WML CONSULTING

Civil, Structural and Geotechnical Engineers

Geo-Environmental Investigation & Assessment

For

Barking Yard Redevelopment

Undertaken on behalf of

Axion Polymers

Report No. 8860G-WML-00-XX RP-G-001

July 2020

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Executive Summary

Site Location	The site is located in the western area of the larger S. Norton & Sons yard off River Road, Barking, London. It is centred on approximate Ordnance Survey National Grid Reference 545798E, 181704N with an indicative postcode of IG11 0DS.
Development Proposals	Modifications are proposed to the existing waste recycling operation.
Ground Conditions	Ground conditions comprise made ground to depths of between 3.70 and 6.00mbgl. This is underlain by alluvium comprising interbedded silty finer sand, soft, silty clay and peat to depths of 7.40 and 8.00mbgl. The alluvium is underlain by sand and gravel superficial deposits possibly representing the Taplow Gravel Member, which in turn is underlain by dense silty sand of the Thanet Member at depths of 13.00 and 14.00mbgl. Groundwater was encountered at depths of 7.00 and 8.00mbgl.
Site Preparation	Buried concrete slabs and possibly other ground obstructions should be anticipated at shallow depth. Excavated concrete should be crushed to a suitable grading and replaced to a specified compaction to provide a stable working platform for construction plant.
Foundations and Floor Slabs	Foundations will need to be piled, with piles probably extending into the Thanet Member. Where floor slabs are constructed as ground bearing, a degree of settlement with resulting ongoing maintenance should be anticipated. Should a low degree of settlement tolerance be required, floor slabs should be suspended.
Groundwater	Significant groundwater inflows are unlikely in near surface excavations with conventional 'sump and pump' dewatering measures being adequate to keep excavations dry.
Concrete Classification	Provided concrete in contact with the made ground and alluvium can be adequately protected, concrete for piled foundations may be designed to DS-2/AC-2 conditions.
Pavement Design	A CBR value not exceeding 3% is recommended for preliminary pavement design purposes.
Ground Gas	The long-term risk from ground gas at the site is considered low. However, it is recommended that health and safety measures such as a no smoking policy are put in place, with personal gas detection monitoring being possibly employed within excavations requiring man entry and in proximity to piling operations.
Ground Contamination	The long-term risk from ground contamination is considered low. However, groundworks may therefore need to be undertaken under a watching brief in consultation with an asbestos specialist, with any ACM so encountered being segregated for removal to landfill under appropriate legislation. Such operations may also need to incorporate specific control measures such as dust suppression, perimeter air monitoring and appropriate Personal Protective Equipment (PPE).
Waste Soils	The majority of made ground will be classified as 'Non-hazardous' with natural soils classified as 'Inert' for landfill disposal. It will be the responsibility of the waste producer to undertake further testing and classification of waste soils for disposal to an appropriately licenced landfill in accordance with current guidelines and Duty of Care requirements.
UXO	No indications of UXO were discovered by the UXO specialist during the ground investigation works. Further UXO assessment and support will be required during future construction works and the UXO specialist should be consulted in this respect.

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APPENDICES

1.0 INTRODUCTION

Appointment

1.1 WML Consulting has been commissioned by Axion Polymers to undertake a Geo-environmental Investigation and Assessment of a site located within an existing recycling facility at S. Norton & Sins Ltd, River Road, Barking, London, IG11 0DS.

Proposed Development

1.2 The project involves the development modifications within the existing site, which are indicated to comprise the following:

- Installation of a new reinforced concrete yard slab.
- Modifications to below ground drainage systems.
- Installation of new surface weighbridge.
- Construction of Non-ferrous building with adjacent canopy covered storage area.
- Construction of new workshop building, incorporating overhead runway crane.
- Installation of new steel material storage bins.
- Installation of new steel push wall.

1.3 The proposed development is indicated on drawing referenced 5326-HMA-V-XX-DR-A-00220, in Appendix 01.

Objective

1.4 The objective of the ground investigation and assessment was to provide geotechnical recommendations for construction design purposes together with a geo-environmental risk assessment in terms of possible ground contamination.

1.5 To achieve the objective, the following tasks were undertaken:

- Establish, through undertaking a limited desk study of published information, the geological, hydrogeological and environmental setting of the site so as to identify any potential ground constraints to development through a site-specific conceptual model.
- Design a ground investigation so as to characterise the ground conditions in terms of geology, soil geotechnical parameters and ground contamination from information provided by the investigation.
- Provide recommendations regarding suitable foundations, floor slabs and new pavement construction, together with any other geotechnical considerations that could affect possible future development.
- Determine a ground conceptual model for the site so as to undertake a ground contamination Generic Quantitative Risk Assessment (GQRA).

Scope

1.6 It is understood that a Phase 1 Desk Study report was not required as part of the planning conditions. Nevertheless, for completeness, this report includes a review of freely available information, along with the findings of the ground investigation, to provide a comprehensive conceptual model for the site.

1.7 The ground investigation comprised the formation of window sample probeholes and cable percussive boreholes undertaken with reference to BS5930:2015+A1:2020 Code of Practice for Ground Investigations and BS10175:2011 together with A1:2013, "Investigation of Potentially Contaminated Sites - Code of Practice" except where superseded by EN ISO 22475-1 "Geotechnical Investigation and Assessment – Sampling by Drilling and Excavation and Groundwater Measurements".

1.8 Geotechnical soil testing has been undertaken in accordance with guidelines provided in BS1377:1990 – Parts 1-9, "Method of Test for Soils for Civil Engineering Purposes". Samples for chemical analysis were obtained and handled generally in accordance with the current guidelines (BS10175: 2011 and A1:2013).

2.0 SITE LOCATION AND DESCRIPTION

Site Location

2.1 The proposed development site is located in the western area of the larger S. Norton & Sons yard off River Road, Barking, London. It is centred on approximate Ordnance Survey National Grid Reference 545798E, 181704N with an indicative postcode of IG11 0DS.

2.2 The main site area is bounded to the south by the River Thames and to the north, east and west by existing industrial premises off River Road.

2.3 The site location plan and red line development plans are included within Appendix 01.

Site Description

2.4 The proposed development site comprises a concrete surfaced yard containing bays for stockpiling of recycled metal and other waste materials.

2.5 Proposed structures are to be constructed to the south of the existing non-ferrous shed and to the south of the existing above-ground bunded fuel tank.

2.6 The topographical survey drawing of the larger site area by Formby Surveys, reference 10477_T:250:1:1, dated February 2019, indicates the development area to be at an approximate level of between 3.00 and 3.40 metres Above Ordnance Survey (mAOD).

2.7 The extreme southern site boundary is formed by a quay wall to the River Thames.

2.8 The topographical survey is presented in Appendix 01.

3.0 SUMMARY OF ENVIRONMENTAL AND HISTORICAL SETTING

3.1 A review of the environmental and historical setting of the site, comprising information from the following freely available sources, has been undertaken to inform the existing investigations.

- British Geological Survey (BGS) Sheet '257' Romford (1:50,000 scale Solid & Drift edition).
- BGS Digital Geological Map of Great Britain (DiGMapGB-50; available as a web map service).
- "Old-Maps" web-based viewer.
- UK Radon Indicative Atlas of Radon in England and Wales as provided by Public Health England.
- BRE Publication 211 (2015) "Radon: Guidance on Protective Measures for New Buildings".
- Review of free public sector information through QGIS viewer licensed under the Open Government Licence v3.0.

Geology

3.2 BGS plans indicate the site to be underlain by Made Ground and Alluvial Drift deposits which mainly comprises sand, silt and clay with some gravel horizons. This is possibly underlain by the Taplow Gravel comprising mainly sand and gravel.

3.3 In the northern section of the site the drift deposits are indicated to be underlain by the Thanet Formation comprising mainly sands. However, in the southern section of the site the drift deposits are indicated to be underlain by the Lewes Nodular Chalk Formation.

3.4 From an understanding of the underlying geology, the risks of shallow, unrecorded mine workings occurring beneath the site can be discounted.

Radon

3.5 The UK Radon Interactive map viewer indicates the site to be within an area where between 1% and 3% of properties are above the action level of exposure for residential properties. However, a review of the maps provided in Appendix A of BRE211:2015 indicates that no protective measures are required for the area under consideration.

Environmental Setting

3.6 The Alluvium beneath the site is classified as a 'Secondary (Undifferentiated) Aquifer. The Thanet Formation underlying the northern part of the site is classified as a 'Secondary A Aquifer'. The Lewes Nodular Chalk Formation underlying the southern section of the site are classified as a 'Principal Aquifer'.

3.7 The site is not located within an Environment Agency (EA) Source Protection Zone (SPZ).

3.8 The nearest surface water feature is the River Thames located immediately south of the site.

3.9 There is a historic landfill recorded around 360m west of the site at Beckton STW, but this is considered sufficiently remote from the site as not to be of influence.

