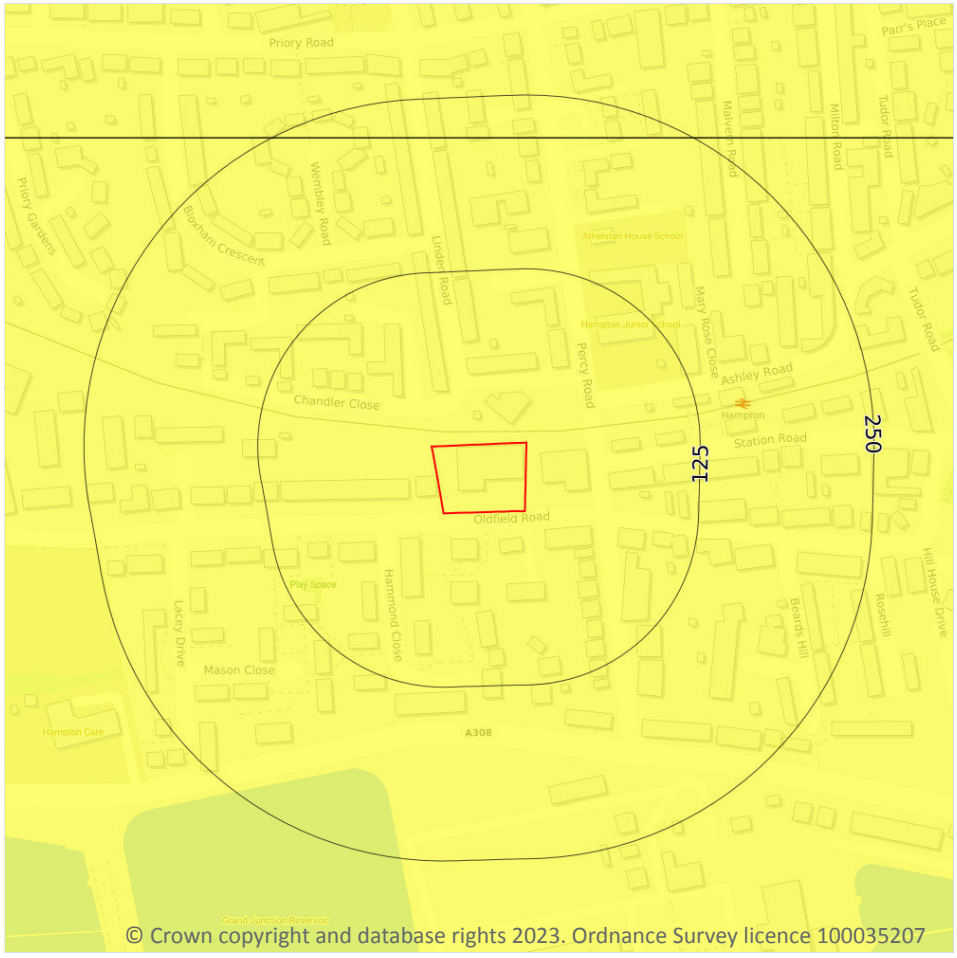
Natural ground subsidence - Collapsible deposits



Site Outline

Search buffers in metres (m)

- No data
- Negligible
- Very low
- Low
- Moderate
- High

17.4 Collapsible deposits

Records within 50m	1

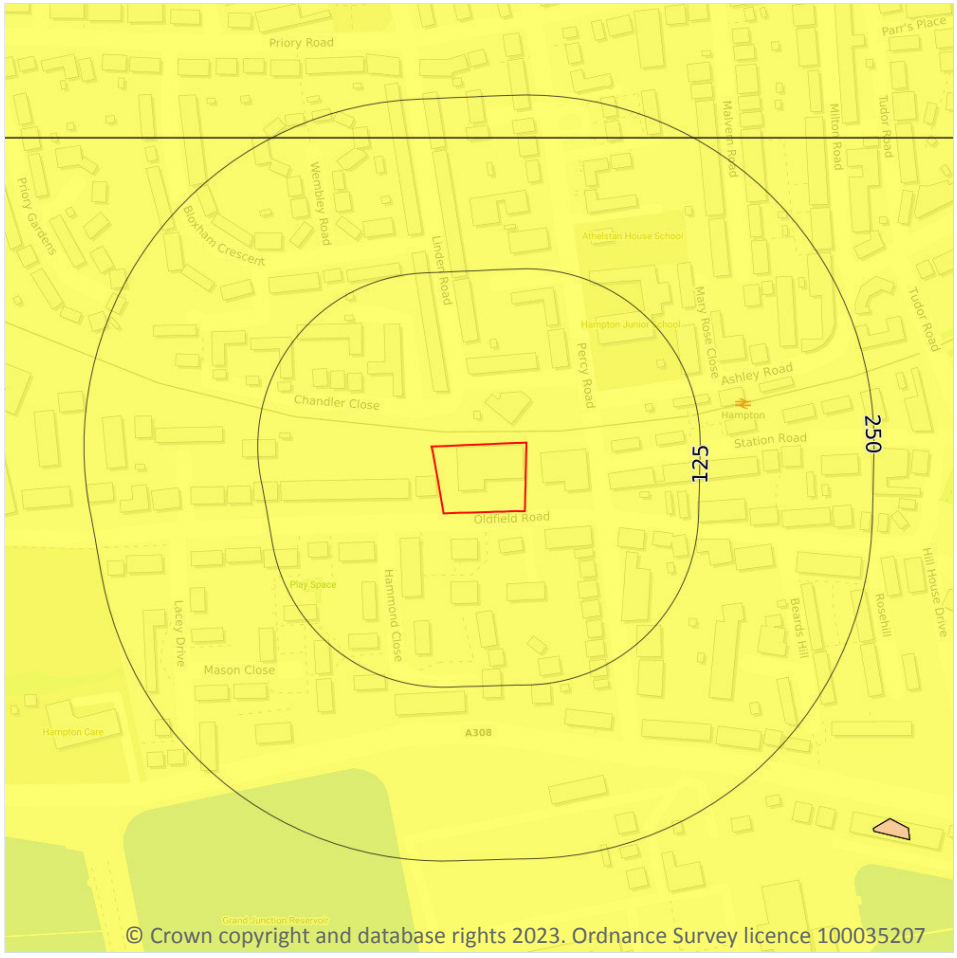
The potential hazard presented by natural deposits that could collapse when a load (such as a building) is placed on them or they become saturated with water.

Features are displayed on the Natural ground subsidence - Collapsible deposits map on **page 112 >**

Location	Hazard rating	Details
On site	**Very low**	**Deposits with potential to collapse when loaded and saturated are unlikely to be present.**

This data is sourced from the British Geological Survey.

Natural ground subsidence - Landslides



Site Outline

Search buffers in metres (m)

- No data
- Negligible
- Very low
- Low
- Moderate
- High

17.5 Landslides

Records within 50m	1

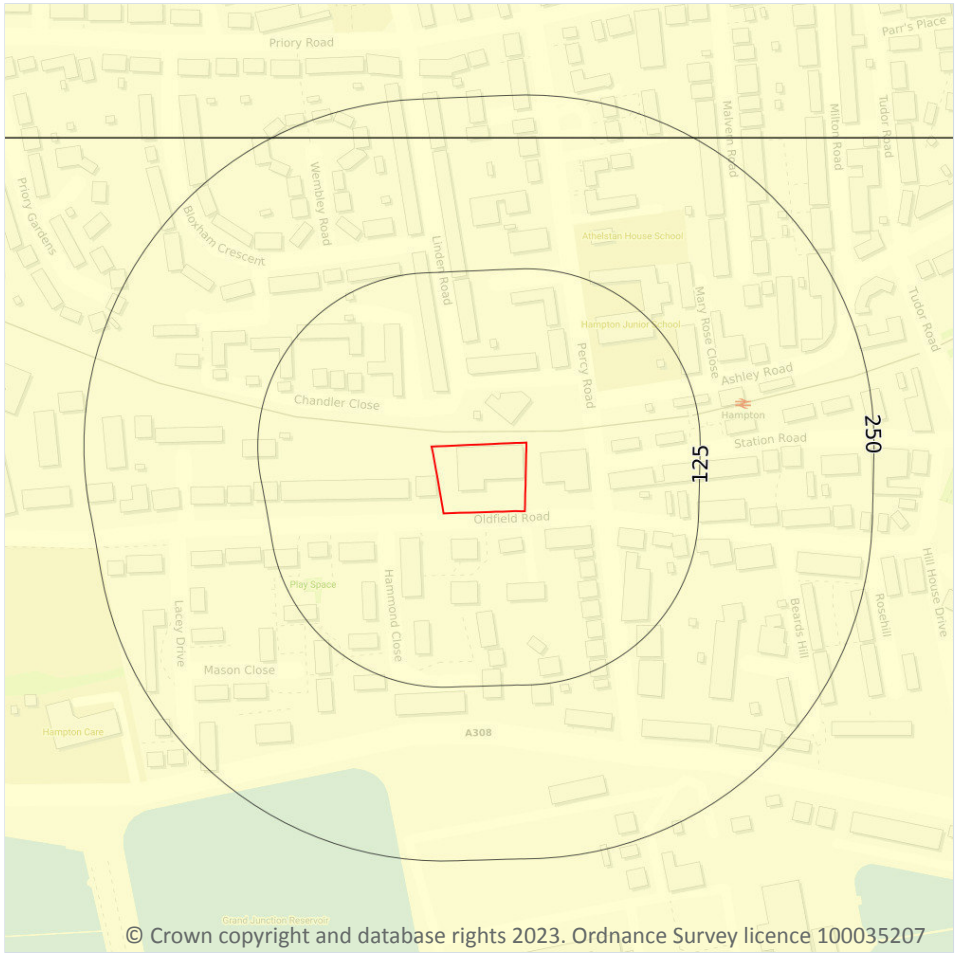
The potential for landsliding (slope instability) to be a hazard assessed using 1:50,000 scale digital maps of superficial and bedrock deposits, combined with information from the BGS National Landslide Database and scientific and engineering reports.

