.8km south of the Site, causing damage to property and 8 No. casualties.

1No. UXB was found in Cobham Street, approximately 0.7km southwest of the Site. This was removed.

1No. HE bomb fell on the Sailing Club which was being used as a Voluntary Aid Detachment (VAD) hospital, approximately 1km east of the Site. The blast severely damaged the building.

Summer 1917

The England Squadron dropped HE bombs on Gravesend golf links, approximately 2.4km south of the Site. No damage was caused.

31st October 1917

Gotha bomber aircraft dropped HEs and IBs in the Prospect Place area of Gravesend, approximately 1km southeast of the Site.

There are no records of the Site being bombed during WWI.

3.4 World War Two (WWII)

3.4.1 General

Heavy Luftwaffe bombing began after the fall of France in June, 1940. Early targets were primarily coastal or industrial: the Orkney Islands, the Welsh coalfields, and industrial and shipping centres of Tyneside, Humberside, Teesside, and Glasgow.

WWII bomb targeting was inaccurate, especially in the first year of the war. A typical bomb load of 50kg HE bombs mixed with IBs which was aimed at a specific location might not just miss the intended target but fall some considerable distance away.

Documenting the bombing was also unavoidably flawed. It was inevitable that during raids that might comprise 80,000No. IBs mixed with HE bombs, keeping track of the numbers was impossible.

Extensive and painstaking work was done by the ARP Wardens both in documenting and defuzing bombs. This provides records that give some appreciation of the density of bombing in the UK but not a complete record and as such, some judgment and extrapolation of these records is required to gain a fair and reasonable judgement of the actual bombing density for the Site.

The intensity of bombing during WWII is understood to have been under-reported. For any given bomb drop, and particularly with respect to mixed payload raids where the effect of IBs masked those of HE bombs, under reporting was inevitable.

The German bombing campaign saw the extensive use of both HE bombs and IBs. The most common HE bombs were the 50kg and 250kg bombs, although 500kg were also used to a lesser extent. More rarely 1000kg, 1400kg and 1800kg bombs were dropped.

The HE bombs tended to contain about half of their weight in explosives and were fitted with one or sometimes two fuzes. Not all HE bombs were intended to explode on impact. Some contained timing mechanisms where detonation could occur more than 70 hours after impact.

Incendiary devices ranged from small 1kg thermite filled, magnesium bodied, bombs to a 250kg 'oil bomb' and a 500kg 'C300' IB. In some cases the IBs were fitted with a bursting charge. This exploded after the bomb had been alight for a few minutes causing burning debris to be scattered over a greater area. The C300 bombs were similar in appearance to 500kg HE bombs, although their design was sufficiently different to warrant a specially trained unit of the Royal Engineers to deal with their disposal.

Anti-personnel bombs and parachute mines (PMs) were also deployed. 2No. types of anti-personnel bombs were in common use, the 2kg and the 12kg bomb. The 2kg bomb could inflict injury across an area up to 150m away from the impact, within 25m of this, death or fatal injury could occur.

PMs (which were up to 4m in length) could be detonated either magnetically or by noise/vibration. The Royal Navy was responsible for ensuring that the bombs were made safe. Removal and disposal was still the responsibility of the Bomb Disposal Unit of the Royal Engineers.

Plate 3 shows a variety of UXBs recovered by the Civil Defence in WWII from an area of London.

Source: Imperial War Museum

Plate 3	Photograph of a variety of UXBs recovered by the Civil Defence during WWII

3.4.2 WWII in northwest Kent and Gravesend

The River Thames was vitally important for the import and export of essential goods in and out of the Port of London. Most goods for London were moved via the river and the dock complexes and then distributed by the rail system. The Tilbury Dock complex situated approximately 1.7km northwest of the Site was very important.

The River Thames was a major navigation aid for German aircraft targeting London. Bombs were commonly dropped along this area during 'tip and run' raids, where bombers would drop their loads early to avoid the AA flak of London. The river itself was also a strategic target for German aircraft laying magnetic mines to destroy and disrupt shipping.

Strategically important targets such as docks and wharves were observed during bombing raids in order to try to record 'missiles' that fell into the water or mud and did not explode. The positions were recorded using a bearing board, ideally from more than 2No. locations, to get the most exact position as possible. Bombs that fell into water and mud will have been

observed on many occasions and, although the probability of detecting them is high, it will not be 100%.

Gravesend was heavily bombed during WWII with more than 280No. HE and approximately 300,000No. IBs falling on the town. The bombing caused 38No. fatalities and 283No.casualties. Damage to property was extensive, with 45No. buildings destroyed and a further 212No. severely damaged and 2,799No. slightly damaged.

3.4.3 WWII Strategic Targets in the Local Area

The presence of local strategic targets significantly increased the likelihood of bombing raids in a particular area. Government buildings, industrial targets important to the war effort, transport links and anti-invasion defences were all targeted by Luftwaffe bombers. The inherent bombing inaccuracies at the time meant that areas surrounding the targets were often subjected to aerial bombardment.

There were important industrial, military and defensive sites within 10km of the Site. The Luftwaffe were aware of these strategic targets and produced detailed target maps of the region.

Plate 4 illustrates a Luftwaffe target map of this section of the Thames estuary showing the location of Gravesend power station, approximately 1.7km west of the Site, and Tilbury Docks, 1.7km northwest of the Site.

North

Site

Source:Clarke

Plate 4	Luftwaffe target map of Gravesend, 1939	**Scale:** NTS

The following section outlines the main strategic targets in the vicinity of the Site.

Industrial sites

The south bank of the River Thames was the location of several different types of industry, all of which were targets for the Luftwaffe.

The Henley's Telegraph Works at Gravesend, approximately 1.4km west of the Site, manufactured wires and cables, notably for submarine telegraphy. It was also involved in the manufacture of gasmasks, mortar bomb components and the sheathing for the pipes used in the 'Pipeline under the Ocean' (PLUTO), the fuel delivery system for the D-Day landings.

There was a large paper industry centred on Northfleet and Gravesend. Some of the mills were commandeered to make other products or were temporarily closed. Part of the Bowaters paper factory at Northfleet, approximately 2.5km west of the Site, was requisitioned for the manufacture of Bofors 40mm LAA guns.

Other local industry was associated with aircraft manufacture such as the manufacture of specialised magnesium alloys used for fuel and oil tanks. Other companies were involved with the manufacture of weapons such as the 3.7-inch HAA gun.

Docks

Gravesend had a variety of moorings and wharves handling a wide range of different types of cargo. The area was also the terminus of the Thames and Medway Canal which was important for shipment of goods. The main basin was located approximately 0.8km southeast of the Site.

Tilbury Docks, approximately 1.7km northwest of the Site, were a strategically important and extensive facility for both cargo and passenger traffic. They were also widely used throughout WWII to handle cargo and troops.

Barracks

Milton Barracks, approximately 0.9km southeast of the Site, was operational during WWII. New hutted accommodation for 342No. personnel was built in the grounds of the old buildings. Troops stationed at the barracks included units of the Royal Engineers.

Military Airfields

There was 1No. operational airfield within 5km of the Site during WWII. This was RAF Gravesend for which details are provided in the following section.