Previous Investigations

3.10 The following information has been provided for review, relating to a previous ground investigation undertaken by Herts & Essex Site Investigations (HESI) relating to a previous development within the wider site area and to the east of the currently proposed redevelopment zone.

- Norton & Sons, River Road, Barking, London, IG11 0DS: Site Investigations, referenced MRS/14927, dated September 2018.

3.11 The HESI report is presented in Appendix 03.

3.12 The investigation was undertaken for piled foundation design purposes and included a cable percussive borehole to a depth of 20.00 metres below ground level (mbgl) and are summarised in the following paragraphs.

Ground Conditions

3.13 The investigations encountered a concrete slab underlain by made ground to a depth of 2.60mbgl. This generally comprised crushed brick and concrete fill.

3.14 The made ground was underlain by alluvial drift deposits to depths of 16.00mbgl and comprised an upper horizon of soft, brown grey, silty, sandy clay to a depth of 6.20mbgl and soft, brown, fibrous peat to a depth of 7.40mbgl. These were in turn underlain by medium dense to dense, locally silty, sand and gravel to a depth of 14.20mbgl and very stiff to hard, grey, silty, sandy clay to a depth of 16.00mbgl.

3.15 Below 16.00mbgl the drift deposits were underlain by weak, moderately weathered, white chalk, extending to a maximum proven depth of 20.00mbgl.

3.16 Standard Penetration Test (SPT) 'N' values within the upper natural cohesive strata ranged between 5 and 7 with 'N' values in the lower granular soils ranging between 34 and in excess of 50 indicating a dense state of compaction. SPT 'N' values in the underlying chalk ranged between 17 and 32, indicating it to be very weak.

3.17 Geotechnical testing indicated that the clay have a low to high volume change potential with plasticity indices ranging between 20 and 53%.

3.18 A moderate inflow of groundwater in the borehole was encountered at a depth of 7.40mbgl, rising to a standing level of 3.40mbgl.

3.19 No visual or olfactory evidence of ground contamination was recorded within the borehole.

Site History

3.20 Prior to its use as a recycling facility, the site was historically part of a large 'Chemical Works' with associated buildings.

3.21 The likelihood of significant ground contamination sources being present as a result of the site's past use cannot therefore be discounted.

Unexploded Ordnance

3.22 Due to the site's location within an area known to have suffered significant German bombing during WWII, a Detailed Unexploded Ordnance (UXO) Risk Assessment was undertaken by 1st Line Defence.

3.23 The report, which is presented in Appendix 02, concluded that the site is at Medium Risk from both German and Allied UXO.

3.24 As such, On-site Support was provided by a UXO Specialist from 1st Line Defence during the WML investigations. This included an Intrusive Magnetometer Survey within the investigation holes. No indications of UXO were recorded.

3.25 Further UXO assessment and support will be required during future construction works and the UXO specialist should be consulted in this respect.

4.0 PRELIMINARY CONTAMINATION RISK ASSESSMENT

4.1 The following paragraphs outline a Preliminary Risk Assessment (PRA) for the site as defined by DEFRA and the EA Model Procedures for the Management of Land Contamination, CLR11 (2004).

4.2 The table in Paragraph 4.5 provides a Preliminary Conceptual Model (PCM) which defines the site in terms of a potential pollution linkage, that is, whether a pathway exists between a contamination source and a sensitive environmental receptor (Source-Pathway-Receptor relationship).

4.3 The table considers whether a pollution linkage is potentially present or not and provides a preliminary qualitative assessment of risk, based on the information currently available and in accordance with guidance provided in the CIRIA document C552 (2001) Contaminated Land Risk Assessment – A Guide to Good Practice. The risk evaluation process is described further in Appendix 08.

4.4 Where a possible linkage is identified, it does not necessarily mean that a significant risk exists, but indicates that further information is required through appropriate site investigation to substantiate the conceptual model.

4.5 Based on the above findings, a Preliminary Conceptual Model and Risk Assessment is outlined for the proposed development as follows:

Source	Pathway	Receptor	Linkage potential	Comment
The presence of significant ground contamination sources due to the site's past use cannot be wholly discounted, although this would likely be localised in nature.	Direct contact, ingestion of soil, dermal contact, dust exposure pathways.	Current Site Users	Low	The site in its current condition is surfaced with hard cover and is in transient use. Therefore, the risk to current site users from direct contact is with historical contamination is considered **LOW**.
		Site End Users	Low	The provision of new building floor slabs and external hard cover will continue to break the direct pollution linkage. Therefore, the risk to site end users will remain **LOW**.
		Construction Workers	Low	Construction workers could potentially be exposed to contaminated soils during earthworks and foundation construction, although the exposure time will be relatively short. Any perceived contamination risks will be mitigated by adopting good site working practices including appropriate health and safety measures during the works, thus providing a **LOW** preliminary risk.
		Adjacent land users	Low	Contact via wind-blown dust/debris, particularly during the development phase is possible, although the exposure time would be relatively short. The current risk is considered **VERY LOW** although this could increase during construction works. Appropriate health and safety measures adopted during site development will ensure that the risk remains low.

Source	Pathway	Receptor	Linkage potential	Comment
The presence of significant soluble and/or liquid and therefore potentially mobile historical contamination occurring beneath the site cannot be wholly discounted, although this would likely be localised in nature.	Direct downward migration through leaching and/or mobile liquids.	Groundwater	Low	The southern part of the site is indicated to be underlain by Chalk which is a Principal Aquifer. However, overlying cohesive alluvium will retard significant vertical migration of contaminants towards the aquifer, although a development specific Piling Risk Assessment may be required in this respect. Therefore, the preliminary risk to groundwater is considered **MODERATE/LOW**.
	Off-site migration in groundwater or surface water flow.	Surface water	Low	The River Thames is located immediately to the south of the site. The river at this location is tidal and therefore of reduced vulnerability. Therefore, the preliminary risk to surface water is considered **LOW**.
		Groundwater/ surface water abstractions	Unlikely	The site is not within an EA Source Protection Zone and surface water abstraction from the Thames for potable use is unlikely. Therefore, risks to groundwater/surface water abstractions are considered **LOW**.
		Adjacent Properties	Unlikely	Relatively impermeable cohesive alluvium will retard significant lateral migration of any mobile contaminants to adjoining properties which, being industrial, are of low sensitivity. Therefore, the preliminary risk to adjacent properties is assessed as **LOW.**
		Ecology	No linkage envisaged	The site is an industrial area with no Designated Environmentally Sensitive Sites within influencing distance. Therefore, risks to the surrounding ecology is considered **VERY LOW**.
The presence of significant volatile contamination beneath the site is unlikely but cannot be wholly discounted, although this would likely be localised in nature.	Inhalation of harmful vapours (indoor and outdoor airspaces)	Current Site Users	Unlikely	Site use is currently transient with occupation being mostly outdoors. Therefore, the preliminary risk to current site users is assessed as **VERY LOW**.
		Site End Users	Unlikely	Site use will remain transient and primarily located outdoors or in well ventilated buildings. The preliminary risk from inhalation of indoor/outdoor air is therefore considered **VERY LOW**.
		Construction Workers	Unlikely	In the unlikely event of construction workers coming into contact with possible volatile compounds, the exposure time will be relatively short. The chronic exposure risk to construction workers, assuming that appropriate health and safety measures will be adopted, is therefore considered **VERY LOW.**

Source	Pathway	Receptor	Linkage potential	Comment
		Adjacent Properties	Unlikely	Relatively impermeable cohesive alluvium will retard significant lateral migration of any volatile contaminants to adjoining properties which, being industrial, are of low sensitivity and transient use. Therefore, the preliminary risk to adjacent properties is assessed as **LOW.**
The site is not within influencing distance of any recorded landfills. The presence of ground gas resulting from shallow unrecorded mine workings can be discounted. Previous investigations have encountered deposits of peat which could contain high concentrations of ground gases, although the continued generation potential is considered low.	Emissions from the ground beneath the site collecting in confined spaces and excavations	Construction/ services maintenance workers	Low	The potential to generate significant volumes of toxic and/ or flammable/ explosive gas beneath or close to the site is considered low. Assuming that appropriate health and safety measures will be adopted during construction, the preliminary risk is therefore considered **LOW**.
	Migration of gases on/off site and collecting in confined spaces on/off site.	Adjoining site users	Unlikely	The potential to generate significant volumes of ground gas beneath the site is considered low. Therefore, the preliminary risk to adjacent properties from the site is considered **VERY LOW**.
		Current/future site users	Unlikely	The potential to generate significant volumes of toxic and/ or flammable/ explosive gas beneath or close to the site is considered low. Therefore, the preliminary risk to current and future site users is considered **LOW**.
The site is in an area which is affected by naturally occurring radon gas.	Natural emissions from the ground collecting in confined spaces within buildings	Site end users	Low	BRE211 indicates that no radon protection measures are required. Therefore, the potential risk to site end users is considered **LOW**.
Chemicals which could prove aggressive to construction materials may be present on site.	Direct contact	Construction concrete, plastic water pipes.	Low	Any risks to construction materials identified after site investigation and assessment will be mitigated as part of the structural design. The preliminary risk is therefore considered **LOW**.