Features are displayed on the Natural ground subsidence - Landslides map on **page 113 >**

Location	Hazard rating	Details
On site	**Very low**	**Slope instability problems are not likely to occur but consideration to potential problems of adjacent areas impacting on the site should always be considered.**

This data is sourced from the British Geological Survey.

Natural ground subsidence - Ground dissolution of soluble rocks



Site Outline

Search buffers in metres (m)

- No data
- Negligible
- Very low
- Low
- Moderate
- High

17.6 Ground dissolution of soluble rocks

Records within 50m	1

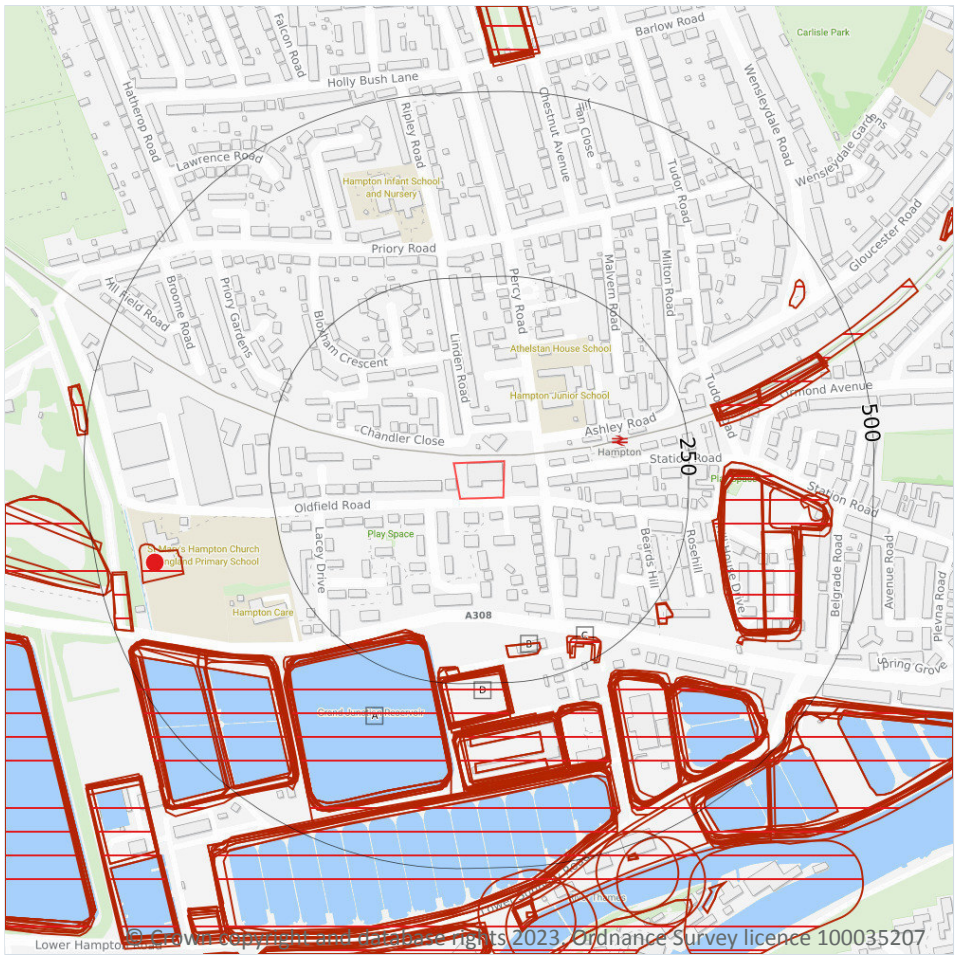
The potential hazard presented by ground dissolution, which occurs when water passing through soluble rocks produces underground cavities and cave systems. These cavities reduce support to the ground above and can cause localised collapse of the overlying rocks and deposits.

Features are displayed on the Natural ground subsidence - Ground dissolution of soluble rocks map on **page 114 >**

Location	Hazard rating	Details
On site	**Negligible**	**Soluble rocks are either not thought to be present within the ground, or not prone to dissolution. Dissolution features are unlikely to be present.**

This data is sourced from the British Geological Survey.

18 Mining and ground workings



Site Outline

Search buffers in metres (m)

- BritPits
- Surface ground workings
- Underground workings
- Underground mining extents
- Historical mineral planning areas
- TCA non-coal mining

Non Coal Mining

- Sporadic underground mining of restricted extent possible
- Localised small scale underground mining possible
- Small scale mining possible
- Underground mining known or likely within or in close proximity
- Underground mining known within or in very close proximity

18.1 BritPits

Records within 500m	1

BritPits (an abbreviation of British Pits) is a database maintained by the British Geological Survey of currently active and closed surface and underground mineral workings. Details of major mineral handling sites, such as wharfs and rail depots are also held in the database.

Features are displayed on the Mining and ground workings map on **page 116 >**

ID	Location	Details	Description
N	421m W	Name: Portlane Bridge Gravel Pit Address: Hampton, TEDDINGTON, Greater London Commodity: Sand & Gravel Status: Ceased	Type: A surface mineral working. It may be termed Quarry, Sand Pit, Clay Pit or Opencast Coal Site Status description: Site which, at date of entry, has ceased to extract minerals. May be considered as Closed by operator. May be considered to have Active, Dormant or Expired planning permissions by Mineral Planning Authority

This data is sourced from the British Geological Survey.

18.2 Surface ground workings

Records within 250m	**34**

Historical land uses identified from Ordnance Survey mapping that involved ground excavation at the surface. These features may or may not have been subsequently backfilled.

Features are displayed on the Mining and ground workings map on **page 116 >**

ID	Location	Land Use	Year of mapping	Mapping scale
A	191m SW	Reservoir	1899	1:10560
A	192m S	Reservoir	1990	1:10000
A	192m S	Pond	1962	1:10560
A	192m S	Reservoir	1973	1:10000
A	192m S	Pond	1965	1:10560
A	194m S	Reservoir	1897	1:10560
A	194m SW	Reservoir	1938	1:10560
A	194m SW	Reservoir	1913	1:10560
A	194m SW	Reservoir	1895	1:10560
A	196m SW	Reservoir	1938	1:10560
A	197m SW	Reservoir	1920	1:10560
A	199m S	Reservoir	1913	1:10560
A	200m SW	Reservoir	1938	1:10560
A	200m S	Reservoir	1938	1:10560
A	200m S	Reservoir	1895	1:10560
B	200m S	Unspecified Pit	1962	1:10560

ID	Location	Land Use	Year of mapping	Mapping scale
B	200m S	Unspecified Pit	1965	1:10560
A	204m S	Reservoir	1913	1:10560
C	207m SE	Unspecified Ground Workings	1913	1:10560
C	212m SE	Unspecified Ground Workings	1899	1:10560
D	227m S	Filter Beds	1938	1:10560
D	227m S	Filter Beds	1913	1:10560
D	227m S	Filter Beds	1938	1:10560
D	228m S	Filter Beds	1920	1:10560
D	228m S	Filter Beds	1920	1:10560
D	229m S	Filter Beds	1895	1:10560
D	229m S	Filter Beds	1913	1:10560
D	229m S	Pond	1897	1:10560
D	231m S	Filter Beds	1938	1:10560
D	231m S	Filter Beds	1938	1:10560
D	233m S	Ponds	1899	1:10560
D	234m S	Filter Beds	1938	1:10560
D	234m S	Filter Beds	1895	1:10560
D	238m S	Filter Beds	1913	1:10560

This is data is sourced from Ordnance Survey/Groundsure.

18.3 Underground workings

Records within 1000m	**0**

Historical land uses identified from Ordnance Survey mapping that indicate the presence of underground workings e.g. mine shafts.

This is data is sourced from Ordnance Survey/Groundsure.

18.4 Underground mining extents

Records within 500m	0

This data identifies underground mine workings that could present a potential risk, including adits and seam workings. These features have been identified from BGS Geological mapping and mine plans sourced from the BGS and various collections and sources.

This data is sourced from Groundsure.