RAF Gravesend (Chalk)

RAF Gravesend TQ 665720 was located approximately 4.4km southeast of the Site. The airfield opened in 1932 as a civilian landing ground. This was developed into Gravesend Airport and was used by the RAF from 1937. Used by many units, it operated a range of aircraft to include fightesr and bombers. It later became a ballon station. At the end of WWII it was immediately put into care and maintenance, and most of the buildings used for storage. The airfield site was later sold and used for the manufacture of aeronatical equipment until 1956, when it was redeveloped for housing.

WWII Decoys

In order to draw enemy aircraft away from towns, airfields and other strategically important targets, a series of decoys were developed in the summer of 1941. They were estimated to have drawn at least 5% of the total weight of bombs away from their intended targets.

Several different types of decoy were devised:

- Night time dummy airfields (Q sites).
- Daytime dummy airfields (K sites).
- Diversionary fires to simulate successful bombing raids on airfields (QF sites), petroleum depots (P sites) and major towns and cities (Starfish sites).
- Simulated urban lighting (QL sites).
- Dummy HAA batteries, factories and buildings (C series).
- Mobile decoys representing 'hards' for troop embarkation (MQLs), tanks and other vehicles.

Machine gun emplacements and Light Anti-Aircraft (LAA) guns were used to prevent possible enemy landings at decoy airfields. By their nature, decoy sites provide a potential risk from UXB, both within the decoy site boundary and in the surrounding areas.

There was 1No. decoy site within 5km of the Site. This was an MQL decoy located at East Tilbury, approximately 3.3km northeast of the Site.

Anti-Aircraft (AA) Defences

Anti-Aircraft (AA) gun batteries were targeted by the Luftwaffe. They were also a source of UXAA Shells which in WWII could fall up to 27km from the firing point, although more typically fell within 15km. 3No. types of AA batteries existed:

- Heavy Anti-Aircraft (HAA) batteries of large guns designed to engage high flying bomber aircraft. These tended to be relatively permanent gun emplacements.
- Light Anti-Aircraft (LAA) weaponry, designed to counter low flying aircraft. These were often mobile and were moved periodically to new locations around strategic targets such as airfields.
- Rocket batteries (ZAA) firing 3" or 3.7" AA rockets with a maximum altitude of 5,800m and a ground range of 9km were also relatively permanent emplacements.

Many AA batteries were associated with searchlights and consequently 'visible' at night, providing clear targets to the Luftwaffe bombers and a potential for UXB.

The Site was within the range of more than 28No. HAA guns during WWII. Table 1 is a list of known HAA gun batteries within 10km of the Site.

Table 1 HAA gun batteries within 10km of the Site

Grid Reference	Serial No	Location	Armament	Approximate Distance and Direction from Site
TQ 663740	TS16	Denton	4No. 4.5″	1.6km SE
TQ 638711	TS17	Northumberland Bottom	4No. 3.7″	3.5km SW
TQ 643796	TN15	Chadwell	4No. 4.5″	5.1km N
TQ 679771	TN13	Buckland	2No. 3.7″ then 4No. x 5. 25″	5.6km NE
TQ 608796	TN23	Belmont Castle	Unknown	6.5km NW
TQ 676683	TS15	Cobham	4No. 4.5″	6.6km SE
TQ 591708	TS18	Greenstreet Green	Unknown	6.8km SW
TQ 583708	TS18	Greenstreet Green	Unknown	7.5km SW
TQ 572746	TS20	Littlebrook Farm	Unknown	7.6km W
TQ 643828	TN14	Orsett	Unknown	8.3kmN
TQ 562733	TS20	-	Unknown	8.7km SW
TQ 577796	TN18	Aveley	Unknown	8.7km NW
TQ 599819	TN16	Buckles Farm	4No. 3.7″	8.8km NW
TQ 691827	TN11	Abbots Hall	4No. 3.7″	9.2km NE

This list is not definitive as mobile LAA units were also used. These could spend a considerable time at any one location.

Known LAA positions within 5km of the Site are listed in Table 2. Records of the exact locations and grid references are not available.

Table 2 LAA gun position within 5km of the Site

Grid Reference	Serial No	Location	Armament	Approximate Distance and Direction from Site
TQ 648752	112	Causeway (Tilbury)	1No. Quad 0.303"	0.6km N
TQ 635751	112	Savoy (Tilbury)	1No. Quad 0.303"	1.2km NW
TQ 646759	112	World's End (Tilbury)	1No. Quad 0.303"	1.3km N
TQ 635755	112	Tilbury	4No. x Bofors 40mm	1.5km NW
TQ 635755	112	Tilbury	4No. x Browning 0.5"	1.5km NW
TQ 635762	112	Ritz (Tilbury)	1No. Quad 0.303"	1.5km NW
TQ 665720	600	RAF Gravesend	2No. x Quad 0.303"	3.2km SE
TQ 665720	600	RAF Gravesend	2No. x Lewis Guns	3.2km SE
TQ 665720	600	RAF Gravesend	4No. Bofors 40mm	3.2km SE
TQ 629752	112	Bridge (Tilbury)	1No. Quad 0.303"	2.0km NW
TQ 643768	112	Goldsborough (Tilbury)	1No. Quad 0.303"	2.2km NW
TQ 625760	112	Mountain (Tilbury)	1No. Quad 0.303"	2.8km NW
TQ 620730	111	Northfleet	1No. Quad 0.303"	3.1km SW
TQ 626723	111	Northfleet	1No. Quad 0.303"	3.3km SW
TQ 612721	111	Northfleet	1No. Quad 0.303"	4.4km SW
TQ 691768		Coalhouse Fort	Bofors 40mm	4.8km NE