4.6 Under the proposed development scenario, potential pollution linkages are, on the whole considered unlikely or low with associated preliminary risks being generally assessed as to low.

4.7 However, due to the site's previous use as a chemical works, it has been considered prudent to verify the conceptual ground model by incorporating chemical analysis of selected samples of soil into the geotechnical ground investigation.

5.0 SITE INVESTIGATION

Rationale

5.1 Intrusive investigations were undertaken primarily to provide geotechnical parameters for structural design purposes but also to verify the preliminary site conceptual model and confirm the anticipated low environmental risk.

5.2 Cable tool percussive boreholes were undertaken to provide information on relatively deep ground conditions for piled foundation design.

5.3 Due to access restrictions and the need to minimise surface disruption, window sample probeholes were undertaken to provide information on near surface deposits and to obtain samples for chemical analysis.

5.4 Due to the small diameter of the probing equipment, the depth of penetration achieved is dependent on favourable ground conditions. As such, ground penetration may be restricted in circumstances where the ground is particularly strong or contains relatively large obstructions such as cobbles and/or boulders.

5.5 The investigation locations were chosen so as not to impact on site operations and the presence of known/suspected services beneath the site.

5.6 Chemical analysis of a general suite of contaminants was undertaken on selected samples of soil. This was to confirm the anticipated low contamination risk and to establish the chemical suitability of soils for possible re-use/disposal purposes.

Intrusive Works

5.7 Ground investigation work was undertaken by Groundtech Limited on the 4th and 5th June 2020. This comprised the formation of 2no cable tool percussion boreholes to a depth of 20.00mbgl and 5no window sample probeholes to a maximum depth of 4.00mbgl.

5.8 The exploratory hole records are presented in Appendix 04 of this report whilst the exploratory hole locations are shown on Drawing 8860G-SK01 in Appendix 01.

Geotechnical and Chemical Testing

5.9 In-situ geotechnical testing was undertaken at regular intervals during the formation of the boreholes and probeholes in the form of Standard Penetration Tests (SPTs). The results for this testing are presented on the descriptive logs in Appendix 04.

5.10 The following laboratory geotechnical soils testing was undertaken on selected samples of soil:

- Natural moisture content.
- Liquid and plastic limits.
- Particle size distribution.
- Dry Density/Moisture Content relationship.
- California Bearing Ratio (CBR).
- Organic matter.
- Sulphur, Sulphate (total), Sulphate (2:1) extract and pH.

5.11 The results are presented in Appendix 05.

5.12 Chemical analysis was undertaken on selected soil samples for the following contaminants of concern:

- Total Arsenic, Boron, Cadmium, Chromium VI, Copper, Lead, Mercury, Nickel, Selenium, Vanadium, Zinc.
- Total Cyanide, Phenols, Sulphur, Sulphate.
- Speciated USEPA Polyaromatic Hydrocarbons (PAH).
- Volatile/Semi-volatile Organic Compounds (VOC/SVOC).
- Speciated Aromatic/Aliphatic Petroleum Hydrocarbons (TPH).
- Asbestos Screen and Identification.
- 2:1 water/soil sulphate extract, pH.

5.13 Selected soil samples were also tested for leachable concentrations of the following contaminants of concern:

- Total Arsenic, Boron, Cadmium, Chromium VI, Copper, Lead, Mercury, Nickel, Selenium, Vanadium, Zinc.
- Total Cyanide, Phenols, Sulphur, Sulphate, pH.
- Speciated USEPA Polyaromatic Hydrocarbons (PAH).

5.14 The results of the chemical analysis are presented in Appendix 06.

6.0 GROUND CONDITIONS

Stratigraphy

6.1 Ground conditions encountered during the intrusive investigation comprised made ground to depths of between 3.70 and 6.00mbgl. This was underlain by alluvium comprising interbedded silty fine sand, soft, silty clay and peat to depths of 7.40 and 8.00mbgl.

6.2 The alluvium was underlain by sand and gravel deposits possibly representing the Taplow Gravel Member, which in turn was underlain by dense silty sand of the Thanet Member at depths of 13.00 and 14.00mbgl.

Made Ground

6.3 Made ground was encountered within all of the exploratory holes from ground level to depths of between 3.70 and 6.00mbgl.

6.4 This comprised a surface cover of reinforced concrete to depths of between 0.25 to 0.45m with a further concrete slabs being encountered at depths of between 0.80 and 1.35mbgl.

6.5 The underlying made ground comprised mixed cohesive and granular, being described as soft black silty clay and brown sand and gravel with inclusions predominantly of ash, clinker, slag, brick and concrete.

6.6 Standard Penetration Test (SPT) 'N' values in the granular made ground of 12 to 15 and 13 to 22 for the cohesive made ground indicate medium dense and firm states of compaction respectively.

6.7 A natural moisture content of 46% for the cohesive made ground, with liquid limit of 84% and plasticity index of 47%, indicates a clay of very high plasticity and a high volume change potential.

6.8 Particle size distribution testing within the cohesive made ground recorded the strata to comprise 19% gravel, 37% sand, 28% silt and 16% clay.

6.9 Compaction testing within the cohesive made ground determined a maximum dry density of 1.33mg/m^3 with an optimum moisture content of 31% indicating the materials to be generally wet of optimum.

6.10 California bearing ratio testing within shallow samples of made ground also determined CBR values of 40 – 56%.

Alluvium

6.11 The made ground was underlain by alluvium which was described in the boreholes as a silty fine sand and very soft silty clay. The alluvium also included a horizon of peat from 6.00 to 6.80mbgl in BH01 and from 5.90 to 6.50mbgl in BH02.

6.12 SPT 'N' values of 10 and 29 in the sandy alluvium indicates a medium state of compaction.

6.13 A natural moisture content of 28% for the cohesive alluvium, with liquid limit of 33% and plasticity index of 17%, indicates a clay of low plasticity and low volume change potential.

Possible Taplow Gravel

6.14 The alluvial deposits were underlain by soils suspected of representing the Taplow Gravel Member at depths of 7.40 and 8.00mbgl.

6.15 This was described in the boreholes generally as brown sand and gravel of mixed lithology.

6.16 SPT 'N' values of between 26 and 42 (average 34) indicate the stratum to be primarily dense in nature.

Thanet Formation

6.17 The drift deposits were underlain at depths of 13.00 and 14.00mbgl by the Thanet Formation, being described in the boreholes as generally green grey, slightly clayey, silty fine sand.

6.18 SPT 'N' values of between 40 and in excess of 50 indicate a very dense state of compaction.

Visual/Olfactory Evidence of Contamination

6.19 No visual and/or olfactory evidence of significant ground contamination was identified within the exploratory holes during the investigation.

6.20 However, Asbestos Containing Material (ACM) in the form of probable asbestos cement was described in BH01A at a depth of 0.70mbgl. This was sampled for analyses.

Groundwater

6.21 Groundwater entries were recorded in the boreholes at depths of 7.00 and 8.00mbgl, being consistent with the interface between alluvium and underlying Taplow Gravel.

6.22 It should be appreciated that the groundwater observations described above have been undertaken during a very short period of time. Significant variations in the long-term groundwater regime may occur at other times, particularly with prolonged, extreme weather conditions, and that no account can be taken of such in this report.

General

6.23 It should also be appreciated that ground conditions may vary between and away from the exploratory hole positions, and that no account can be taken in this report of such variations.

7.0 GEOTECHNICAL APPRAISAL

Site Preparation

7.1 Existing underground services crossing the proposed areas of construction will need to be accurately located, identified and possibly diverted prior to any works commencing.

7.2 Buried concrete slabs and possibly other ground obstructions should be anticipated at shallow depth and should be broken out to facilitate foundation construction.

7.3 Excavated concrete could be crushed to a suitable grading and replaced to a specified compaction to provide a stable working platform for construction plant if/where the slabs are to be removed.

Foundations

7.4 Made ground and alluvium should be considered unsuitable for the direct support of structural loads as they will be weak and compressible, leading to possibly unacceptable total and differential settlements.

7.5 Structural loads will therefore need to be taken to competent strata which occur at approximate depths in excess of 7.50mbgl.

7.6 As such, foundations will need to be piled, with piles probably being driven to achieve a set in the Thanet Member at depths in excess of 14.00mbgl.

7.7 However, the choice of pile type would be largely dependent on the need to balance optimum construction methods against environmental issues such as noise and vibration effects. Consultation with a reputable piling contractor, ideally with local experience, will be required to determine the final choice and design of pile type.