18.5 Historical Mineral Planning Areas

Records within 500m	0

Boundaries of mineral planning permissions for England and Wales. This data was collated between the 1940s (and retrospectively to the 1930s) and the mid 1980s. The data includes permitted, withdrawn and refused permissions.

This data is sourced from the British Geological Survey.

18.6 Non-coal mining

Records within 1000m	0

The potential for historical non-coal mining to have affected an area. The assessment is drawn from expert knowledge and literature in addition to the digital geological map of Britain. Mineral commodities may be divided into seven general categories - vein minerals, chalk, oil shale, building stone, bedded ores, evaporites and 'other' commodities (including ball clay, jet, black marble, graphite and chert).

This data is sourced from the British Geological Survey.

18.7 JPB mining areas

Records on site	0

Areas which could be affected by former coal and other mining. This data includes some mine plans unavailable to the Coal Authority.

This data is sourced from Johnson Poole and Bloomer.

18.8 The Coal Authority non-coal mining

Records within 500m	0

This data provides an indication of the potential zone of influence of recorded underground non-coal mining workings. Any and all analysis and interpretation of Coal Authority Data in this report is made by Groundsure, and is in no way supported, endorsed or authorised by the Coal Authority. The use of the data is restricted to the terms and provisions contained in this report. Data reproduced in this report may be the copyright of the

Coal Authority and permission should be sought from Groundsure prior to any re-use.

This data is sourced from The Coal Authority.

18.9 Researched mining

Records within 500m	2

This data indicates areas of potential mining identified from alternative or archival sources, including; BGS Geological paper maps, Lidar data, aerial photographs (from World War II onwards), archaeological data services, websites, Tithe maps, and various text/plans from collected books and reports. Some of this data is approximate and Groundsure have interpreted the resultant risk area and, where possible, specific areas of risk have been captured.

Location	Mineral type
202m S	Stone
371m SW	Stone

This data is sourced from Groundsure.

18.10 Mining record office plans

Records within 500m	0

This dataset is representative of Mining Record Office and/or plan extents held by Groundsure and should be considered approximate. Where possible, plans have been located and any specific areas of risk they depict have been captured.

This data is sourced from Groundsure.

18.11 BGS mine plans

Records within 500m	0

This dataset is representative of BGS mine plans held by Groundsure and should be considered approximate. Where possible, plans have been located and any specific areas of risk they depict have been captured.

This data is sourced from Groundsure.

18.12 Coal mining

Records on site	0

Areas which could be affected by past, current or future coal mining.

This data is sourced from the Coal Authority.

18.13 Brine areas

Records on site	0

The Cheshire Brine Compensation District indicates areas that may be affected by salt and brine extraction in Cheshire and where compensation would be available where damage from this mining has occurred. Damage from salt and brine mining can still occur outside this district, but no compensation will be available.

This data is sourced from the Cheshire Brine Subsidence Compensation Board.

18.14 Gypsum areas

Records on site	0

Generalised areas that may be affected by gypsum extraction.

This data is sourced from British Gypsum.

18.15 Tin mining

Records on site	0

Generalised areas that may be affected by historical tin mining.

This data is sourced from Groundsure.

18.16 Clay mining

Records on site	0

Generalised areas that may be affected by kaolin and ball clay extraction.

This data is sourced from the Kaolin and Ball Clay Association (UK).

19 Ground cavities and sinkholes

19.1 Natural cavities

Records within 500m	0

Industry recognised national database of natural cavities. Sinkholes and caves are formed by the dissolution of soluble rock, such as chalk and limestone, gulls and fissures by cambering. Ground instability can result from movement of loose material contained within these cavities, often triggered by water.

This data is sourced from Stantec UK Ltd.

19.2 Mining cavities

Records within 1000m	0

Industry recognised national database of mining cavities. Degraded mines may result in hazardous subsidence (crown holes). Climatic conditions and water escape can also trigger subsidence over mine entrances and workings.

This data is sourced from Stantec UK Ltd.

19.3 Reported recent incidents

Records within 500m	0

This data identifies sinkhole information gathered from media reports and Groundsure's own records. This data goes back to 2014 and includes relative accuracy ratings for each event and links to the original data sources. The data is updated on a regular basis and should not be considered a comprehensive catalogue of all sinkhole events. The absence of data in this database does not mean a sinkhole definitely has not occurred during this time.

This data is sourced from Groundsure.

19.4 Historical incidents

Records within 500m	0

This dataset comprises an extract of 1:10,560, 1:10,000, 1:2,500 and 1:1,250 scale historical Ordnance Survey maps held by Groundsure, dating back to the 1840s. It shows shakeholes, deneholes and other 'holes' as noted on these maps. Dene holes are medieval chalk extraction pits, usually comprising a narrow shaft with a number of chambers at the base of the shaft. Shakeholes are an alternative name for suffusion sinkholes, most commonly found in the limestone landscapes of North Yorkshire but also extensively noted around the Brecon Beacons National Park.

Not all 'holes' noted on Ordnance Survey mapping will necessarily be present within this dataset.

This data is sourced from Groundsure.

19.5 National karst database

Records within 500m	0

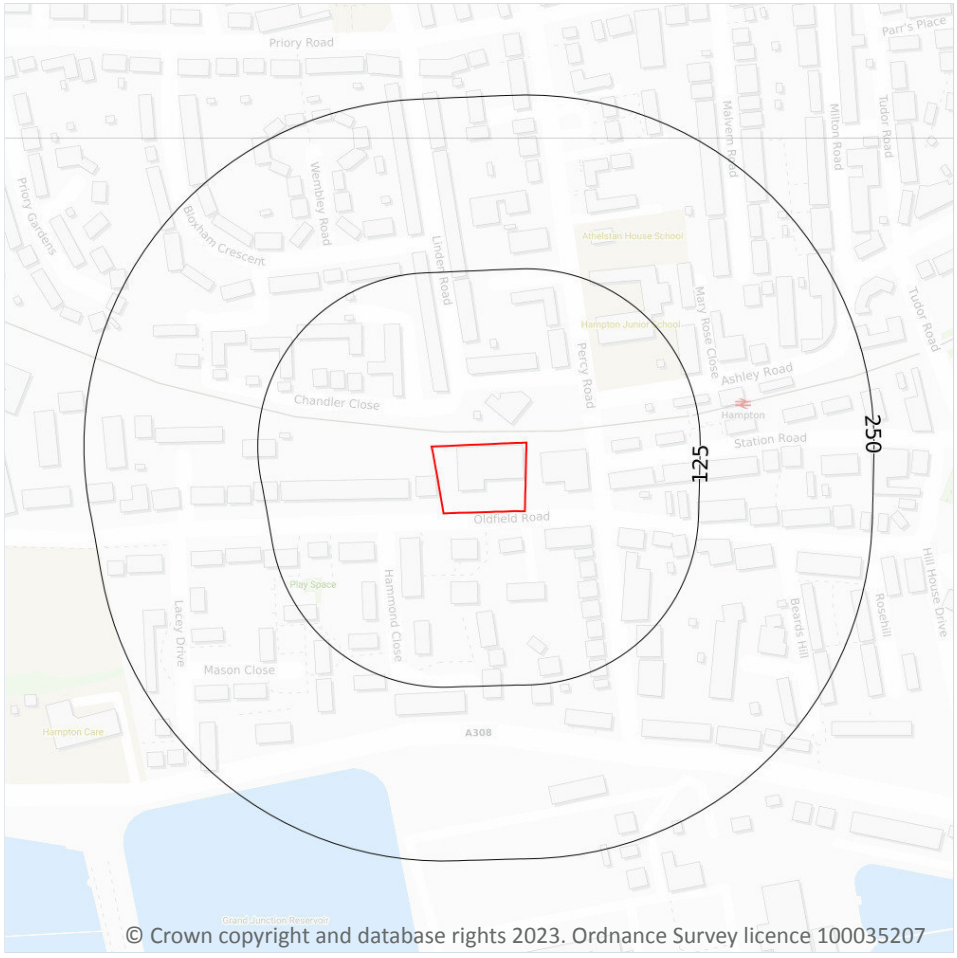
This is a comprehensive database of national karst information gathered from a wide range of sources. BGS have collected data on five main types of karst feature: Sinkholes, stream links, caves, springs, and incidences of associated damage to buildings, roads, bridges and other engineered works.

Since the database was set up in 2002 data covering most of the evaporite karst areas of the UK have now been added, along with data covering about 60% of the Chalk, and 35% of the Carboniferous Limestone outcrops. Many of the classic upland karst areas have yet to be included. Recorded so far are: Over 800 caves, 1300 stream sinks, 5600 springs, 10,000 sinkholes.

The database is not yet complete, and not all records have been verified. The absence of data does not mean that karst features are not present at a site. A reliability rating is included with each record.

This data is sourced from the British Geological Survey.