Coastal Batteries

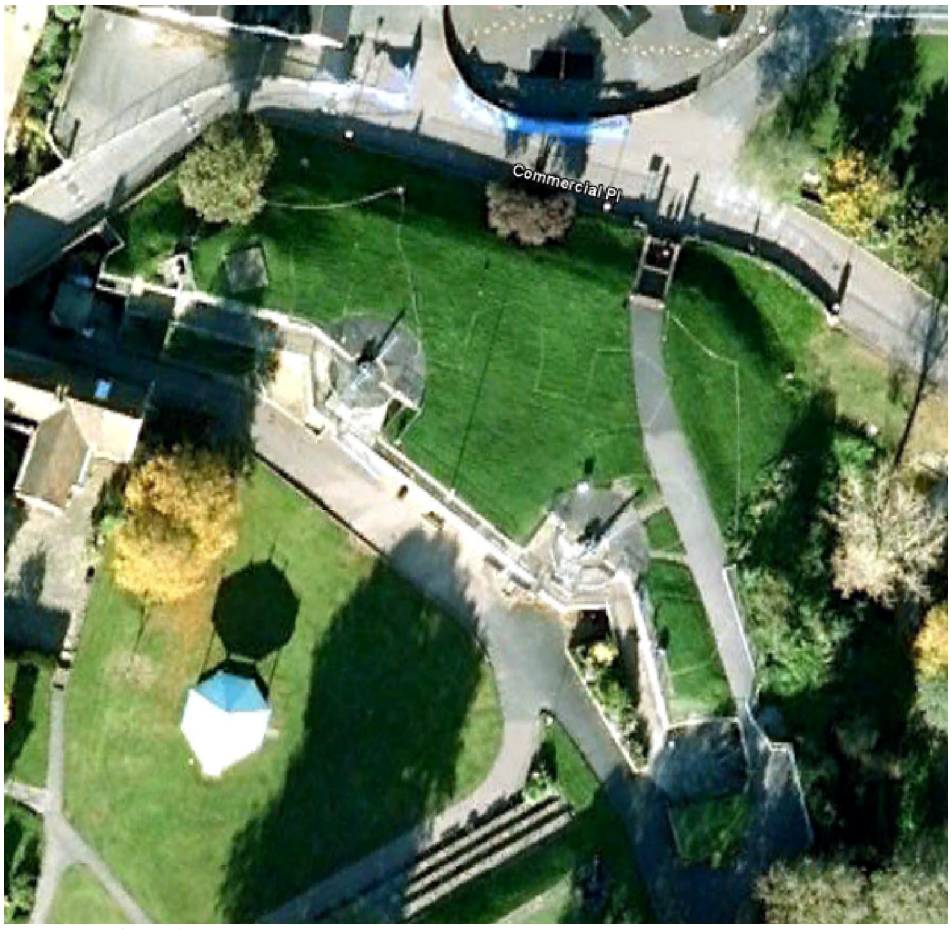
Both existing coastal batteries that had been in position for many centuries, as well as new positions, were in use during WWII to protect shipping routes and to defend the coast from potential invasion. The guns were mainly directed to sea, but there were some that had defences facing inland.

A list of those relevant to the Site is given in Table 3.

Table 3 Coastal Batteries within 10km of the Site

Grid Reference	Location	Type	Armament	Approximate Distance and Direction from Site
TQ 653742	New Tavern Fort	Coastal battery	2No. x 6"	0.5km SE
TQ 625755	Tilbury Fort	Coastal battery		0.9km N
TQ 693748	Shornemead Fort	Coastal battery		4.4kmE
TQ 687774	East Tilbury Battery	Coastal battery		4.8km NE
TQ 691768	Coalhouse Fort	Coastal battery	2No. x 5.5"	4.9km NE
TQ 707768	Cliffe Fort	Coastal battery		6.3kmNE

An example of the defences is illustrated in Plate 5, a contemporary photograph of the guns and their emplacements at New Tavern Fort, approximately 0.5km east of the Site.



Source: Google Earth

Plate 5 Contemporary photograph of New Tavern Fort Gravesend, 2006

Anti-invasion Defences

The rapid advance of German Troops into France, Holland and Belgium after the start of WWII prompted the War Office to review the vulnerability of the UK to invasion and a decision was taken to begin work on a national plan of anti-invasion defences.

Anti-invasion defence structures were constructed along so-called 'Stop Lines' in order to impede enemy progress for long enough to allow mobile defending forces to counter-attack in the event of an invasion.

Stop Lines were further integrated into a network of fortified nodal points and 'Anti-Tank (AT) Islands'. These fortifications included road blocks, ditches, anti-tank blocks, pimples, mined bridges, demolition charges, spigot mortar and machine gun emplacements and in the event of invasion, their defence was usually the responsibility of the Home Guard. The Home Guard were well equipped with weapons and ordnance by 1941.

Defence structures are a potential source of UXB as they were targeted by enemy aircraft. Some, such as pillboxes, are also potential sources of UXO in their own right due to the associated use and storage of ordnance.

Gravesend was defended against invasion by a number of different structures. A list of those within 5km of the Site is given in Table 4.

Table 4 Anti-invasion defences within 5km of the Site

Grid Reference	Location	Type	Approximate Distance and Direction from Site
NZ 393644	Tilbury Marsh	Pillbox	1.7km NE
TQ 695748	Shorne Marsh	Pillbox	4.7km E
TQ 696748	Shorne Marsh	Pillbox	4.8km E
TQ 691768	Coalhouse Fort	2No. Spigot Mortar pits	4.9km NE

Many of these have since been removed and none are considered to pose any UXO hazard to the Site.

3.4.4 Bombing Density and Incidents

Local Authority and Civil Defence bomb maps, historic aerial photographs and air raid incident records, along with other records and archives, have been consulted to ascertain the bombing history of the Site.

Table 5 gives the bombing statistics for Gravesend Municipal Borough (MB), together with the neighbouring districts of Northfleet Urban District (UD), Strood Rural District (RD) and Thurrock UD on the opposite shore of the Thames.

The figures for the London Borough (LB) of West Ham, generally considered to be high risk, are included for comparison.

Table 5 Bombing statistics

Area	Bombs reported				
	High Explosive	Parachute Mines	Other	Total	Bombs per 1,000 acres (405ha)
Gravesend MB	**272**	**0**	**14**	**286**	**71.3**
Northfleet UD	364	3	7	374	99.2
Strood RD	1804	24	55	1883	38.6
Thurrock UD	1614	44	21	1679	41.4
LB of West Ham	1498	45	23	1566	334.0

Note that Table 6 excludes the figures for IBs, Pilotless Aircraft, also known as Flying Bombs or 'Doodlebugs' (V1s) and Long Range Rockets (V2s).

Discrepancies between this list and other records, (such as bomb clearance records) demonstrate that this data is likely to under-represent actual bombing.

The following section details the main incidents affecting the Site and surrounding area.

6th June 1940.

In the first raid on the region, more than 1,500No. IBs fell on the residential area between Northfleet High Street, Lawn Road and Downs Road, Northfleet, approximately 2.7km west of the Site.

16th August 1940

108No. HE bombs fell in the area of Colyers Road, Detling Road and Bowater's paper mill on the banks of the River Thames, between approximately 1.5km west of the Site and 2.7km southwest of the Site. The raid resulted in 29No. fatalities and 27No. casualties.

1st September 1940

HE bombs fell in Raphael Road and the Canal Basin area, between approximately 0.8km southeast of the Site and 1.3km southeast of the Site.

1No. Delayed Action Bomb (DAB) fell against the canal lock gates and later self-exploded, damaging the gates.

2nd September 1940

11No. HE bombs fell at RAF Gravesend, approximately 3.2km southeast of the Site. Damage to the utilites was caused but there was no damage to aircraft or buildings.

5th September 1940

1No. HE bomb fell on 16, Pelham Road, approximately 0.7km southwest of the Site.

1 No. HE bomb fell on 19-22, Peter Street, approximately 1km south of the Site, demolishing all of the properties. Many IBs also fell on the area.

1No. HE bomb fell at the rear of 10, Christ Church Road, approximately 1km south of the Site. Part of the property was demolished.

2No. HE bombs fell in New House Lane, approximately 2km southwest of the Site.

1No. HE bomb fell on Hampton Crescent, approximately 2.4km southeast of the Site.

Many IBs fell in the Denton area of Gravesend, approximately 2.5km southeast of the Site.

Many IBs fell in the area of the golf course, approximately 2.7km south of the Site.