Floor Slabs

7.8 Where floor slabs are constructed as ground bearing, a degree of settlement with resulting ongoing maintenance should be anticipated.

7.9 Should a low degree of settlement tolerance be required, floor slabs should be suspended.

Groundwater

7.10 Excavations will be feasible using conventional hydraulic plant. All excavations at the site and specifically requiring man-entry will need adequate lateral support, or will need to be battering back to a safe angle to ensure their stability.

7.11 Significant groundwater inflows are unlikely in near surface excavations with conventional 'sump and pump' dewatering measures being adequate to keep excavations dry.

Pavement Design

7.12 A single laboratory CBR test undertaken on recompacted made ground provided a value of 40%. However, this is not considered to represent in situ conditions for the made ground and a value not exceeding 3% is recommended for preliminary design purposes.

7.13 The CBR will need to be reviewed and confirmed by site inspection and possibly suitable in-situ testing at formation levels prior to pavement construction.

Concrete Design

7.14 Design/mix of buried concrete should be undertaken in accordance with the "Aggressive Chemical Environment for Concrete" (ACEC) classification, of BRE Special Digest 1:2005 (Concrete in Aggressive Ground). With reference to the site history, it is deemed appropriate to classify the site as "Brownfield", with respect to BRE Special Digest.

7.15 Analysis for 2:1 water/soil extract for sulphate and pH provide the following results with typical design sulphate (DS) class and "Aggressive Chemical Environment for Concrete" (ACEC) class for the site:

Strata	SO_4 (2:1) mg/l	pH	DS/ACEC
Made Ground	150-4300	6.4-12.4	DS-4/AC-4
Alluvium	3500-4100	7.2-8.0	DS-4/AC-4
Taplow Gravel	870 and 950	7.3 & 8.1	DS-2/AC-2
Thanet Member	240-700	6.9-9.0	DS-2/AC-2

7.16 A measured concentration of 15,000mg/l for Taplow Gravel in BH02 at 9.00mbgl is likely to be spurious and has been discounted in the above assessment.

7.17 Therefore, provided concrete in contact with the made ground and alluvium can be adequately protected, concrete for piled foundations may be designed to DS-2/AC-2 conditions.

7.18 However, as the new structure is likely to be piled, together with the groundwater beneath the site being tidal, all new concrete should be designed in accordance with BS6349 -1: 2000 – 'Maritime Structures' taking into considerations the risks of chloride attack on both concrete and metal reinforcement.

8.0 GENERIC QUANTITATIVE RISK ASSESSMENT (GQRA)

General

8.1 A review of the desk study information has concluded that the potential for a significant pollution linkage to be present at the site is low with overall corresponding low risk to human health and the environment.

8.2 Further to this, no visual or olfactory evidence of significant ground contamination has been recorded from the intrusive investigations.

8.3 However, it has been considered prudent to adopt a precautionary principal and undertake chemical analysis of the sub-surface soils to confirm the low human health risk status of the site.

Human Health

8.4 Selected samples have been analysed for a general suite of contaminants of concern and compared against Screening Levels (SL's) for human health to determine the significance of the measured concentrations in relation to the site conceptual model. Thus, a Generic Quantitative Risk Assessment has been undertaken in line with guidelines provided in CLR11, Model Procedures for the Management of Land Contamination, 2004.GQRA).

8.5 The criteria for a limited number of contaminants have been derived by DEFRA in their document entitled SP1010: Development of Category 4 Screening Levels for Assessment of Land Affected by Contamination, April 2014.

8.6 Within the document, Category 4 Screening Levels (C4SL's) are described as being more pragmatic than previous screening criteria and represent concentrations in soil that present an 'acceptable' level of risk within the context of Part 2A.

8.7 The National Planning Policy Framework states that 'after development, as a minimum, land should not be capable of being determined as contaminated land under Part 2A of the Environmental Protection Act 1990'. Therefore, by inference, the C4SL's are appropriate for use in the planning context.

8.8 Although the SP1010 document states that C4SL only apply for a 'sandy loam soil with 6% soil organic matter', it is generally accepted that assessment criteria for metals are not sensitive to changes in soil organic content (SOM). The C4SL's have therefore been adopted as assessment criteria in this report for the listed metals within the SP1010.

8.9 Subsequent to SP1010, LQM/CIEH have published a document entitled 'The LQM/CIEH S4ULs for Human Health Risk Assessment' 2015. In brief, the document provides updated assessment criteria which have been derived in accordance with UK legislation, national as well as EA policy and using a modified version of the CLEA software and available guidance. The new screening criteria, or Suitable 4 Use Levels (S4ULs), are intended to provide a complete and updated replacement to the previous LQM/CIEH GAC of 2009. As such they are considered appropriate for use in this assessment for other contaminants not covered by C4SL's and/or for organic contaminants assuming a worst-case Soil Organic Matter (SOM) of 1% as an initial conservative assessment.

8.10 For each contaminant, S4UL's and C4SL's have been calculated for six land use scenarios, namely:

- Residential with homegrown produce.
- Residential without homegrown produce.
- Allotments.
- Commercial.
- Public Open Space, near residential housing.
- Public Parks, remote from residential housing.

8.11 In light of the proposed continued industrial use, the SL's for a "Commercial" end-use are considered appropriate for the assessment at this stage.

8.12 A table of relevant SL's are provided in Appendix 07.

Controlled Waters

8.13 Generic assessment criteria (GAC) for the assessment of potential groundwater contamination have been derived from very conservative guidelines protective of drinking water and environmental quality, namely:

- UK Drinking Water Standards (DWS) as defined by The Water Supply (Water Quality) Regulations, 2016;
- UK Environmental Quality Standards (EQS) for Freshwater, based on a Hardness of 50 - 100mg/l (soft to moderately hard), 2000;
- Petroleum Products in Drinking-water, Background document for development of WHO Guidelines for Drinking-water Quality, 2011.

Soil Test Results

8.14 9no soil samples were analysed for a suite of Contaminants of Concern (CoC). None of the concentrations were measured exceeded the SL's for "Commercial" end-use.

8.15 Chrysotile and Amosite asbestos was detected in 3no of the 7no samples analysed as microscopic loose fibres and bundles.

Leachate Testing

8.16 Comparison of the leachate analysis results against the adopted stringent generic assessment criteria indicates the following exceedences.

Contaminant	Ref Value ug/l			Exceedances in ug/l			Sample
	EQS	UKDWS	WHO	EQS	UKDWS	WHO	
Arsenic	50	10	-	54 & 610	54 & 610	-	WS03 0.90m WS04 0.90m
Mercury	1	-	-	2	-	-	WS02 0.30m
PAH	-	0.1	-	-	1.43	-	WS03 0.90m

Contaminant	Ref Value mg/l			Exceedances in mg/l			Sample
	EQS	UKDWS	WHO	EQS	UKDWS	WHO	
Sulphate	400	250	-	630	630	-	WS03 0.90m

Notes
PAHs reference values are based on the sum of four – benzo[b]fluoranthene, benzo[ghi]perylene, benzo[k]fluoranthene and indendo[1,2,3-cd]pyrene.

8.17 Notwithstanding the above, no significant concentrations of arsenic, mercury or PAH's were measured in the soil.

Discussion and Conclusions

Human Health

8.18 In light of no exceedences of generic SL's in the samples analysed, ground contamination at the site is not considered to represent a significant long-term risk to human health.

8.19 Notwithstanding this, chrysotile and amosite asbestos has been encountered sporadically within the made ground and it cannot be discounted that ACM and/or free fibres together with other unidentified contamination could occur on and beneath other areas of the site.

8.20 Following site development, the site will be surfaced with buildings and hardstanding, with no mechanism for a direct contact pollution linkage to any unidentified contaminants or for any asbestos fibres to become airborne. Therefore, the risk to end-users and to the general public will be negligible.

8.21 However, as there is a possibility of asbestos fibres becoming airborne during site enabling and ground works, there is a perceived risk to construction workers and the general public of exposure, particularly during dry weather conditions.

8.22 Groundworks may therefore need to be undertaken under a watching brief in consultation with an asbestos specialist, with any ACM so encountered being segregated for removal to landfill under appropriate legislation. Such operations may also need to incorporate specific control measures such as dust suppression, perimeter air monitoring and appropriate Personal Protective Equipment (PPE).

Controlled Waters

8.23 Analysis for potentially leachable contaminants in random soil samples indicates exceedences of stringent water quality standards for arsenic, mercury, sulphate and PAH. However, this does not imply that the contaminants will enter the water environment at hazardous concentrations.

8.24 The site will be covered by relatively impermeable concrete hardcover and will maintain a positive drainage system. As such, the potential for surface water infiltration and resulting mobilisation of contaminants towards the groundwater and surface water receptors will be greatly reduced.

8.25 In addition, the River Thames adjacent to the site is tidal, therefore providing significant dilution of any mobilised contamination entering the river from the site.