20 Radon



Site Outline

Search buffers in metres (m)

- Greater than 30%
- Between 10% and 30%
- Between 5% and 10%
- Between 3% and 5%
- Between 1% and 3%
- Less than 1%

20.1 Radon

Records on site	1

The Radon Potential data classifies areas based on their likelihood of a property having a radon level at or above the Action Level in Great Britain. The dataset is intended for use at 1:50,000 scale and was derived from both geological assessments and indoor radon measurements (more than 560,000 records). A minimum 50m buffer should be considered when searching the maps, as the smallest detectable feature at this scale is 50m. The findings of this section should supersede any estimations derived from the Indicative Atlas of Radon in Great Britain (1:100,000 scale).

Features are displayed on the Radon map on **page 124 >**

Location	Estimated properties affected	Radon Protection Measures required
On site	**Less than 1%**	**None**

This data is sourced from the British Geological Survey and UK Health Security Agency.

21 Soil chemistry

21.1 BGS Estimated Background Soil Chemistry

Records within 50m	1

The estimated values provide the likely background concentration of the potentially harmful elements Arsenic, Cadmium, Chromium, Lead and Nickel in topsoil. The values are estimated primarily from rural topsoil data collected at a sample density of approximately 1 per 2 km^2. In areas where rural soil samples are not available, estimation is based on stream sediment data collected from small streams at a sampling density of 1 per 2.5 km^2; this is the case for most of Scotland, Wales and southern England. The stream sediment data are converted to soil-equivalent concentrations prior to the estimation.

Location	Arsenic	Bioaccessible Arsenic	Lead	Bioaccessible Lead	Cadmium	Chromium	Nickel
On site	**No data**	**No data**	**100 mg/kg**	**60 mg/kg**	**1.8 mg/kg**	**No data**	**No data**

This data is sourced from the British Geological Survey.

21.2 BGS Estimated Urban Soil Chemistry

Records within 50m	9

Estimated topsoil chemistry of Arsenic, Cadmium, Chromium, Copper, Nickel, Lead, Tin and Zinc and bioaccessible Arsenic and Lead in 23 urban centres across Great Britain. These estimates are derived from interpolation of the measured urban topsoil data referred to above and provide information across each city between the measured sample locations (4 per km^2).

Location	Arsenic (mg/kg)	Bioaccessible Arsenic (mg/kg)	Lead (mg/kg)	Bioaccessible Lead (mg/kg)	Cadmium (mg/kg)	Chromium (mg/kg)	Copper (mg/kg)	Nickel (mg/kg)	Tin (mg/kg)
On site	**12**	**2.1**	**110**	**76**	**0.5**	**66**	**30**	**18**	**8**
On site	**9**	**1.6**	**98**	**67**	**0.5**	**66**	**25**	**14**	**6**
19m NE	9	1.6	98	67	0.5	66	23	13	6
22m NW	12	2.1	128	88	0.5	64	29	17	8
30m SW	12	2.1	94	65	0.6	67	30	18	7
31m SW	15	2.6	101	69	0.6	66	34	22	9
34m E	8	1.4	88	60	0.5	66	22	12	6
39m NE	7	1.2	86	59	0.5	66	20	11	5

Location	Arsenic (mg/kg)	Bioaccessible Arsenic (mg/kg)	Lead (mg/kg)	Bioaccessible Lead (mg/kg)	Cadmium (mg/kg)	Chromium (mg/kg)	Copper (mg/kg)	Nickel (mg/kg)	Tin (mg/kg)
47m SE	10	1.8	96	66	0.5	66	27	16	6

This data is sourced from the British Geological Survey.

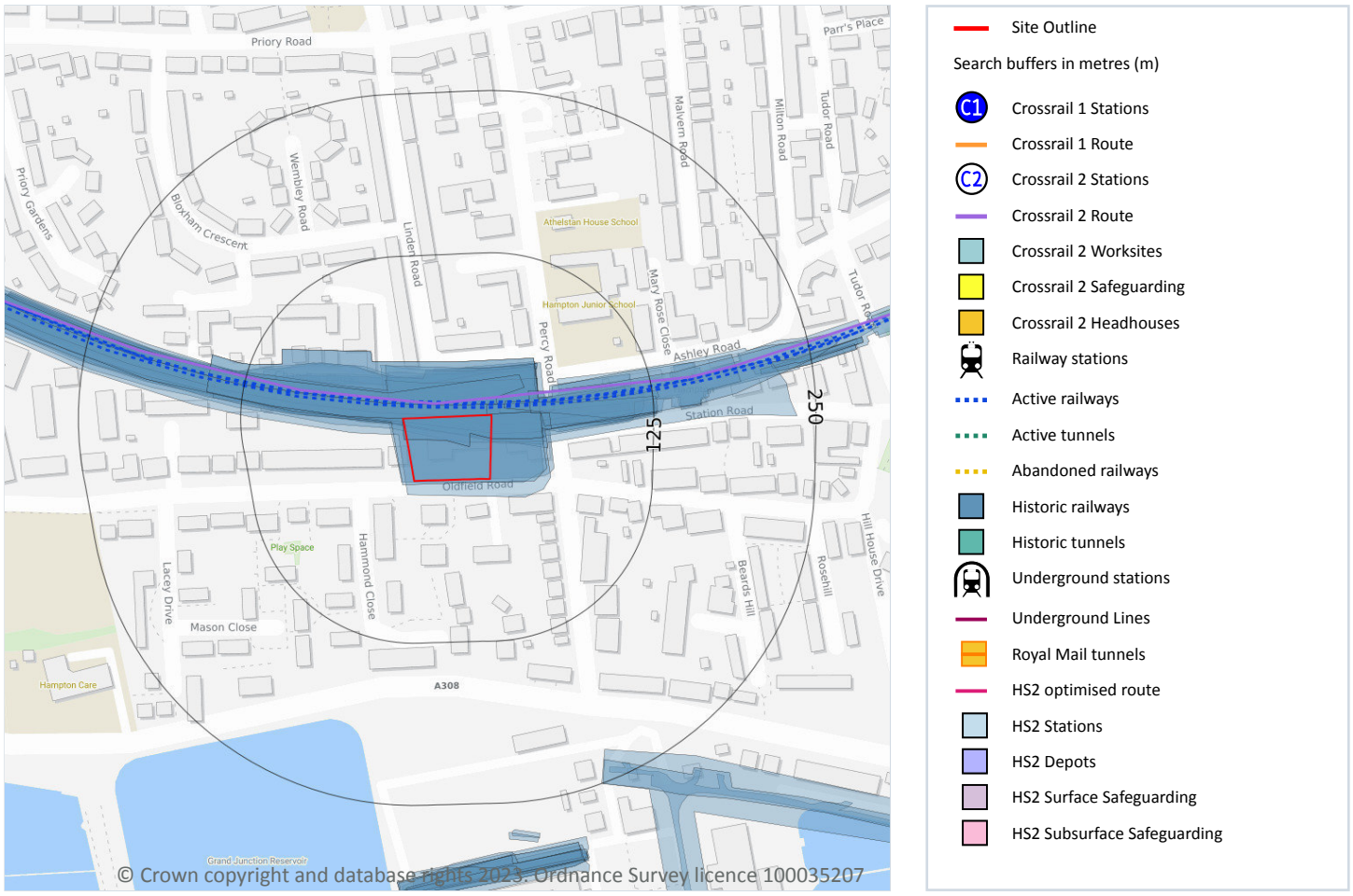
21.3 BGS Measured Urban Soil Chemistry

Records within 50m	**0**

The locations and measured total concentrations (mg/kg) of Arsenic, Cadmium, Chromium, Copper, Nickel, Lead, Tin and Zinc in urban topsoil samples from 23 urban centres across Great Britain. These are collected at a sample density of 4 per km^2.

This data is sourced from the British Geological Survey.

22 Railway infrastructure and projects



22.1 Underground railways (London)

Records within 250m	0

Details of all active London Underground lines, including approximate tunnel roof depth and operational hours.

This data is sourced from publicly available information by Groundsure.

22.2 Underground railways (Non-London)

Records within 250m	0

Details of the Merseyrail system, the Tyne and Wear Metro and the Glasgow Subway. Not all parts of all systems are located underground. The data contains location information only and does not include a depth assessment.

This data is sourced from publicly available information by Groundsure.

22.3 Railway tunnels

Records within 250m	0

Railway tunnels taken from contemporary Ordnance Survey mapping.

This data is sourced from the Ordnance Survey.

22.4 Historical railway and tunnel features

Records within 250m	26

Railways and tunnels digitised from historical Ordnance Survey mapping as scales of 1:1,250, 1:2,500, 1:10,000 and 1:10,560.