22nd September 1940

1No. DAB bomb fell in the garden of a house in Clarence Row, approximately 0.9km south of the Site.

24th September 1940

The eastern parts of Gravesend were raided.

3No. HE bombs fell in the River Thames opposite Three Crowns Wharf, approximately 0.3km west of the Site.

1No. HE bomb fell in the River Thames approximately 10m off of the Promenade, approximately 0.6km east of the Site. It was recorded as UXB. There is no further information about this bomb.

1No. HE bomb fell in the River Thames, approximately 1.2km east of the Site, next to the TS Cornwall (built 1815) and sank her.

2No. HE bombs fell in the grounds of Denton Hospital, approximately 1.7km east of the Site, and 4No. HE bombs fell on the marshes adjacent to the Hospital.

1No. HE bomb fell in the river opposite the hospital. It was recorded as UXB. There is no further information about this bomb.

8No. HE bombs fell on the sewage works, approximately 1.7km southeast of the Site., resulting in damage to the filter beds and facilites.

1No. HE bomb fell on the railway line east of Denton Halt , approximately 1.9km southeast of the Site.

27h September 1940

Approximately 100No. IBs fell in the fields along Wrotham Road between the golf course and the allotments, approximately 2.2km southest of the Site.

28h September 1940

4No. OBs fell in a field south of Bourne Road, approximately 2.6km southeast of the Site.

3rd October 1940

Approximately 100No. IBs fell on the marshes near Milton rifle range, approximately 3.5km east of the Site. There were no casualties and minimal damage.

5th October 1940

HE bombs fell in Northfleet, approximately 2.7km west of the Site. There were 3No. fatalities and 6No.casualties. Residential property was damaged.

2No. HE bombs fell in a field to the east of Denton Hospital, approximately 2.4km east of the Site.

10th October 1940

3No. HE bombs fell near Dennis Road, approximately 2.1km south of the Site. They were recorded as UXB.

1No. HE bomb fell in the garden of 33, Oak Road, approximately 2.6km southeast of the Site. This resulted in 1No. fatality and 5No.casualties.

1No. HE bomb fell between Nos. 38 and 39, Poplar Avenue, approximately 2.8km southeast of the Site, resulting in minor damage.

2No. HE bombs fell in Cedar Avenue, approximately 3km southeast of of the Site. They were recorded as UXB.

16th October 1940

Several IBs fell in Bourne Road, approximately 2.5km southeast of the Site.

21st October 1940

1No. HE bomb fell on 71, Hillside Avenue, approximately 2km southeast of the Site, resulting in damage to property.

2No. HE bombs fell on playing fields, approximately 4km south of the Site, causing minimal damage.

22nd October 1940

HE bombs fell in the Crete Hall Road area, approximately 1.4km southwest of the Site. There was minimal damage.

23rd October 1940

1No. HE bomb fell on Park Road, approximately 1.5km south of the Site. A water main was damaged.

1No. HE bomb fell on New House Lane, approximately 2.1km south of the Site. The property was damaged.

1No. HE bomb fell on 59-60 Thong Lane, approximately 3.6km southeast of the Site. The properties were demolished. There was 1No. fatality and 4No. casualties.

30th October 1940

2No. HE bombs fell on the Boy's School in Church Walk, approximately 2.5km south of the Site, resulting in minimal damage.

31st October 1940

2No. HE bombs fell on the golf course, approximately 2.7km southeast of the Site, damaging properties. 1No. was recorded as a UXB.

A large number of IBs fell in the southeast part of the borough, approximately 3.1km southeast of the Site.

1st November 1940

3No. HE bombs fell on open ground at Denton Marshes, approximately 3km southeast of the Site, damaging properties. 1No. was recorded as a UXB.

2nd November 1940

1No. HE bomb fell on open ground near Whitehill School, Sun Lane, approximately 2km south of the Site. The school was damaged.

5th November 1940

HE bombs fell on Denton Hospital, approximately 2km east of the Site, severely damaging 1No. ward.

6th November 1940

HE bombs fell on Albion Terrace, approximately 0.8km southeast of the Site, damaging properties.

Many IBs fell on the area and the Imperial Paper Mills, approximately 0.8km west of the Site, were partially destroyed by fire.

1No. HE bomb fell in Trafalgar Road, approximately 1km south of the Site.

10th November 1940

12No. HE bombs fell on Gordon Promenade, approximately 0.6km east of the Site. This resulted in 3No. fatalities and 5No.casualties. The swimming baths were damaged.

HE bombs fell in the Woodlands Park area, approximately 1.6km south of the Site.

20th November 1940

6No. HE bombs fell on Filborough Marshes, approximately 3.7km southeast of the Site. 5No. of these were recorded as UXBs.

12th January 1941

1No. HE bomb fell in the back garden of 4, Arnold Road, approximately 1.9km southeast of the Site. An Anderson shelter was hit, resulting in 1No. fatality and 3No. casualties.

1No. HE bomb fell on 73, Whitehill Road, approximately 1.9km south of the Site.

1No. HE bomb fell on 3, Smart's Road, approximately 2km south of the Site.

1No. HE bomb fell on 45, Central Avenue, approximately 2km south of the Site.

1No. HE bomb fell on 43, The Fairway, approximately 2km south of the Site.

1No. HE bomb fell on 24, Gatwick Road, approximately 2km south of the Site.

1No. HE bomb fell on the junction of Hillside Avenue and Valley Drive, approximately 2.1km southeast of the Site, damaging utilities.

1No. HE bomb fell on waste ground to the south of Hillside Avenue, approximately 2.1km southeast of the Site.

1No. HE bomb fell on 2, Barr Road, approximately 2.8km southeast of the Site.

Large numbers of IBs fell across Gravesend, particularly in the Kings Farm area, approximately 2.5km south of the Site.

20th February 1941

HE bombs fell in fields to the west of Northfleet Green, approximately 3.9km southwest of the Site, causing little damage.

15th March 1941

1No. HE bomb fell on the junction of Thong Lane and Rochester Road, approximately 2.8km southeast of the Site.

1No. UXB was recorded in the garden of 58, Chalk Road, approximately 2.8km southeast of the Site.

19th April 1941

11No. HE bombs and many IBs fell on Gravesend resulting in 1No. fatality and 6No. casualties.

2No. HE bombs fell in Lynton Road and Kent Road, approximately 1.3km south of the Site.

1No. HE bomb fell on a bowling club at the junction of Wrotham Road and Old Road West, approximately 1.4km south of the Site.

1No. UXB was recorded in a field near Lamorna Avenue, approximately 2.2km southeast of the Site. This was removed.

1No. HE bomb fell in Gloucester Road, approximately 2.6km south of the Site.

1No. UXB was recorded at the southeast corner of the golf course, adjacent to Singlewell Lane, approximately 3km south of the Site. This was removed.

3No. HE bombs fell in the Thong Lane area, approximately 3.6km southeast of the Site.

Numerous IBs fell across Gravesend.

18th January 1943

1No. AA shell exploded outside 12, Old Road, approximately 1.5km south of the Site.