8.26 In view of the above, the risk to controlled waters from ground contamination at the site is considered low.

Waste Disposal

8.27 It is assumed that waste soils will be removed from site through appropriate Duty of Care.

8.28 For preliminary guidance based on the current information, it is likely that the majority of made ground would be classified as 'Non-hazardous' with natural soils classified as 'Inert' for landfill disposal.

8.29 However, it will be the responsibility of the waste producer to undertake further testing and classification of waste soils for disposal to an appropriately licenced landfill in accordance with current guidelines and Duty of Care requirements.

9.0 GROUND GAS RISK ASSESSMENT

Ground Gas Conceptual Model

9.1 The site is indicated by UK Radon to be to be within an area where between 1% and 3% of properties are above the action level of exposure for residential properties. However, a review of the maps provided in Appendix A of BRE211:2015 indicates that no protective measures are required for the area under consideration.

9.2 There are no recorded current or historic landfills within influencing distance of the site.

9.3 In consideration of the underlying geology, risks of shallow abandoned mine workings which could contain hazardous gases can be discounted.

9.4 Ground investigation has indicated no significant thicknesses of degradable soils capable of generating hazardous ground gas in significant volumes.

9.5 A thin layer of peat occurs beneath the site, which can contain methane in significant concentrations due to ancient degradation of plant material. However, continued generation of ground gas within the peat deposit is unlikely, with such gases only being released if the peat is significantly disturbed or consolidated.

9.6 Such disturbance could occur due to piling operations although the release of gases from the peat layer would likely be immediate.

9.7 Further to this, the proposed development is to comprise open, well ventilated buildings with no enclosed spaces.

Risk Assessment

9.8 In consideration of the above, the long-term risk from ground gas at the site is considered low.

9.9 However, it is recommended that health and safety measures such as a no smoking policy are put in place, with personal gas detection monitoring being possibly employed within excavations requiring man entry and in proximity to piling operations.

APPENDIX 01

Drawings

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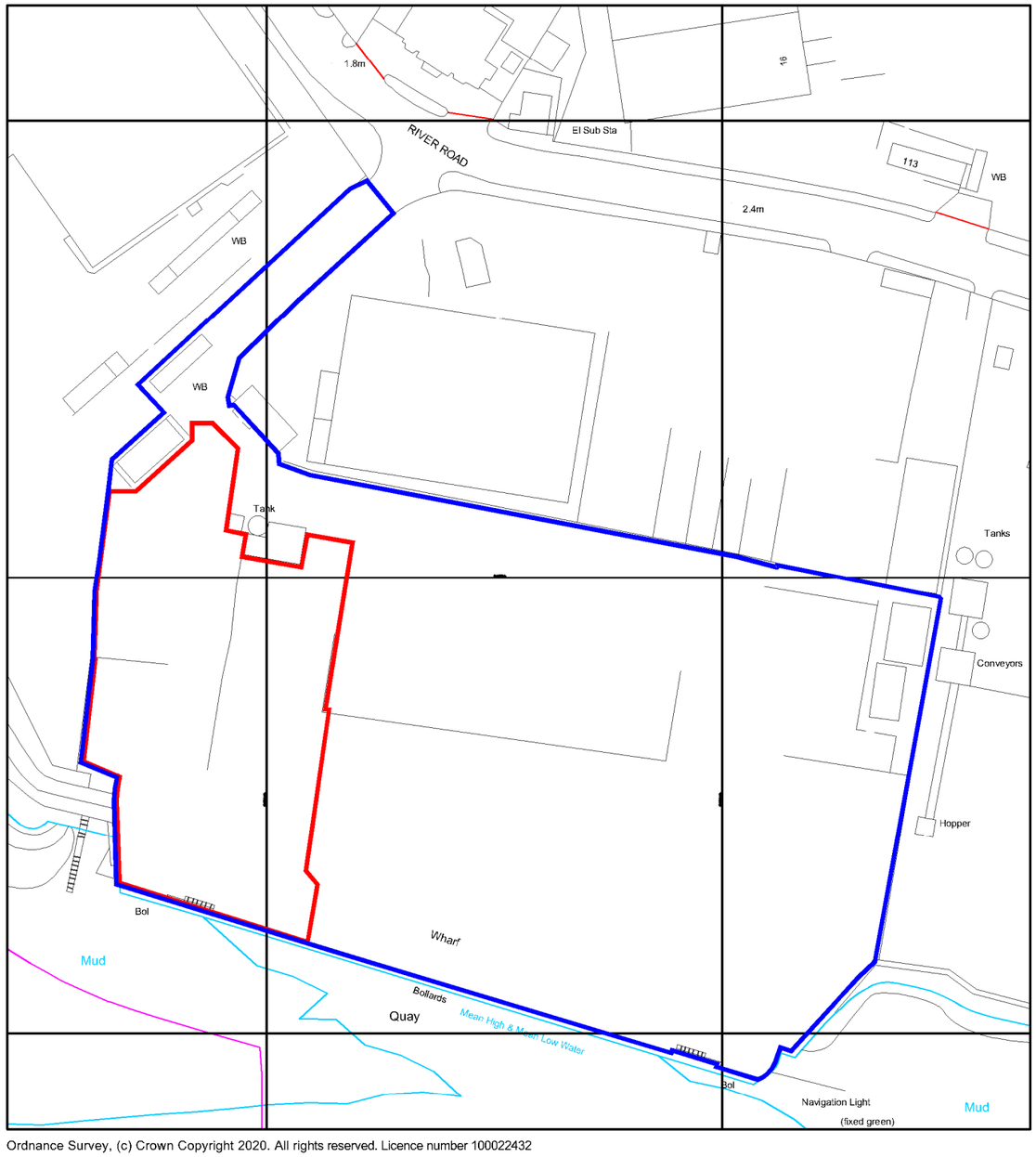

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N

Key

Site Boundary

Ownership Boundary

0 12.5m 25m 50m

1:1250 @ A3

Revision	Description	Date	Drawn	Checked
P1	Issued for Planning Application.	08.06.20	PC	PC
	PLANNING APPLICATION			

Halliday Meecham Architects Limited

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HALLIDAY MEECHAM ARCHITECTS

Client:	S Norton Co
Project:	Barking Yard Redevelopment
Phase/ Location:	River Rd, Barking, IG11 0DS
Drawing:	Location Plan

Scale @ A3	Date:	Drawn:	Checked:	Job No.	Drawing No.
1:1250	JUN 20	PC	OC	5326	00001

Drawing Ref.	Revision
5326-HMA-V-XX-DR-A-00001	P1

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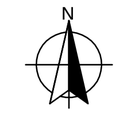

Site Entrance

Key

Site Boundary

Ownership Boundary

Existing weighbridge

No works to
entrance area of site

2 containers

3 storey cabins

Existing tanks retained

Concrete slab

Existing building to be removed
allow for new Non FE Shed

Existing Office cabin
to be demolished

No works to eastern side of site

Concrete slab

0 5m 10m 20m

1:250 @ A1

Revision	Description	Date	Drawn	Checked
P1	Issued for Planning Application.	08.06.20	PC	OC
PLANNING APPLICATION				

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HALLIDAY MEECHAM ARCHITECTS

Client:	S Norton & Co
Project:	Barking Site Redevelopment
Phase/ Location:	River Rd, Barking, IG11 0DS
Drawing:	Existing Site Plan

Scale @ A1	Scale @ A3	Date:	Drawn:	Checked:	Job No.	Drawing No.
1:250	1:500	JUN 20	PC	OC	5326	00120

Drawing Ref.	Revision
5326-HMA-V-XX-DR-A-00120	P1

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N

R ROAD

Site Entrance

WB

Key

Site Boundary

Ownership Boundary

New concrete hardstanding - where laids to falls these are shown locally on plan

Existing weighbridge

No works to entrance area of site

2 containers retained

EXISTING BUILDING

Existing Modular Office and Amenities block retained

New in-situ concrete kerb along slab edge, with new pedestrian railing fixed to top

16513

New manhole to allow for drainage of surface water

29433

New manhole to allow for drainage of surface water

EXISTING TANK

EXISTING STORAGE TANK

952

New vehicle and pedestrian barriers

15758

Existing palisade fence to be replaced

13480

Proposed ASM Detector

4529

Proposed section of palisade fence to site boundary

Proposed weighbridge

14556

Refer to plans and elevations for details of Non FE Shed and Battery Store proposals