Features are displayed on the Railway infrastructure and projects map on **page 128 >**

Location	Land Use	Year of mapping	Mapping scale
On site	**Railway Sidings**	**1956**	**2500**
On site	**Railway Sidings**	**1956**	**1250**
On site	**Railway Sidings**	**1897**	**2500**
On site	**Railway Sidings**	**1915**	**2500**
On site	**Railway Sidings**	**1934**	**2500**
On site	**Railway**	**1934**	**-**
On site	**Railway**	**1897**	**-**
On site	**Railway Sidings**	**1938**	**10560**
On site	**Railway Sidings**	**1913**	**10560**
On site	**Railway Sidings**	**1920**	**10560**
On site	**Railway Sidings**	**1965**	**10560**
On site	**Railway Sidings**	**1962**	**10560**
1m NE	Railway Sidings	1895	10560
7m NW	Railway Sidings	1971	1250
8m NE	Railway Sidings	1913	10560
11m NE	Railway Sidings	1897	10560
30m NE	Railway Sidings	1865	10560

Location	Land Use	Year of mapping	Mapping scale
99m W	Railway Sidings	1956	2500
101m W	Railway Sidings	1956	1250
204m E	Railway Sidings	1897	2500
210m E	Railway Sidings	1897	2500
210m E	Railway Sidings	1915	2500
219m E	Railway Sidings	1956	2500
226m SE	Tramway Sidings	1938	10560
233m SE	Railway Sidings	1938	10560
240m SE	Tramway Sidings	1934	2500

This data is sourced from Ordnance Survey/Groundsure.

22.5 Royal Mail tunnels

Records within 250m	0

The Post Office Railway, otherwise known as the Mail Rail, is an underground railway running through Central London from Paddington Head District Sorting Office to Whitechapel Eastern Head Sorting Office. The line is 10.5km long. The data includes details of the full extent of the tunnels, the depth of the tunnel, and the depth to track level.

This data is sourced from Groundsure/the Postal Museum.

22.6 Historical railways

Records within 250m	0

Former railway lines, including dismantled lines, abandoned lines, disused lines, historic railways and razed lines.

This data is sourced from OpenStreetMap.

22.7 Railways

Records within 250m	7

Currently existing railway lines, including standard railways, narrow gauge, funicular, trams and light railways.

Features are displayed on the Railway infrastructure and projects map on **page 128 >**

Location	Name	Type
6m NE	Shepperton Line	rail
8m NE	Not given	Multi Track
10m NE	Shepperton Line	rail
121m E	Not given	Multi Track
154m E	Shepperton Line	rail
202m W	Not given	Multi Track
239m E	Not given	Multi Track

This data is sourced from Ordnance Survey and OpenStreetMap.

22.8 Crossrail 1

Records within 500m	**0**

The Crossrail railway project links 41 stations over 100 kilometres from Reading and Heathrow in the west, through underground sections in central London, to Shenfield and Abbey Wood in the east.

This data is sourced from publicly available information by Groundsure.

22.9 Crossrail 2

Records within 500m	**2**

Crossrail 2 is a proposed railway linking the national rail networks in Surrey and Hertfordshire via an underground tunnel through London.

Features are displayed on the Railway infrastructure and projects map on **page 128 >**

Location	Route Type	Name	Under consultation
10m N	Network Rail Regional Branch	Shepperton Line	No
156m E	Network Rail Regional Branch	Shepperton Line	No

This data is sourced from publicly available information by Groundsure.

22.10 HS2

Records within 500m	0

HS2 is a proposed high speed rail network running from London to Manchester and Leeds via Birmingham. Main civils construction on Phase 1 (London to Birmingham) of the project began in 2019, and it is currently anticipated that this phase will be fully operational by 2026. Construction on Phase 2a (Birmingham to Crewe) is anticipated to commence in 2021, with the service fully operational by 2027. Construction on Phase 2b (Crewe to Manchester and Birmingham to Leeds) is scheduled to begin in 2023 and be operational by 2033.

This data is sourced from HS2 ltd.

Data providers

Groundsure works with respected data providers to bring you the most relevant and accurate information. To find out who they are and their areas of expertise see https://www.groundsure.com/sources-reference ↗.

Terms and conditions

Groundsure's Terms and Conditions can be accessed at this link: https://www.groundsure.com/terms-and-conditions-april-2023/ ↗.

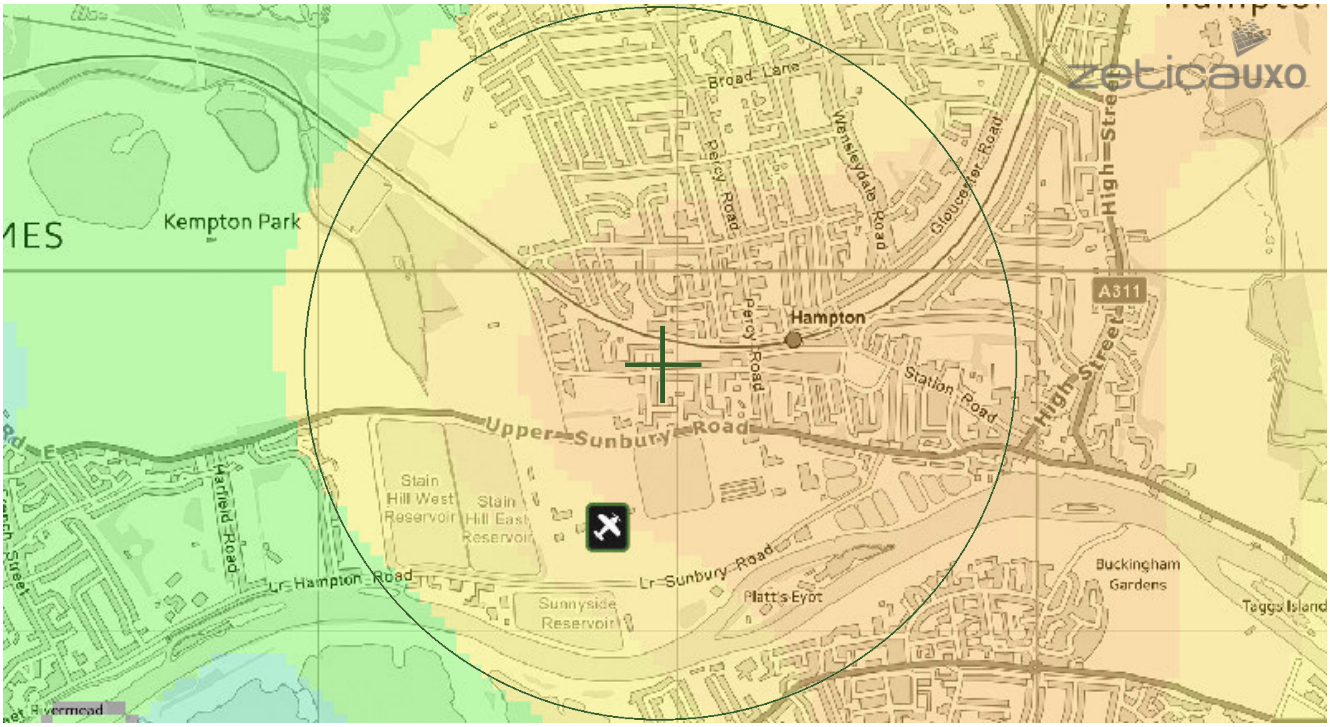
APPENDIX D

UXO Screening Map and Detailed UXO Desk Study

UNEXPLODED BOMB RISK MAP

SITE LOCATION

Location: TW12 2HR,
Map Centre: 512964,169744



LEGEND

London Bomb Risk

miltary	industry	UXO find	Other
transport	dock	Luftwaffe targets	
utilities	abandoned bombs	Bombing decoy	

How to use your Unexploded Bomb (UXB) risk map?

The map indicates the potential for Unexploded Bombs (UXB) to be present as a result of World War Two (WWII) bombing.

You can incorporate the map into your preliminary risk assessment* for potential Unexploded Ordnance (UXO) for a site. Using this map, you can make an informed decision as to whether more in-depth detailed risk assessment* is necessary.

Relative UXB risk across London

The relative risk for the London area is established by plotting the recorded bombing densities.

These are represented as counts of high explosive bombs in km2 area. The areas coloured green represent a record of less than 10 bombs per km2.

Compared to other areas of the UK, this still represents a significant density. However, this is much lower than parts of Central London, where the red colouration indicates in excess of 150 bombs falling per km2, representing a very significant bombing density.

What do I do if my site is in a moderate or high density area?

Generally, we recommend that a detailed UXO desk study and risk assessment is undertaken for sites with a moderate or high bombing density.

Similarly, if your site is near to a designated Luftwaffe target or bombing decoy then additional detailed research is recommended.

More often than not, this further detailed research will conclude that the potential for a significant UXO hazard to be present on your site is actually low.

Never plan site work or undertake a risk assessment using these maps alone. More detail is required, particularly where there may be a source of UXO from other military operations which are not reflected on these maps.

If my site is in a low risk area, do I need to do anything?

If both the map and other research confirms that there is a low potential for UXO to be present on your site then, subject to your own comfort and risk tolerance, works can proceed with no special precautions.

A low risk really means that there is no greater probability of encountering UXO than anywhere else in the UK.

If you are unsure whether other sources of UXO may be present, you can ask for one of our **pre-desk study assessments (PDSA)**

If I have any questions, who do I contact?

tel: **+44 (0) 1993 886682**
email: **uxo@zetica.com**
web: **www.zeticauxo.com**

The information in this UXB risk map is derived from a number of sources and should be used in conjunction with the accompanying notes on our website: **(https://zeticauxo.com/downloads-and-resources/risk-maps/)**

It is important to note that this map is not a UXO risk assessment and should not be reported as such when reproduced.