4th March 1943

HE bombs fell in the Grange Road area of Gravesend, approximately 1km southwest of the Site. This resulted in 1No. fatality, 23No. casualties and damage to several buildings.

18th October 1943

The Northfleet area, approximately 2.5km east of the Site was heavily bombed. This resulted in 3No. fatalities, 18No. casualties and considerable damage to buildings.

2nd November 1943

HE bombs fell in the Chalk Road and Lower Higham Road area of Gravesend, approximately 3km southeast of the Site. This resulted in 1No. fatality and 14No. casualties.

21st December 1943

HE bombs fell in the Park Avenue area of Northfleet, approximately 1.9km southwest of the Site.

21st January 1944

RAF Gravesend, approximately 4.4km east of the Site, was raided.

22nd January 1944

Gravesend and RAF Gravesend, approximately 4.4km east of the Site, were raided.

2No. HE bombs fell in the gardens of houses in Old Road East, approximately 1.7km southeast of the Site.

Many IBs fell across the town.

29th January 1944

Many IBs fell along the water front in Gravesend within approximately 0.2km east and west of the Site, resulting in some fire damage.

4th February 1944

2No. HE bombs fell at the junction of Wrotham Road and Cross Lane West, approximately 1.7km south of the Site.

Large numbers of IBs fell in the Tollgate and Wrotham Road allotments, approximately 1.7km south of the Site.

13th June 1944

1No. V1 fell on waste land in Swanscombe, approximately 4.1km west of the Site.

30th July 1944

1No. V1 fell in Taunton Road, Swanscombe, approximately 3.9km west of the Site. This resulted in 13No. fatalities and 91No. casualties. Several houses were demolished.

7th August 1944

1No. V1 fell in Swanscombe, approximately 4.1km west of the Site. This resulted in 2No. fatalities and 47No. casualties.

8th November 1944

1No. V1 fell in Swanscombe, approximately 4.1km west of the Site. This resulted in 1No. fatality and 30No. casualties.

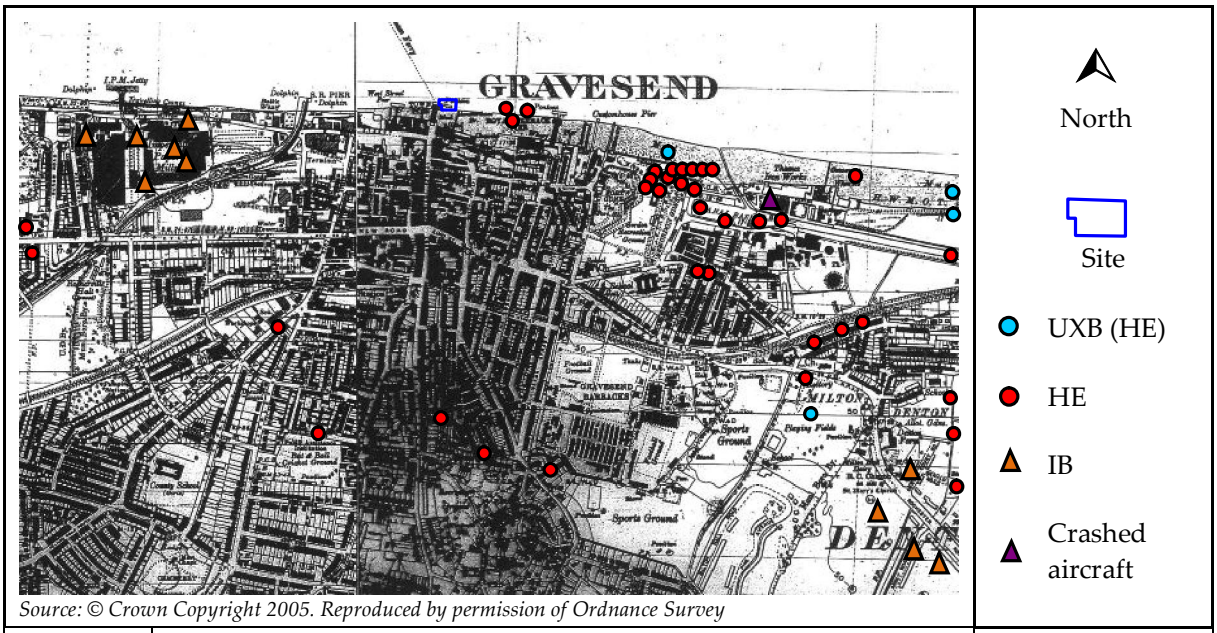
13th November 1944

1No. V2 fell in Portland Avenue, approximately 1.7km south of the Site. This resulted in 4No. fatalities and 72No. casualties.

29th November 1944

1No. V2 fell in the Milton Place area of Gravesend, approximately 0.5km southeast of the Site. This resulted in 8No. fatalities and many casualties. Several important properties were destroyed.

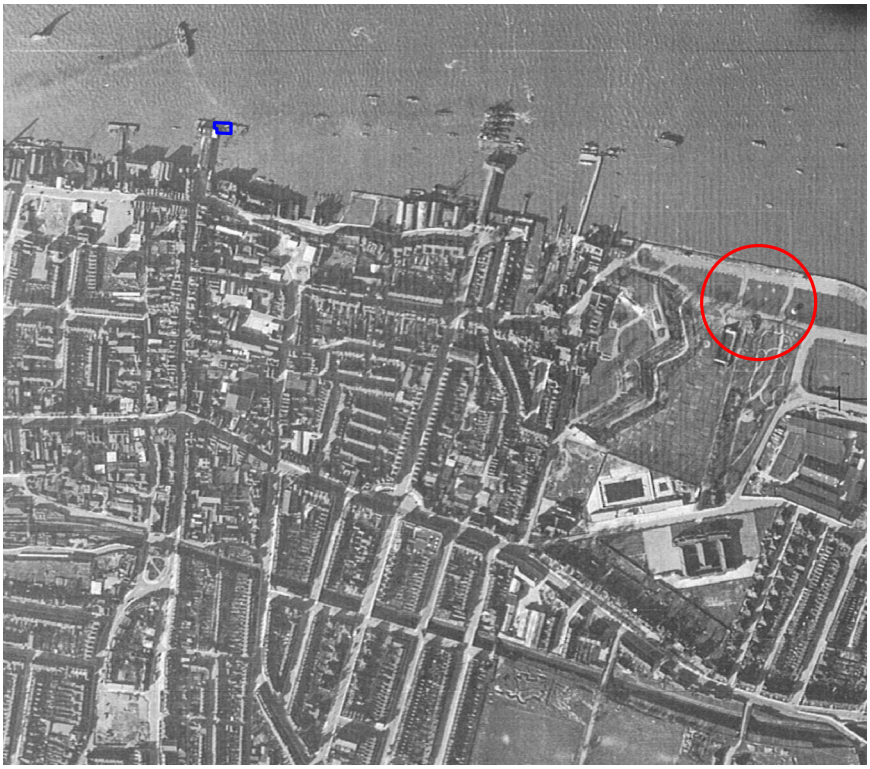
Figure 4 shows a compilation of the approximate location of recorded bomb impacts in the vicinity of the Site between 1940 and 1945. The locations have been compiled from a number of different sources. This shows that the majority of incidents occurred to the east of the Site.