Proposed Non FE Shed

18641

Proposed Workshop

1232

New section of palisade fence with gate

Refer to plans and elevations for details of Workshop proposals

2375

New section of palisade fence

668

25176

2734

Proposed floodlights

New section of palisade fence

Proposed Battery Store Under Canopy

8021

New 6m high steel fences to form new storage bays

New 6m high steel fence

32955

New section of pedestrian railings

Proposed floodlights

RAMP UP 1:50 APPROX

T.O.C. 4.350m

Mud

0 5m 10m 20m

1:250 @ A1

P1	Issued for Planning Application.	08.06.20	PC	OC
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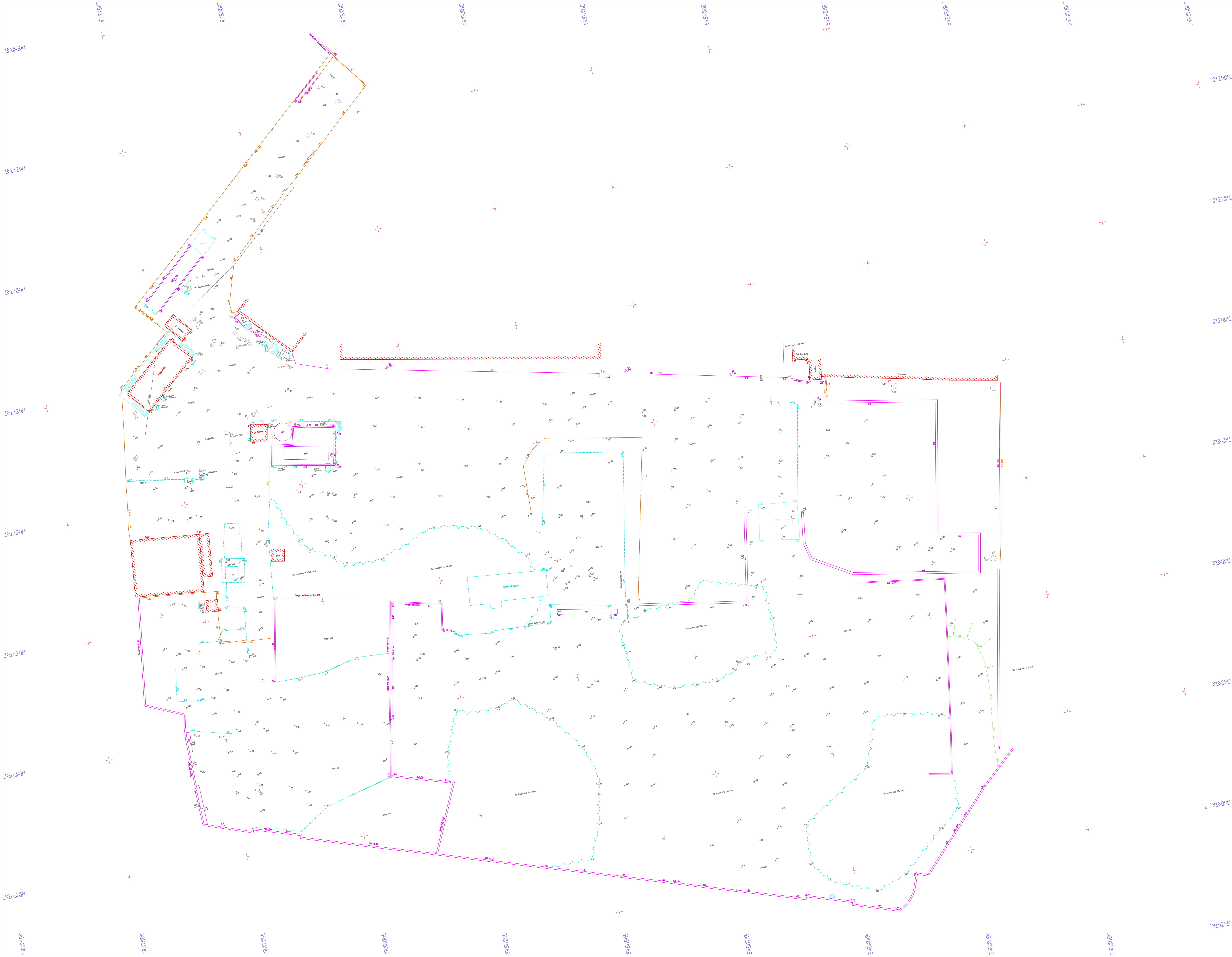
HALLIDAY MEECHAM ARCHITECTS

Client:	S Norton & Co
Project:	Barking Yard Redevlopment
Phase/ Location:	River Rd, Barking, IG11 0DS
Drawing:	Proposed Site Plan

Scale @ A1	Scale @ A3	Date:	Drawn:	Checked:	Job No.	Drawing No.
1:250	1:500	JUN 20	PC	OC	5326	00220

Drawing Ref.	Revision
5326-HMA-V-XX-DR-A-00220	P1



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A0

This survey has been produced at the survey scale detailed below with its accuracy commensurate with the indicated scale and should only be used for its original intended purpose. Any scaling should only be undertaken using a stable media print produced using the original data The plotted scale may differ (for presentation purposes) from the survey scale.

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All ground features that were visible at the time of the survey have been located, however there may have been items obscured. Pipe sizes and flow direction have been visually assessed from the surface and should be considered as approximate only.

All data remains in the ownership of Formby Surveys Ltd and any discrepancies between this survey and any other information should be reported to Formby Surveys Ltd.

Topographical Legend

(where applicable)

Building
Gate
Hedge
Foliage
Tree
Ø0.35/MS/H6
Dia/Trunk/Ht
NB:Spread & Heights are indicative
Spot Level
×50.00
Survey Station
FS01
Borehole
Trial Pit
Window Sample
Dynamic Cone Penetrometer
Top of Bank
Bottom of Bank
Contours
25.50
Photo Position (& orientation)

Abbreviations

(where applicable)

AB	Air Brick	IT	Intercom
AV	Air Valve	JTN	Junction Box
BB	Belisha Beacon	KL	Keep Left
BC	Building Canopy	KO	Kerb Outlet
BH	Borehole	LP	Lamp Post
BL	Bed Level	MB	Mooring Bollard
BM	Bench Mark	ME	Meter Manhole
BDY	Boundary	MH	Manhole
BO	Bollard	MK	Marker
BS	Bi-Stem (Tree)	MS	Multi-Stem (Tree)
BST	Bus Stop	MY	Mercury Manhole
BT	British Telecom Manhole	NB	Notice Board
C	Crest	NFS(**)	Additional Survey Station
CE	Cat's Eye	NP	Road Name Plate
CCTV	Closed Circuit Television	OB	Out Building
CL	Ceiling Level	OS	Ordnance Survey
CP	Concrete Post	P	Post
CR	Cycle Rack	PB	Post Box
CTV	Cable Television Manhole	PED	Pedestrian Pad
CUL	Culvert	PI	Pipe
DK	Drop Kerb	PM	Parking Meter
DP	Drain Pipe	PO	Post Office Manhole
DPC	Damp Proof Course	PP	Power Point
D	Drain	RE	Rodding Eye
DCP	Dynamic Core Penetrometer	RS	Road Sign
DWB	Dog Waste Bin	RTW	Retaining Wall
EB	Electricity Box	RWP	Rainwater Pipe
EL	Electricity Manhole	SDP	Stand Pipe
EP	Electricity Pole	SK	Soakaway
ER	Earthing Rod	SOF	Soffit Level
FBR	Footbridge	SWMH	Storm Water Manhole
FCL	Fence (Chain Link)	ST	Stop Tap
FFL	Finished Floor Level	SU	Stump (Tree)
FIR	Fence (Iron Railing)	SV	Stop Valve
FL	Floor Level	SVP	Soil Vent Pipe
FWMH	Foul Water Manhole	SW	Storm Water
FP	Flag Pole	SY	Stay (e.g. Pylon, TP)
FPC	Fence (Post & Chain)	TBM	Temporary Benchmark
FPP	Fence (Post & Panel)	TCB	Telephone Call Box
FPR	Fence (Post & Rail)	TH	Threshold Level
FPW	Fence (Post & Wire)	TL	Traffic Light
FSB	Fence (Safety Barrier)	TOW	Top of Wall
FS**	Permanent Survey Station	TP	Telegraph Pole
FW	Foul Water	TPT	Trial Pit
FWM	Fence (Wire Mesh)	TS	Tri-Stem (Tree)
GV	Gas Valve	TSI	Traffic Signal Manhole
GL	Ground Level	U/B	Under Beam
GP	Gate Post	UP	Upright
GS	Gravestone	UTR	Unable To Raise
GU	Gully	VP	Vent Pipe
H	Height	WCL	Window Cill Level
HY	Hydrant	WHL	Window Head Level
IC	Inspection Chamber	WL	Wall Level
IS	Information Sign	WM	Water Meter

Survey Control

Station	Easting	Northing	Level
R1	545909.150	181698.453	4.37
R2	545892.495	181707.036	5.63
R3	545871.044	181711.584	5.46
R4	545821.793	181721.059	4.99
R5	545808.645	181709.502	4.67
R6	545807.435	181702.753	4.67

Grid & Datum

Survey Grid: Local Grid ☐ Nat. Grid (OSGB36) ☑ Nat. Grid (Graph. Fit) ☐ Existing Grid ☐

Survey Datum: Local Datum ☐ Nat. Grid (OSGB36) ☑ Nat. Grid (Spot Level) ☐ O.S.B.M. ☐

The survey grid & level datum relate to the Ordnance Survey active GPS network (OSGB36) established via Leica SmartNET, plotted with no scale factor applied.