*Preliminary and detailed UXO risk assessments are advocated as good practice by industry guidance such as CIRIA C681 'Unexploded Ordnance (UXO), a guide for the construction industry'.

Detailed
Unexploded Ordnance (UXO)
Risk Assessment

Project Name	Oldfield Road, Hampton
Client	Brownfield Solutions Limited
Site Address	Oldfield Road, Hampton, Middlesex TW12 2HR
Report Reference	DA18413-00
Date	11/08/23
Author	MTA
Quality Assurance	ERG
Final Check	AB

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Web www.1stlinedefence.co.uk Company Reg No. 07717863

1ST LINE DEFENCE

Executive Summary

Site Location and Description

The site is located in Oldfield Road in Hampton, within the London Borough of Richmond upon Thames.

Recent aerial photography indicates that the site comprises a large commercial structure, hardstanding access ways, car parking areas and small areas of vegetation.

A railway line borders the north boundary of the site. The east boundary of the site is adjacent to an access road and a Waitrose store. Oldfield Road is situated adjacent to the south boundary, and a structure, hardstanding ground and vegetation border to the west.

The site is approximately centred on the OS grid reference: **TQ 13140 69765.**

Proposed Works

The proposed works are understood to include the development of both stairs and an elevator to the structure located on site. Furthermore, there is the possible development of additional loading and unloading space, in the hardground area situated in the south boundary of the site. This will include the use of 20/25m Caple Percussive boreholes and a 5m Window Sampler.

Geology and Bomb Penetration Depth

The British Geological Survey (BGS) map shows the site to be underlined by the London Clay Formation – clay and silt. The sedimentary bedrock was formed during the Palaeogene Period. Superficial deposits include the Taplow Gravel Formation – sand and gravel, which formed during the Quaternary period.

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

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

UXO Risk Assessment

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

The Risk from German Air-Delivered UXO

- During WWII, the site was situated within the Municipal Borough of Twickenham, which was subject to an overall moderate-high density of bombing according to official Home Office bombing statistics, with an average of 82.8 bombs recorded per 1,000 acres.
- During WWII, the site composed predominantly open ground and vegetation; with structures present for storing coal, and a section of railway siding running through the site in the north. The site was bordered by Oldfield Road and the Upper Sunbury branch for the industrial railway between the Metropolitan Water Board's pumping stations and coal wharf.[1]
- Despite the moderate-high density recorded in the area, a local bomb map, local written records and London Bomb Census mapping does not record any HE bomb strikes on site, or within the immediate vicinity. The closest recorded strike is plotted approximately 60m south-west of the site within the vicinity of Oldfield Road Grammar School. This is recorded as a UXB, falling on 15th October 1941 in the 'Damage to Properties' record set. This incident is however, too far removed to have had any direct impact on the site boundary.
- As the site predominantly comprised undeveloped land, limited structures were present on site to incur observable damage. However, the MCC War Damage Map does not record any damage to the structures that were present on site, or those within the immediate vicinity. Post-war aerial photography also does not indicate any obvious signs of bomb

[1] https://webblocos.co.uk/history/the-railway

damage, such as severely disturbed ground, cratering or extensive structural changes. While the structures on site do not appear to have any roofs, they match up with historical OS mapping and are thought to comprise the function of coal bunkers/storage for the *Coal Yard* on site. **Annex O2** highlights some potential cases of disturbed ground in the vicinity, however, this does not directly affect the site boundary.

- During WWII the terrain on site was predominantly undeveloped. While areas of undeveloped land have the potential to obscure possible evidence of UXB entry holes (in shifting earth and vegetation), sections of the site that were developed would have been more conducive to this. Furthermore, it is anticipated that the site would have experienced somewhat frequent levels of access during the war, due to the fact the site operated as a coal yard and had a section of railway siding running thought the north. Additionally, the site was located adjacent to a railway line and a *Goods Shed*. Items of UXO are more likely to be spotted, recorded and dealt with, within frequently accessed areas.
- In summary, no positive evidence has been found of any HE bombing on/adjacent to the site boundary within the available record set and no obvious indicators of bomb damage was found while analysing post-WWII aerial photography and OS mapping. While HE bombing and damage was recorded in the wider area, these cases were of a sufficient distance away from the site to not warrant an increased risk to the site itself. While the predominantly undeveloped nature of the site has the potential to obscure evidence of UXB entry holes, access to the site is thought to have remained frequent throughout the war due to the sites usage as a *Coal Yard*. Items of UXO are more likely to be spotted, recorded and dealt with within frequently accessed areas.
- No evidence has therefore been found to suggest that the risk on site would be above the 'background risk' for this area. As a result, it is not deemed necessary to warrant proactive risk mitigation measures, and the site has therefore been assessed to be of **Low Risk** from German aerial delivered UXO contamination.

The Risk from Allied UXO

- No evidence could be found to indicate that the site formerly had any military occupation or usage that could have led to contamination with items of Allied ordnance, such as LSA and SAA.
- The conditions in which HAA or LAA projectiles may have fallen unnoticed within the site boundary are however analogous to those regarding air delivered ordnance.

Post-WWII Redevelopment

- Recent aerial imagery indicates that the site has experienced noticeable post-war development. The majority of the site boundary is now occupied by a large commercial structure and associated hardstanding ground.
- The risk of UXO remaining is considered to be mitigated at the location of and down to the depth of any post-war redevelopment on site. For example, the risk from deep buried UXO will only have been mitigated within the volumes of any post-war pile foundations or deep excavations for basement levels. The risk will however remain within virgin geology below and amongst these post-war works, down to the maximum bomb penetration depth.

Recommended Risk Mitigation Measures

The following risk mitigation measures are recommended to support the proposed works at the Oldfield Road, Hampton site:

Activity	Recommended Risk Mitigation Measure
All Works	• UXO Risk Management Plan • **Site Specific UXO Awareness Briefings to all personnel conducting intrusive works.**

Note – proactive on-site UXO support/survey should not be necessary for any works taking place at the location of and down to the depths of significantly worked post-war made ground/post-war fill.

Glossary

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

Contents

Annexes

List of Report Annexes	
Annex A	Site Location Maps
Annex B	Recent Aerial Photography
Annex C	Client Provided Site Plan
Annex D	Pre and Post-WWII Historical Maps
Annex E	Example of UXO Entry Hole / The 'J-curve' Effect Principle
Annex F	Examples of UXO Incidents
Annex G	WWI Map of Air Raids and Naval Bombardments
Annex H	London WWII Bomb Density Map
Annex I	Luftwaffe Target / Reconnaissance Photography
Annex J	London Bomb Census Mapping
Annex K	London V-1 Flying Bomb Map
Annex L	Twickenham Bomb Map
Annex M	Twickenham: Damage to Properties
Annex N	Middlesex County Council War Damage Map
Annex O	WWII-era RAF Aerial Photography of the Site

Appendices

List of Report Appendices	
Appendix i-iii	Examples of German Air-Delivered Ordnance
Appendix iv	Examples of Anti-Aircraft Projectiles

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

Site: Oldfield Road, Hampton
Client: Brownfield Solutions Limited

1. Introduction

1.1. Background

1st Line Defence has been commissioned by Brownfield Solutions Limited to conduct a Detailed Unexploded Ordnance (UXO) Risk Assessment for the works proposed at Oldfield Road, Hampton.

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

UXO in the UK can originate from three principal sources:

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

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

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

2. Method Statement

2.1. Report Objectives

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

2.2. Risk Assessment Process

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

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

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

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

2.3. Sources of Information

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

- The National Archives, the Richmond Archives and Twickenham Archives.
- Historical mapping datasets.
- Historic England National Monuments Record.
- Relevant information supplied by Brownfield Solutions Limited.
- Available material from 33 Engineer Regiment (EOD) Archive (part of 29 Explosive Ordnance and Disposal and Search Group).
- 1st Line Defence's extensive historical archives, library and UXO geo-datasets.
- Open sources such as published books and internet resources.

3. Background to Bombing Records

3.1. General Considerations of Historical Research

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

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

3.2. German Bombing Records

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

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

3.3. Allied Records

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

4. UK Regulatory Environment and Guidelines

4.1. General

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

4.2. CDM Regulations 2015

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

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

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

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

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

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

4.4. CIRIA C681

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

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

4.5. Additional Legislation

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

5. The Role of Commercial UXO Contractors and The Authorities

5.1. Commercial UXO Specialists

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

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

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

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

5.2. The Authorities

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

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

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

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

6. The Site

6.1. Site Location

The site is located in Oldfield Road in Hampton, within the London Borough of Richmond upon Thames.

A railway line borders the north boundary of the site. The east boundary of the site is adjacent to an access road and a Waitrose store. Oldfield Road is situated adjacent to the south boundary, and a structure, hardstanding ground and vegetation border to the west.

The site is approximately centred on the OS grid reference: **TQ 13140 69765**.

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

6.2. Site Description

Recent aerial photography indicates that the site comprises a large commercial structure, hardstanding access ways, car parking areas and small areas of vegetation.