Source: © Crown Copyright 2005. Reproduced by permission of Ordnance Survey

Figure 4	Compiled bomb map for the vicinity of the Site	**Scale:** NTS

Plate 6 is an aerial photograph of the Site and surrounding area dated the 14th March 1941 on which areas of bomb damage have been outlined. The only visible bomb damage is on the seafront adjacent to the fort, approximately 0.5km southeast of the Site.



North

Site

Areas of possible bomb damage

Source: English Heritage

Plate 5	Aerial photograph, 14th March 1941	**Scale:** NTS

4 ABANDONED BOMBS AND EOC TASKS

Official UK bombing statistics have been compiled from both British and German sources. There were differences in the way the figures were originally reported and collated which has led to discrepancies in the summary data.

Based on data from 1939 to 1945, War Office statistics indicate that 200,195No. HE bombs exploded within Great Britain. Additionally, 25,195No. HE bombs (representing 11%) were recorded as UXBs. However, records from the Royal Engineers who were responsible for bomb disposal at the time indicate that as of 27th February 1946 upwards of 45,000No. UXBs were disposed of.

On average 8.5% UXBs later self-exploded. In some cases the bombs had delayed action fuzes or were never intended to explode, their purpose being to cause inconvenience and fear.

Given the discrepancy in records and the fact that UXBs are still being found unexpectedly, it is clear that the original figures are understated and provide only an approximation of the number of potential UXBs in the UK.

War Office statistics also show that between October 1940 and May 1941 most of the UXBs (93%) were either 50kg or 250kg. It should be noted that neither recovery nor size of the UXB were always accurately reported.

4.1 Abandoned Bombs

Information from the MoD on any officially registered abandoned bombs which may affect the Site was unavailable at the time of issuing this report. Where significant, this information will be forwarded as an addendum to this report.

4.2 EOC Tasks

Information from the MoD on official Explosive Ordnance Clearance (EOC) which may affect the Site was unavailable at the time of issuing this report. Where significant, this information will be forwarded as an addendum to this report.

Other sources indicate that several post-WWII EOC tasks have been carried out.

18th January 2001

1No. live Type 36 Mills Bomb was found on the railway at Stanbrooke Road bridge, approximately 1.4km southwest of the Site. It was subsequently removed.

5 UXB HAZARD

5.1 Anticipated Ordnance Types

When assessing the risk from UXO including UXB, it is important to be aware of ordnance type and function. The following Section briefly describes the main ordnance types that could potentially affect the Site.

5.1.1 Shells

A shell is a projectile containing an explosive charge designed to burst the casing that can contain HEs, pyrotechnic compounds or other chemicals.

Shells can be found in a range of sizes, from <20mm to several times this size. There is a prospect of finding AA shells on the Site that have fallen back to the ground unexploded. Most commonly used shells were 2" and 3.7" HE shells. If fired and found as UXO, shells can offer a particular hazard from accidental detonation as they can have sensitive fuze mechanisms.

5.1.2 Bombs

Probably the most common and certainly most publicised UXOs to be found in the UK are bombs. Air-dropped bombs as a result of WWII enemy action are found on a relatively frequent basis as UXO. They tend to be highly publicised (at least on a local basis) due to the common disruption where an evacuation of the potentially affected area is put in place.

The amount of HE and the potential for a fuze to still be activated means that these devices have the potential of causing some of the most widespread damage. WWII bombs were particularly sophisticated for their time, with time-delay and anti-tamper fuzes. Many German bombs were designed to not explode on impact and instead to cause disruption as a UXB. Some fuzes were set with a delay time of over 70 hours. During this time, an anti-tamper fuze could also be activated to detonate should it be disturbed.

The most commonly used bombs during WWII were the 50kg and 250kg sized general purpose bombs. Less frequently, the 500kg bomb was also used. Larger bombs were used, but so infrequently that any assessment of hazard is more typically based on bombs ranging up to 500kg only. It should be noted that the June 2008 find of a 1000kg bomb in the Lea Valley, London demonstrates that larger bombs can be found and any risk mitigation measures should consider this.

War Office statistics for October 1940 to May 1941 show that 7% of recovered UXBs were larger than 250kg. The larger WWII UXBs are often difficult to recover due to both penetration depths and the presence of two or more fuzes combined with more sensitive fillings of explosive mixtures including Amatol and Trialen.

Since WWII, UXBs have been found on a regular basis. On the 2nd June 2008, a 1000kg 'Hermann' HE bomb was discovered at Sugar House Lane in the Lea Valley. It caused considerable disruption over several days while the disposal operation took place.

The 'Hermann' bomb which is 1.2m in length and 0.6m in diameter was defuzed by a combination of techniques due to the sensitivity of the HE. Much of the HE was removed before the remaining HE could be safely detonated, some 4 days after discovery. A photograph of the Sugar House Lane 'Hermann' bomb is shown in Plate 7.

Source: East London Advertiser

Plate 7	Photograph of 1000kg 'Hermann' bomb, Sugar House Lane, 2008

Marine Mines

Marine mines are designed to lie at the bottom of relatively shallow water and explode when the earth's magnetic field becomes distorted by any large metal object such as a ship coming within range.

Clearance certification for UXO within a marine environment may be valid only for a limited period because storms, tides and general current movement can cause UXO to migrate into an area that may have been cleared of UXO only hours before. This also makes it very difficult to accurately predict where UXO may be found.

A mine can be washed up on a beach or found drifting in the water around any part of the UK's coastline. Given the location of the Site, there is a probability (albeit low) of finding mines in the area.

5.2 Geology and Bomb Penetration Depths

It is important to consider the soil type present at the time that a bomb was dropped in order to establish its maximum penetration depth. British Geological Survey (BGS) 1:50,000 Sheet 171 Dartford (Solid and Drift) was consulted.

The geology of the Site is understood to consist of variable thicknesses of Alluvium over Upper Chalk.

The following Table 6 provides an estimate of average bomb penetration depths from ground level assuming 5m of soft clay over more than 50m of soft rock.

Table 6 Estimated average bomb penetration depths

Estimated average bomb penetration depths for anticipated geology		
Bomb Weight	50kg	6.0m
	500kg	9.5m
	1000kg	10.5m

The estimate of bomb penetration depths in Table 7 is based on the following assumptions:

a) High level release of the bomb resulting in an impact velocity of 260 m/s (>5,000 m altitude).

b) A strike angle of 10 to 15 degrees to the vertical.

c) That the bomb is stable, both in flight and on penetration.

d) That no retarding units are fitted to the bomb.

e) That the soil type is homogenous.

A high altitude release of a bomb will result in ground entry at between 10° and 15° to the vertical with the bomb travelling on this trajectory until momentum is nearly lost. The bomb will then turn abruptly to the horizontal before coming to rest. The distance between the centre of the entry hole and the centre of the bomb at rest is known as the 'offset'. A marked lateral movement from the original line of entry is common.

Low level attacks may have an impact angle of 45° or more, which will frequently lead to a much greater amount of offset movement during soil penetration.