The current survey has been merged with existing survey data, from either a previous project or from a third party. This data may not truly represent current features due to site changes and may have been produced at a different scale to the most recent information.

General Notes

1. All arrows on steps / ramps etc indicate an UP direction unless otherwise stated.
2. Site traffic or obstructions encountered at the time of the survey may have resulted in surface features being omitted.

Rev	Date	Description	CAD

Client

Axion Polymers

measure+ manage+ deliver+

FormbySurveys

Professional Measurement Surveyors

Formby Surveys Ltd
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E info@formbysurveys.com
W www.formbysurveys.com

Topographical Survey

Land at River Road, Barking London, LG11 0DS

Plotted Scale: A0@1:250
NB: Survey Scale: 1:250
0.0 5.0 10.0 15.0m

Surveyor: NT | CAD: BM | Checker: JO | Rev:

Date of Issue: February 2019 | FSL Ref No: 10477_T:250:1:1

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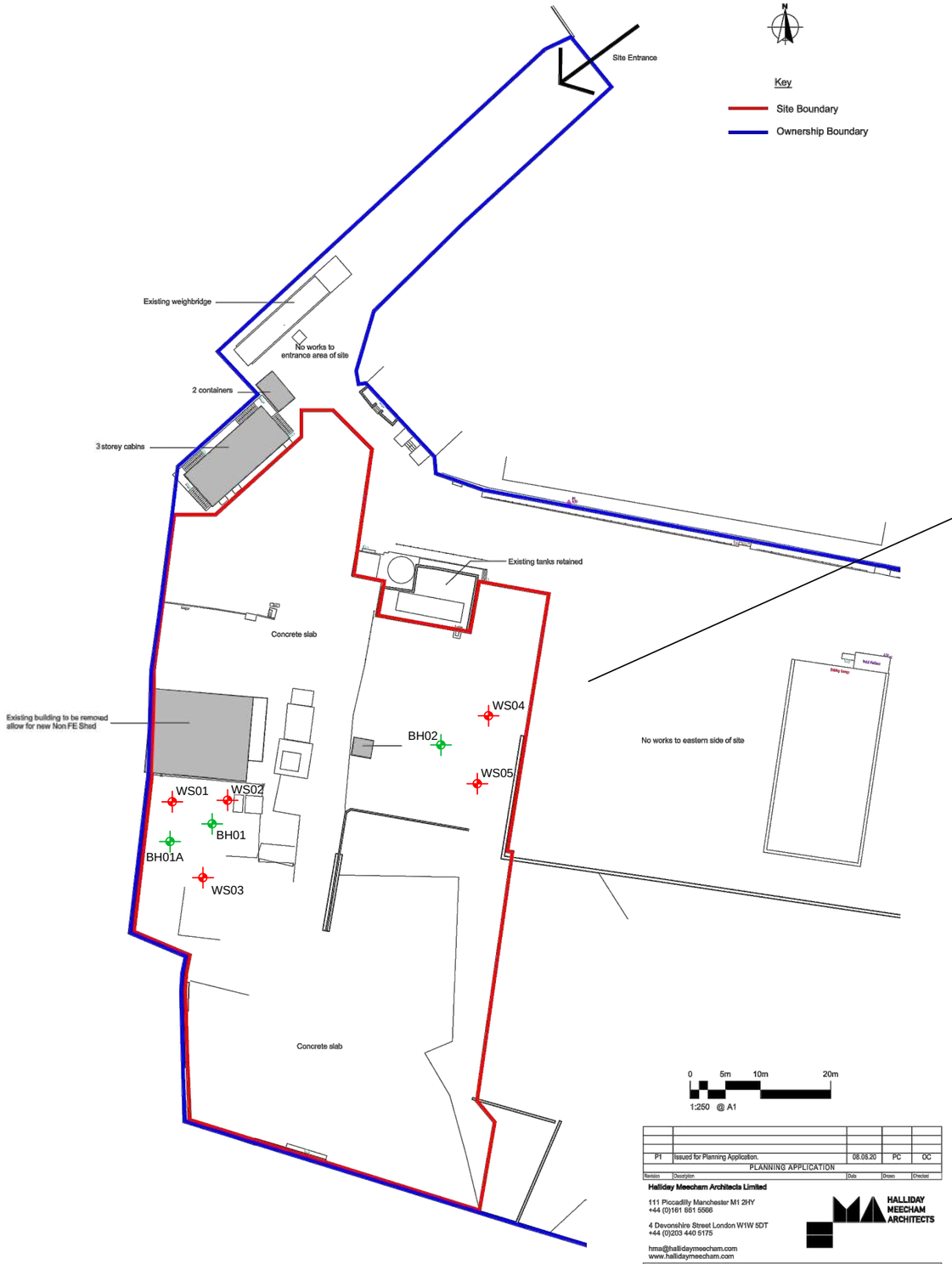

P1	Issued for Planning Application.	08.06.20	PC	OC
	PLANNING APPLICATION			
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HALLIDAY MEECHAM ARCHITECTS

Client:	S Norton & Co
Project:	Barking Site Redevelopment
Project Location:	River Rd, Barking, IG11 0DS
Drawing:	Existing Site Plan

Scale @ A1	Scale @ A3	Date:	Drawn:	Checked:	Job No.	Drawing No.	Revision
1:250	1:500	JUN 20	PC	OC	5326	00120	P1

Drawing Ref.: 5326-HMA-V-XX-DR-A-00120

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Key
Site Boundary
Ownership Boundary

0 12.5m 25m 50m
1:1250 @ A3

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HALLIDAY MEECHAM ARCHITECTS

Client:	S Norton Co
Project:	Barking Yard Redevelopment
Project Location:	River Rd, Barking, IG11 0DS
Drawing:	Location Plan

Scale @ A1	Scale @ A3	Date:	Drawn:	Checked:	Job No.	Drawing No.	Revision
1:1250		JUN 20	PC	OC	5326	00001	

Drawing Ref.: 5326-HMA-V-XX-DR-A-00001 — Revision: P1

KEY

WIDER SITE BOUNDARY

REDEVELOPMENT AREA

BH01 — CABLE PERCUSSIVE BOREHOLE

WS01 — WINDOW SAMPLE HOLE

Rev.	Amendment	Date	By	Chkd
	ISSUE REVISION.	00-00-00	BY	Chk

Project
BARKING YARD REDEVELOPMENT

Client
AXION

Title
EXPLORATORY HOLE LOCATION PLAN

Drawn	Checked	Date	Scale
SCS	PGD	06/06/20	AS INDICATED

WML CONSULTING
Civil, Structural & Geotechnical Engineers

No.8 Oak Green
Earl Road
Stanley Green Business Park
Cheadle Hulme
Cheshire SK8 6QL
Tel 0161 482 0600
Fax 0161 486 9210
e-mail info@wmlconsulting.com
www.wmlconsulting.com

Job No.	Drawing No.
8860G	SK-01

APPENDIX 02

Detailed Unexploded Ordnance Risk Assessment

1ST LINE DEFENCE

Detailed Unexploded Ordnance (UXO) Risk Assessment

Project Name	S. Norton & Sons, River Road, Barking
Client	WML Consulting
Site Address	River Road, Barking, London, IG11 0DS
Report Reference	DA10683-00
Date	1st April 2020
Originator	CB

Find us on Facebook, Twitter and LinkedIn
Company No: 7717863 VAT No: 128 8833 79
www.1stlinedefence.co.uk

1st Line Defence Ltd
Unit 3, Maple Park, Essex Road, Hoddesdon, Herts. EN11 0EX
Tel: +44 (0)1992 245 020 info@1stlinedefence.co.uk

Executive Summary

Site Location and Description

The site is located in Barking, east London. Recent aerial photography indicates the site footprint to currently comprise the premises of S. Norton & Sons, a metal recycling company, consisting of a large open hard surfaced yard area containing some small structures and several large piles of metal waste. It is bound to the north by a waste recycling plant on River Road, to the east by a hard surfaced yard area of a presumed industrial nature, to the south by the River Thames and to the west by open ground of both a hard surfaced and grassland nature.

The site is approximately centred on the OS grid reference: **TQ 45825 81667**.

Proposed Works

The proposed works are understood to involve the construction of 2no commercial/industrial units and a weighbridge.

Geology and Bomb Penetration Depth

The British Geological Survey (BGS) map shows the site area to be underlain by a combination of the following:

- Lewes Nodular Chalk Formation, Seaford Chalk Formation and Newhaven Chalk Formation (undifferentiated) – chalk, of the Cretaceous Period.
- Thanet Formation – sand, of the Palaeogene Period.