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

7. Scope of the Proposed Works

7.1. General

Information provided by the client indicates that the proposed works include the development of both stairs and an elevator to the structure located on site. Furthermore, there is the possible development of additional loading and unloading space, in the hardground area situated in the south boundary of the site. This will include the use of 20/25m Caple Percussive boreholes and a 5m Window Sampler.

8. Ground Conditions

8.1. General Geology

The British Geological Survey (BGS) map shows the site to be underlined by the London Clay Formation – clay and silt. The sedimentary bedrock was formed during the Palaeogene Period. Superficial deposits include the Taplow Gravel Formation – sand and gravel, which formed during the Quaternary period.

8.2. Site-Specific Geology

Site-specific geotechnical data was not provided by the client during the production of this report.

9. Site History

9.1. Introduction

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

9.2. Site History

The site operated as a coal yard for an extended railway line which was part of the Upper Sunbury branch for the industrial railway between the Hampton Metropolitan Water Board's pumping stations and the Hampton coal wharf.[2]

9.3. Ordnance Survey Historical Maps

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

Pre-WWII		
Date	Scale	Description
1934	1: 2,500	This pre-WWII OS map, dated 1934, indicates that the site predominantly comprised open land. Three joined structures are labelled in the north of the site and a railway siding runs through the most northerly section, from north to east. A railway line borders the north boundary of the site. The east boundary of the site is situated adjacent to a structure, a *Goods Shed* and a further section of the railway siding. *Oldfield Road* is situated adjacent to the south and the west boundary is bordered by a structure and open terrain.

Post-WWII		
Date	Scale	Description
1957-62	1: 2,500	This post-WWII OS map, dated 1957-63, indicates that the site has experienced some change, namely the development of further structures towards the centre and west of the site. Additionally, the site is now labelled as a *Coal Yard.* In the vicinity, the structure to the west is now labelled as a *Hall* and some development has occurred further to the west and to the south, across *Oldfield Road* with the construction of some residential properties and *Oldfield House Remedial School.*

[2] https://webblocos.co.uk/history/the-railway

10. Introduction to German Air Delivered Ordnance

10.1. General

During WWI and WWII, the UK was subjected to bombing which often resulted in extensive damage to city centres, docks, rail infrastructure and industrial areas. The poor accuracy of WWII targeting technology and the nature of bombing techniques often resulted in neighbouring areas to targets sustaining collateral damage.

In addition to raids which concentrated on specific targets, indiscriminate bombing of large areas also took place. This occurred most prominently in the London 'Blitz', though affected many other towns and cities. As discussed in the following sections, a proportion of the bombs dropped on the UK did not detonate as designed. Although extensive efforts were made to locate and deal with these UXBs at the time, many still remain buried and can present a potential risk to construction projects.

The main focus of research for this section of the report will concern German air delivered ordnance dropped during WWII, although WWI bombing will also be considered.

10.2. Generic Types of WWII German Air Delivered Ordnance

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

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

10.3. Failure Rate of German Air Delivered Ordnance

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

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

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

10.4. UXB Ground Penetration

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

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

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

10.4.1. The J-Curve Principal

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

10.4.2. WWII UXB Ground Penetration Studies

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

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

10.4.3. Site Specific Bomb Penetration Considerations

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

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

It has not been possible to determine maximum bomb penetration capabilities at this stage due to the limitations of site-specific geotechnical information provided for the purpose of this report. An assessment can be made once further information becomes available or by an UXO Specialist on-site.

10.5. V-Weapons

Hitler's 'V-weapon' campaign began from mid-1944. It used newly developed unmanned cruise missiles and rockets. The V-1, known as the flying bomb or pilotless aircraft, and the V-2, a long range rocket, were launched from bases in Germany and occupied Europe. A total of 2,419 V-1s and 517 V-2s were recorded in the London Civil Defence region alone. A total of 9,251 V-1s and 1,115 V-2s were recorded in the United Kingdom.

Although these weapons caused considerable damage, their relatively low numbers allowed accurate records of strikes to be maintained. These records have mostly survived. There is a negligible risk from unexploded V-weapons on land today. Even if the 1,000kg warhead failed to explode, the weapons are so large that they would have been observed and dealt with at the time. Therefore, any V-weapons referenced in this report are referenced not as a viable risk factor, but primarily in order to help account for evidence of damage and clearance reported.

11. The Likelihood of Contamination from German Air Delivered UXBs

11.1. World War I

During WWI Britain was targeted and bombed by Zeppelin Airships as well as Gotha and Giant fixed-wing aircraft. The objective of these raids was to unnerve the British public, to destroy strategic targets and to ultimately attempt to coerce Britain's capitulation from the war. A WWI map of air raids and naval bombardments across the UK was consulted, see **Annex G**. This source does not record any WWI bomb incidents on, or in the immediate vicinity of the site.

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

11.2. World War II Bombing of the Municipal Borough Twickenham

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

During WWII the site was located within the Borough of Twickenham, which sustained an overall moderate-high density of bombing, as represented by bomb density data figures and maps, see **Annex H.** Although Twickenham itself did not contain a significant amount of targets for the Luftwaffe in comparison to the industrial east end of London, the area did experience regular bombing throughout the Blitz. The main Luftwaffe target in association to the site's location comprised the Mosley Water Works, located approximately 1.4km south-west of the site. See Luftwaffe target reconnaissance photography in **Annex I.**

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

Records of bombing incidents are presented in the following sections.

11.3. WWII Home Office Bombing Statistics

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

Record of German Ordnance Dropped on the Municipal Borough of Twickenham		
Area Acreage		7,013
Weapons	High Explosive bombs (all types)	505
	Parachute mines	2
	Oil bombs	25
	Phosphorus bombs	21
	Fire pots	0
	Pilotless aircraft (V-1)	27
	Long range rocket bombs (V-2)	1
Total		581
Number of Items per 1,000 acres		82.8
Source: Home Office Statistics This table does not include UXO found during or after WWII.		

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

11.4. London Civil Defence Region Bomb Census Maps

During WWII, the ARP Department within the Research and Experiments Branch of the Ministry of Home Security produced both consolidated and weekly bomb census maps for the London Civil Defence Region, as well as census mapping of V-1 pilotless aircraft. These maps collectively show the approximate locations of bombs, mines and rockets dropped in the region. The site area was checked on each available map sheet. Those showing bomb incidents on and in the immediate vicinity of the site are discussed below and are presented in **Annex J**.

Consolidated London Bomb Census Maps – **Annex J1**	
Date Range	Comments
Night Bombing up to 7th October 1940	No incidents are recorded on site or within the immediate vicinity. The closest strike is located approximately 180m north-west of the site.
Night Bombing 7th October 1940 to 6th June 1941	No incidents are recorded on site or within the immediate vicinity. The closest strike is located approximately 60m south-west of the site.

Weekly London Bomb Census Maps – **Annex J2**	
Date Range	Comments
4th - 11th November 1940	No incidents are recorded on site or within the immediate vicinity. The closest strikes are recorded as a high explosive bomb and an unexploded bomb, which landed on the 7th November, approximately 0.5km north-west of the site.
21st – 27th February 1944	No incidents are recorded on site or within the immediate vicinity. The closest strikes are recorded to be incendiary bombs, which fell on the 23rd February. The 'mean point' of these strikes is recorded approximately 260m north-west of the site.

V-1 Pilotless Flying Bomb Census Map – **Annex K**	
Date Range	Comments
1944-145	The closest recorded V-1 strike was located in the vicinity of *Upper Sunbury Road,* within the *Water Works*. The date of this strike was 19th May 1944. The strike was approximately 350m south-west from the site.

11.5. Twickenham Bomb Map

A local bomb map compiled by local Air Raid Precaution (ARP) personnel and volunteers during the war, showing HE bomb and incendiary bomb strikes on the Twickenham borough, was obtained from Richmond Archives. The section showing the area of the site is described in the table below and presented in **Annex L**.

Twickenham Bomb Map – **Annex L**	
Date Range	Comments
1940-1944	No bomb strikes are recorded on site or within the immediate vicinity. The closest recorded bomb strikes included five high explosive bomb strikes and one unexploded bomb strike approximately 300m to the north.

11.6. Twickenham: Damage to Properties

Written records were obtained from the Richmond Archives. These outlined damage to properties in the area and included information such as location and type of bomb. A transcript of the relevant written records is presented in the table below. Example imagery of these entries are presented in **Annex M**.

Twickenham: Damage to Properties – **Annex M**			
Date	Size of bomb	Record Transcription	Comments
23rd September 1940	IB	St. Mary's Pl. Fields	*It is unknown which St. Mary's PL. Fields the reference specifically relates to, there was a St. Marys approximately 180m south-west from the site. However, this is still too far removed to have had any direct impact on the risk to the site.*
29th September 1940	HE	Bloxham Crescent	*Bloxham Crescent was located approximately 140m north-west of the site.*
15th October 1941	UXB	Grammar School Yards	*Grammar School Yards was located approximately 35-70m south-west of the site.*
23rd February 1944	IB	Oldfield Road. Grammar School	*Oldfield Road Grammar School was located approximately 50m south-west of the site.*
24th February 1944	IB	Field, Oldfield Road, Hampton	*It is unknown which. Field on Oldfield Road the reference specifically relates to, there was a field approximately 37m west from the site. However, this is still too far removed to have had any direct impact on the risk to the site.*
29th November 1944	UXB	St. Mary's Pl. Fields	*It is unknown which St. Mary's PL. Fields the reference specifically relates to, there was a St. Marys approximately 180m south-west from the site. However, this is still too far removed to have had any direct impact on the risk to the site.*

11.7. Middlesex County Council War Damage Map

Map sheets compiled by Middlesex County Council (MCC) showing the extent of wartime damage over the area of the site were consulted at London Metropolitan Archives. The section showing the area of the site is described in the table below and presented in **Annex N**.