The average offset is one third of the penetration depth, i.e. an offset of 2.0m may be expected for a 50kg bomb in dry silts and clays.

If hard standings or Made Ground were present during WWII, bomb penetration depths would have been significantly reduced but offset distances may have been up to four times greater

5.3 Effects and Consequences

There have been a limited number of recorded incidents in the UK since WWII where bombs have detonated during engineering works, though a significant number of bombs have been discovered. Incidents involving smaller ordnance are, however, relatively common in the UK.

In the UK, there are no recorded incidents since the decade after WWII, of a UXB accidentally detonating. In recent years, bombs have been found that have fuze mechanisms that have started to operate indicating that given the right conditions a UXB may still function. In 2003 during construction work in Sunderland, a UXB was uncovered and the fuze mechanism started to operate.

In June 2008 the UXB uncovered in the Lea Valley caused difficulty to No.33 Regiment (Explosive Ordnance Disposal) Royal Engineers because the fuze mechanism started to operate. The 1000kg bomb, the first of this size to be found in over 30 years, took 5 days to deactivate. This demonstrates that larger bombs can be found and any risk mitigation measures should provide the option to deal with this size of device.

In May 2009 1No. 50kg WWII bomb was found on a building site in Bexhill-on-Sea, Sussex, and on the 16th August 2009, 1No. 250kg WWII bomb was found near Ebberston, North Yorkshire. Both of these were destroyed in controlled explosions by Bomb Disposal Units.

There is a long list of incidents during construction work in Germany that in some cases have led to the deaths of workers. In September 2008, 17No. people were injured and considerable damage occurred to adjacent buildings when a bomb exploded on a construction site in Hattingen, Germany.

In October 2006 during road works on a motorway near Aschaffenburg in Bavaria, southern Germany, a bomb was struck by a machine and detonated. The plant driver was killed and 5No. others injured, including passing motorists. In a similar incident in October 2004 in Linz, Austria a bomb exploded injuring 3No. workers and causing considerable damage to plant.

In September 2008, a WWII bomb under a back garden in Vienna, Austria, was detonated by a minor earth tremor, after remaining undiscovered for over 60 years.

Further details of similar finds can be found at www.zetica.com/uxb_downloads.htm

The effects of a partial or full detonation of ordnance are usually shock, blast, heat and shrapnel damage. A 50kg buried bomb can damage brick / concrete structures up to a distance of approximately 16m away. Unprotected personnel on the surface up to 70m away from the blast could also be seriously injured. Larger ordnance would obviously be more destructive.

Explosives rarely lose effectiveness with age, although over time mechanisms such as fuzes and gaines can become more sensitive and therefore more prone to detonation, regardless of whether the device has been submersed in water or embedded in silt, clay or similar materials.

The effects of a detonation of explosive ordnance are usually extremely fast, often catastrophic and invariably traumatic to any personnel involved.

6 RISK ASSESSMENT & RECOMMENDATIONS

During WWII it was estimated that 286No. HE bombs fell in the Gravesend area. The bombing density for Gravesend is 71.3 bombs/ha, which is considered as relatively low in comparison with many of the London Boroughs.

There is no evidence that the Site or areas immediately surrounding it were directly hit by HE bombs during WWII.

Taking into consideration the available information indicating the intensity of bombing on both sides of the River Thames, the density of known strikes immediately adjacent to the Site, the distance of the Site from strategic targets, the ground conditions during WWII and the quality of the data, it is considered that the Site has a low risk of UXB being present.

It is considered prudent to highlight the fact that the number of AA batteries surrounding the Site poses a risk (albeit low) of UXAA Shells being present on the Site.

6.1 Risk Management

Table 7 gives recommended actions in relation to potential UXB risk and the anticipated Site activity. The actual mitigation will depend on the detail and nature of any planned works.

It would be prudent to ensure that all staff have an awareness of the risk through the site safety induction process, as detailed in Table 8. This would ensure that appropriate action is taken in the event that a suspect item is uncovered. Appropriate action is required to be detailed within site procedures.

If a zero risk attitude is taken, then clearance certification should be considered. Clearance certification for boreholes or piles can be provided by the use of MagCone or MagDrill UXB detection techniques. These techniques advance a magnetometer by probing or drilling into the ground, depending on the geology, in advance of a borehole or pile. The magnetometer is capable of detecting large ferrous metal objects such as UXB. If no objects comparable to a UXB are detected, then the borehole or pile position is considered clear of UXB.

It should be noted that storms, tides and general current movement can cause UXO within the marine environment to migrate into an area that may have been cleared of UXO only hours before. As a result, clearance certification for marine UXO may be valid for a limited period.

Table 7 Risk mitigation for typical site activities

Level of Risk	Typical Future Activity on the Site			
	None	Shallow Excavations (<1.0m)	Deep Excavations (>1.0m)	Boreholes or Pile Construction
Low	Ensure suitable records and procedures are in place to highlight the risk should future development be planned.	Ensure site staff, are informed as part of the site safety induction that the potential presence of UXO cannot be discounted. Appropriate action is required to be detailed within site procedures.	Ensure site staff, are informed as part of the site safety induction that the potential presence of UXO cannot be discounted. Appropriate action is required to be detailed within site procedures.	Ensure site staff, are informed as part of the site safety induction that the potential presence of UXO cannot be discounted. Appropriate action is required to be detailed within site procedures. Clearance certification for borehole or pile locations would be considered prudent but not essential.
Moderate	As low risk.	Ensure site staff, are informed as part of the site safety induction that there is a potential for UXO to be discovered during site works. EOC Operative supervision is considered prudent.	Ensure site staff, are informed as part of the site safety induction that there is a potential for UXO to be discovered during site works. Non-intrusive investigation method prior to excavation should be considered. EOC Operative supervision is considered prudent.	Ensure site staff, are informed as part of the site safety induction that there is a potential for UXO to be discovered during site works. Clearance certification for borehole or pile locations would be considered essential.
High	As low risk.	Ensure site staff, are informed as part of the site safety induction that there is a high potential for UXO to be discovered during site works. EOC operative supervision is considered essential where ground has not been developed post war.	Ensure site staff, are informed as part of the site safety induction that there is a high potential for UXO to be discovered during site works. Non-intrusive investigation methods considered prudent with excavation of any targets identified. EOC operative supervision is also considered essential.	Ensure site staff, are informed as part of the site safety induction that there is a high potential for UXO to be discovered during site works. Clearance certification for borehole or pile locations would be considered essential.

The above table is for guidance only.