It should be highlighted that this source only records the following damage categories: 'Category 1: Total damage, building to be demolished', 'Category 2: Some repairs possible, but could become Cat 1' and 'Category 3: Borderline areas, uncertain whether repairs possible, might have to be demolished'. The lesser damage categories, such as seriously damaged but repairable at cost and general blast damage, were not used.

MCC War Damage Map – Annex N	
Date Range	Comments
1940-1945	**As the site predominantly comprised undeveloped land, limited structures were present onsite to incur damage. However, this map does not record any damage to the structures that were present on site, or those within the immediate vicinity.** **The closest recorded damage is situated approximately 140m north-west of the site, along Bloxham Crescent. This damage is depicted as** *"total damage, building to be demolished".*

11.8. WWII-Era Aerial Photography

WWII-era aerial photography for the site area was obtained from the National Monuments Record Office (Historic England). This photography provides a record of the potential composition of the site during the war, as well as its condition immediately following the war (see **Annex O**).

WWII-Era Aerial Photography – Annex O	
Date/Title	Description
14th April 1947	This post-WWII aerial image indicates that the site itself, or immediate vicinity, has not experienced any noticeable bomb damage, such as missing or ruined structures, areas of severely disturbed ground or structural changes. While the structures on site do not appear to have any roofs, they match up with historical OS mapping and are thought to comprise the function of coal bunkers/storage for the *Coal Yard* on site. Highlighted in **Annex O2** are some potential ground disturbances approximately 40m west of the site. While these are not thought to be the result of bombing, they are potentially indicative of bomb craters. However, due to their distance from the site, they are not situated in a proximity which would elevate the risk on site.

11.9. Abandoned Bombs

A post air-raid survey of buildings, facilities, and installations would have included a search for evidence of bomb entry holes. If evidence of an entry hole was encountered, Bomb Disposal Officer Teams would normally have been requested to attempt to locate, render safe, and dispose of the bomb. Occasionally, evidence of UXBs was discovered but due to a relatively benign position, access problems, or a shortage of resources the UXB could not be exposed and rendered safe. Such an incident may have been recorded and noted as an 'abandoned bomb'.

Given the inaccuracy of WWII records, and the fact that these bombs were 'abandoned', their locations cannot be considered definitive or the lists exhaustive. The MoD states that 'action to make the devices safe would be taken only if it was thought they were unstable'. It should be noted that other than the 'officially' abandoned bombs, there will inevitably be UXBs that were never recorded.

1st Line Defence holds no records of officially registered abandoned bombs at or near the site of the proposed works.

11.10. Bomb Disposal Tasks

The information service from the Explosive Ordnance Disposal (EOD) Archive Information Office at 33 Engineer Regiment (now part of 29 EOD & Search Group) no longer processes commercial requests for information. 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, Brownfield Solutions Limited will be advised.

11.11. Evaluation of German Air Delivered UXO Records

German Air Delivered UXO Records Summary	
Factors	**Conclusion**
Density of Bombing *It is important to consider the bombing density when assessing the possibility that UXBs remain in an area. High bombing density could allow for error in record keeping due to extreme damage caused to the area.*	During WWII, the site was situated within the Municipal Borough of Twickenham, which was subject to an overall moderate-high density of bombing according to official Home Office bombing statistics. An average of 82.8 bombs were recorded per 1,000 acres. This was mainly due to the sites location in London. London Bomb Census mapping, a local Richmond bomb plot map and local written records, do not record any HE bomb strikes on the site or within its immediate vicinity. The closest recorded HE bomb strike is plotted approximately 60m south-west to the site, within the vicinity of Oldfield Road Grammar School. This is recorded as a **UXB, falling on 15th October 1941 in the 'Damage to Properties' record set. This incident is, however, too far removed to have had any direct impact on the site boundary.**
Damage *If buildings or structures on a site sustained bomb or fire damage, any resulting rubble and debris could have obscured the entry holes of unexploded bombs dropped during the same or later raids. Similarly, a high explosive bomb strike in an area of open agricultural land will have caused soil disturbance, increasing the risk that a UXB entry hole would be overlooked.*	As the site predominantly comprised undeveloped land, limited structures were present on site to incur observable damage. However, the MCC War Damage Map does not record any damage to the structures that were present on site, or those within the immediate vicinity. Post-WWII aerial photography indicates that the site experienced no noticeable damage. There is no evidence of damage within the site, such as missing or ruined structures, areas of severely disturbed ground or extensive structural changes. While the structures on site do not appear to have any roofs, they match up with historical OS mapping and are thought to comprise the function of coal bunkers/storage for the *Coal Yard* on site. Highlighted in **Annex O2** are some potential ground disturbances approximately 40m west of the site. While these are not thought to be the result of bombing, they are potentially indicative of bomb craters. However, due to their distance from the site, they are not situated in a proximity which would elevate the risk on site.
Ground Cover *The nature of the ground cover present during WWII would have a substantial influence on any visual indication that may indicate UXO being present.*	The site prior to and during WWII, was predominantly composed of open ground and vegetation. This terrain has the potential to obscure possible evidence of potential UXB and bomb entry holes, especially as a UXB entry hole could have been as small as 20cm in diameter. Sections of the site that comprised structures and railway sidings would however, have been more conducive to this damage.

Access Frequency *UXO in locations where access was irregular would have a greater chance of passing unnoticed than at those that were regularly occupied. The importance of a site to the war effort is also an important consideration as such sites are likely to have been both frequently visited and subject to post- raid checks for evidence of UXO.*	At the outset of WWII, although much of the site was undeveloped, it is anticipated that access levels will have been somewhat frequent. This is due to the fact that the site comprised structures/railway sidings and was situated adjacent to a railway line and *Goods Shed.* Post-WWII OS mapping depicts the site to have comprised a *Coal Yard* which is likely to have been accessed by workers on a regular basis. Online information indicates that the site was part of the Upper Sunbury branch for the industrial railway between the Metropolitan Water Board's pumping stations and coal wharf.[3] Items of UXO are more likely to be spotted, recorded and dealt with within frequently accessed areas.
Bomb Failure Rate	There is no evidence to suggest that the bomb failure rate in the locality of the site would have been dissimilar to the 10% normally used.
Abandoned Bombs	1st Line Defence holds no records of abandoned bombs at or within the site vicinity.
Bombing Decoy sites	1st Line Defence could find no evidence of bombing decoy sites within the site vicinity.
Bomb Disposal Tasks	1st Line Defence could find no evidence of bomb disposal tasks within the site boundary and immediate area.

[3] https://webblocos.co.uk/history/the-railway

12. Introduction to Allied Ordnance

12.1. General

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

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

It should be highlighted that there is no evidence that the site formerly had any military occupation or usage that could have led to contamination with such items of Allied ordnance. Despite this, urban areas, such as the location of the site, can be at risk from buried unexploded anti-aircraft projectiles fired during WWII – as addressed below.

12.2. Defending the UK From Aerial Attack

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

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

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

12.3. Anti-Aircraft Artillery (AAA)

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

Anti-Aircraft Artillery				
Item	**Description**			
HAA	These large calibre guns such as the 3.7" QF (Quick Firing) were used to engage high flying enemy bombers. They often fired large HE projectiles, which were usually initiated by integral fuzes, triggered by impact, area, time delay or a combination of aforementioned mechanisms.			
LAA	These mobile guns were intended to engage fast, low flying aircraft. They were typically rotated between locations on the perimeters of towns and strategically important industrial works. As they could be moved to new positions with relative ease when required, records of their locations are limited. The most numerous of these were the 40mm Bofors gun which could fire up to 120 x 40mm HE projectiles per minute to over 1,800m.			
Variations in HAA and LAA Ammunition	**Gun type**	**Calibre**	**Shell Weight**	**Shell Dimensions**
	3.0 Inch	76mm	7.3kg	76mm x 356mm
	3.7 Inch	94mm	12.7kg	94mm x 438mm
	4.5 Inch	114mm	24.7kg	114mm x 578mm
	40mm	40mm	0.9kg	40mm x 311mm
Z-AA	Rockets were commonly designed to destroy heavily armoured military vehicles (anti-tank weapon). The device contains an explosive head (warhead) that can be accelerated using internal propellants to an intended target. Anti-aircraft rocket batteries were also utilised as part of air defence measures.			

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

Illustrations of Anti-Aircraft artillery, projectiles and rockets are presented at **Appendix iv**.