Appendix 1 Abbreviations & Glossary

Abbreviations

AA	Anti-Aircraft
AFU	Advanced Flying Unit
AI	Airborne Interception
ANS	Air Navigation School
ARP	Air Raid Precaution
ASACS	Air Surveillance and Control System
ASV	Air to Surface
BD	Bomb Disposal
BDO	Bomb Disposal Officer
BDU	Bomb Disposal Unit
BEF	British Expeditionary Force
CB	County Borough
CFS	Central Flying School
DAB	Delayed Action Bomb
DSDA	Defence Storage and Distribution Agency
ECFS	Empire Central Flying School
EFS	Empire Flying School
EFTS	Elementary Flying Training School
EOC	Explosive Ordnance Clearance
FIDO	Fog Intensive Dispersal Operation
FITS	Flying Instructors Training School
FTS	Flying Training School
GCHQ	Government Communications Headquarters
GCI	Ground Control Intercept
HAA	Heavy Anti-Aircraft
HCU	Heavy Conversion Unit
HE	High Explosive

HMEF	His/Her Majesty's Explosives Factory
HMFF	His/Her Majesty's Filling Factory
HQ	Head Quarters
HSE	Health and Safety Executive
IB	Incendiary Bomb
ICBM	Inter-Continental Ballistic Missile
IRBM	Intermediate Range Ballistic Missile
LAA	Light Anti-Aircraft
LB	London Borough
MAP	Ministry of Aircraft Production
MB	Municipal Borough
MC	Maintenance Command
MCA	Maritime Coastguard Agency
MoD	Ministry of Defence
MMU	Mobile Meteorological Unit
MU	Maintenance Unit
NATO	North Atlantic Treaty Organisation
NSF	National Shell Factory
NTS	Not to Scale
OCU	Operational Conversion Unit
OTU	Operational Training Unit
POW	Prisoner of War
PTC	Personnel and Training Command
RAF	Royal Air Force
RASC	Royal Army Service Corps
RD	Rural District
RDX	Research Development Explosive
RE	Royal Engineers
REME	Royal Electrical and Mechanical Engineers

RFC	Royal Flying Corps
RLG	Relief Landing Ground
ROC	Royal Observer Corps
ROF	Royal Ordnance Factory
RRE	Royal Radar Establishment
SAS	Special Arms Service
SI	Secret Installation
SIP	Special Incendiary Phosphorous
SLG	Satellite Landing Ground
SOE	Special Operations Executive
SOS	Services of Supply
STC	Strike Command
TA	Territorial Army
TFU	Telecommunications Flying Unit
TRE	Telecommunications Research Establishment
UD	Urban District
UKHO	United Kingdom Hydrographic Office
UKWMO	United Kingdom Warning and Monitoring Organisation
USAF	United States Air Force
USAAF	United States Army Air Force
UXB	Unexploded Bomb
UXO	Unexploded Ordnance
WWI	World War One
WWII	World War Two

Glossary

Camouflet	The type of cavity produced when a charge explodes underground without breaking the surface of the earth to form a crater.
Conflagration	A very large self sustaining destructive fire
Dannert Wire	Barbed wire in the form of a coil which could be extended concertina-like to form a barrier to impede the movement of hostile troops.
Deflagration	The fast and violent burning of an energetic material (as opposed to detonation).
Demil	Derived from the term 'Demilitarisation', it refers to the break down and the recycling or disposal of ordnance components.
Detonation	The high-speed chemical breakdown of an energetic material producing heat, pressure, flame and a shock wave.
Device	This term is used for any component, sub-assembly or completed ordnance, which may or may not have an explosive risk. It can apply to detonators, primers, gaines, fuzes, shells or bombs.
EOC Operative	EOC is an abbreviation for Explosive Ordnance Clearance. This term is more commonly used today instead of the more traditional term EOD (Explosive Ordnance Disposal) that specifically refers to the disposal of ordnance. An EOC Operative is a trained person (usually military trained with formal qualifications) capable of conducting ordnance recognition and remediation tasks.
Explosive	The term explosive refers to compounds forming energetic materials that under certain conditions chemically react, rapidly producing gas, heat and pressure. Obviously, these are extremely dangerous and should only be handled by qualified professionals.
Firing Template	The 'template' is the area of a firing range (sea or land) that ordnance is fired into. This is an area usually monitored by the MoD Police and/or Coast Guard to prevent non-authorised persons or vessels straying into the area.
Fuze	A fuze is the part of an explosive device that initiates the main explosive charge to function. In common usage, the word fuze is used indiscriminately, but when being specific (and in particular in a military context), fuze is used to mean a more complicated device, such as a device within military ordnance.

Gaine	Small explosive charge that is sometimes placed between the detonator and the main charge to ensure ignition.
Geophysical survey	A geophysical survey is essentially a range of methods that can be used to detect objects or identify ground conditions without the need for intrusive methods (such as excavation or drilling). This is particularly suited to ordnance as disturbance of ordnance items is to be avoided where ever possible.
Gold line	This is the estimated limit of blast damage from an explosive storage magazine. It usually means that development within this zone is restricted.
High Explosive	Secondary explosives (commonly known as High Explosives (HE)) make up the main charge or filling of an ordnance device. They are usually less sensitive than primary explosives. Examples of secondary explosives are: Nitro glycerine (NG), Trinitrotoluene (TNT), AMATOL (Ammonia nitrate + TNT), Gunpowder (GP), and Cyclotrimethylenetrinitramine (RDX).
Inter-Continental Ballistic Missile	An intercontinental ballistic missile, or ICBM, is a very long-range (greater than 5,500km or 3,500 miles) ballistic missile typically designed for nuclear weapons delivery, that is, delivering one or more nuclear warheads.
Luftflotte	German military air force squadron.
MagCone	MagCone is a method by which ordnance (or other similar metallic items) can be detected at significant depths. This is conducted by the use of a specialised probe. The probe contains a sensitive magnetometer that is pushed into the ground. The magnetometer is able to detect items such as buried ordnance and thus advise on clear routes for drilling, piles, deep excavation or alike.
MagDrill	Similar technique to MagCone, but utilises a drilling (rather than probing) technique to advance the magnetometer into the soil.

Primary Explosive	Primary explosives are usually extremely sensitive to friction, heat, and pressure. These are used to initiate less sensitive explosives. Examples of primary explosives are: Lead Azide, Lead Styphnate, and Mercury Fulminate. Primary explosive are commonly found in detonators.
Propellants	Propellants provide ordnance with the ability to travel in a controlled manner and deliver the ordnance to a predetermined target. Propellants burn rapidly producing gas, pressure and flame. Although usually in solid form they can be produced in liquid form. Examples of propellants are: Ballistite often found in a flake form and Cordite used in small arm ammunition.
Pyrotechnics	Pyrotechnic compositions are used to produce effects such as smoke, flares (illumination) and occasionally propulsion (as you would see in fireworks).
Unexploded Ordnance (UXO)	UXO is explosive ordnance that has been either primed, fuzed, armed or prepared for use and has been subsequently fired, dropped, launched, projected or placed in such a manner as to present a hazard to operations, persons or objects and remains unexploded either by malfunction or design.
V1 Rocket	The Vergeltungswaffe-1, V-1, also designated Fieseler Fi 103/FZG-76, known colloquially in English as the Flying Bomb, Buzz Bomb or Doodlebug, was the first guided missile used in WWII and the forerunner of today's cruise missile.
V2 Rocket	The Vergeltungswaffe 2 (V-2) ("Reprisal Weapon 2") was the first ballistic missile. It was used by the German Army primarily against Belgian and British targets during the later stages of WWII. The V-2 was the first man-made object launched into space, during test flights that reached an altitude of 189km (117 miles) in 1944.

Appendix 2 References

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