Superficial deposits are indicated to comprise Alluvium – clay, silt, sand and peat, of the Quaternary Period.

Site-specific geotechnical data provided by WML Consulting confirmed 0.4m of concrete underlain by made ground (6F2) to 2.6m bgl. The made ground was underlain by soft clay to 6.2m bgl, peat to 7.4m bgl and medium dense sand and gravel interbedded with firm clay to 16m bgl where the nodular chalk was encountered. However, due to the limitations of the data available, a maximum bomb penetration depth could not be assessed. An assessment of maximum bomb penetration depth can be made once more 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 a **Medium Risk** from items of German aerial delivered UXO and Allied UXO across the site. This assessment is based on the following factors:

- During WWII, the site area was situated within the Municipal Borough of Barking. A borough of 3,877 acres, Barking sustained an overall very high density bombing campaign; an average of 156.8 items of ordnance were recorded per 1,000 acres, according to Home Office statistics. This bombing density can be attributed to the presence of a number of Luftwaffe bombing targets in the vicinity, including the Beckton Gas Works and Barking Power Station. The site itself was an industrial facility in a prominent position on the banks of the Thames – it may in itself have constituted an obvious and viable target from the air.
- The site was occupied by the Lawes Chemical Works and a section of the River Thames during WWII. The chemical works consisted of a large structure in the centre of the site area, several smaller structures, open hard surfaced ground and a wharf.
- London bomb census mapping and local bomb plot mapping both record incidents within and immediately adjacent to the site area, including HE bomb strikes in the centre of the boundary and to the immediate north and north-west. An anti-aircraft shell is also recorded on the north-western border. However, whilst analysing available written records, no references to incidents occurring within the site area were found. It should be noted that the available written records were often ambiguous regarding the locations of incidents.
- Aerial photography taken in 1941 does not identify any obvious areas of structural clearance or significant damage within the site footprint. However, when comparing with post-WWII photography taken in 1946, whilst the general composition of the site area does not alter, there is evidence suggesting that structures present on site sustained bomb damage i.e. repairs to roofing. However, given the limitations of the available record set, the exact extent of any damage is unknown.
- At the outset of WWII, the land based area of the site is likely to have experienced frequent and regular levels of access due to its occupation by an industrial feature. Furthermore, the ground cover present should have been largely conducive to the visual detection of UXO i.e. structures, hard surfaced ground at the outset of WWII. However, following the recorded bombing incidents, there is the potential for conditions unconducive to the detection of UXO to have been

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UXO Risk Assessment

created i.e. rubble and debris. This will also have potential resulted in a decrease in access levels for a period. Items of UXO are considered more likely to fall unnoticed in areas occupied by rubble and debris and poorly accessed areas such as the disturbed ground in the eastern section of the site

- During WWII, the southern section of the site was occupied by open water and an area of mud/foreshore. It is considered very unlikely that any UXO falling within these areas would have been noted and reported at the time as there would have been little if any evidence of their presence left. These sections of the site are considered to be at a somewhat greater risk of contamination. It is noted that some of this southern section of the site has been subject to infill post-war. Whilst there is not considered to be any significant risk of contamination within the levels of post-war fill, below these levels a risk of encountering UXO would still remain.
- There is no evidence 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 aerial delivered ordnance.

Recommended Risk Mitigation Measures

The following risk mitigation measures are recommended to support the proposed works at the S. Norton & Sons site in Barking:

All Works

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

Open Intrusive Works (trial pits, service pits, open excavations, shallow foundations etc.)

- UXO Specialist On-site Support

Boreholes and Piled Foundations

- Intrusive Magnetometer Survey of all borehole and pile locations/clusters down to maximum bomb penetration depth.

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Glossary

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

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

Site: S. Norton & Sons, River Road, Barking
Client: WML Consulting

1. Introduction

1.1. Background

1st Line Defence has been commissioned by WML Consulting to conduct a Detailed Unexploded Ordnance (UXO) Risk Assessment for the works proposed at the S. Norton & Sons site on River Road, Barking.

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

UXO in the UK can originate from three principal sources:

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

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

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

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2. Method Statement

2.1. Report Objectives

The aim of this report is to conduct a comprehensive assessment of the potential risk from UXO at the S. Norton & Sons site on River Road, Barking. The report will also recommend appropriate site and work-specific risk mitigation measures to reduce the risk from explosive ordnance during the envisaged works to a level that is as low as reasonably practicable.

2.2. Risk Assessment Process

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

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

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

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

2.3. Sources of Information

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

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

Research involved a visit to The National Archives and Barking & Dagenham Archives.

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3. Background to Bombing Records

3.1. General Considerations of Historical Research

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

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

3.2. German Bombing Records

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

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

3.3. Allied Records

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

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

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4. UK Regulatory Environment and Guidelines

4.1. General

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

4.2. CDM Regulations 2015

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

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

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

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

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

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

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4.4. CIRIA C681

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

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

4.5. Additional Legislation

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

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5. The Role of Commercial UXO Contractors and The Authorities

5.1. Commercial UXO Specialists

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

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

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

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

5.2. The Authorities

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

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

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

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

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6. The Site

6.1. Site Location

The site is located in Barking, east London. It is bound to the north by a waste recycling plant on River Road, to the east by a hard surfaced yard area of a presumed industrial nature, to the south by the River Thames and to the west by open ground of both a hard surfaced and grassland nature.

The site is approximately centred on the OS grid reference: **TQ 45825 81667**.

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

6.2. Site Description

Recent aerial photography indicates the site footprint to currently comprise the premises of S. Norton & Sons, a metal recycling company, consisting of a large open hard surfaced yard area containing some small structures and several large piles of metal waste.

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

7. Scope of the Proposed Works

7.1. General

The proposed works are understood to involve the construction of 2no commercial/industrial units and a weighbridge.

8. Ground Conditions

8.1. General Geology

The British Geological Survey (BGS) map shows the site area to be underlain by a combination of the following:

- Lewes Nodular Chalk Formation, Seaford Chalk Formation and Newhaven Chalk Formation (undifferentiated) – chalk, of the Cretaceous Period.
- Thanet Formation – sand, of the Palaeogene Period.

Superficial deposits are indicated to comprise Alluvium – clay, silt, sand and peat, of the Quaternary Period.

8.2. Site Specific Geology

Site-specific geotechnical data provided by WML Consulting confirmed 0.4m of concrete underlain by made ground (6F2) to 2.6m bgl. The made ground was underlain by soft clay to 6.2m bgl, peat to 7.4m bgl and medium dense sand and gravel interbedded with firm clay to 16m bgl where the nodular chalk was encountered.

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9. Site History

9.1. Introduction

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

9.2. Summary of the Historical Background of the Site

During WWII, the site was occupied by the Lawes Chemical Company. Founded in 1857, the main factory and workmen's cottages were built at Barking Creek, Essex at some point prior to 1875. The business was purchased from Lawes in 1872 and incorporated as Lawes Chemical Manure Co. Ltd, to manufacture artificial fertilisers, sulphuric acid and other chemical fertilisers. The company became Lawes Chemical Co. Ltd. in 1935 and went into liquidation in 1969, the business continuing to trade under the name of Seabright Chemicals Ltd.

Between the 1920s and 1940s, the structures on site appear to have been locally modified, prior to being developed into a smaller unnamed works sometime prior to 1944. Sometime between the late 1980s and the late 1990s the site was redeveloped into its current configuration as S. Norton & Sons metal recyclers.

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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**
1916	1:2,500	This map edition indicates the site area to have been primarily occupied by a large industrial structure, known to have been the premises of the Lawes Chemical Company. Some smaller structures situated in the west and north-west of the boundary are assumed to be associated with the chemical works. To the immediate south of the chemical works is an embankment labelled to consist of *mud*. Features in this area of the site include two *cranes*, a *wharf* and a *pier*. The boundary also comprises part of the River Thames. The site's immediate surrounds are defined by workmen's cottages to the north-west, a further part of the chemical works to the east and the River Thames to the south.

Post-WWII		
Date	**Scale**	**Description**
1958 – 1962	1:1,250	The larger structure previously present on site is indicated to have been cleared and replaced with a number of smaller structures; these structures are known to still comprise the chemical works. The *cranes* and *pier* are no longer labelled in the south of the boundary. Clearance has also occurred to the immediate north-west of the boundary; the workmen's cottages are no longer present. It should be noted however that the date of this map is dated around fifteen years post-war, and any structural changes noted may not be indicative of bomb damage.

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9.4. Historical Photography of the Site

Historical photography has been obtained from the Aerofilms collection available from *Britain From Above*. This imagery provides a view of the site in 1921 and 1931 (see **Annex E**). See below for a description:

Title of Photograph	Comments
EPW006139 – Lawes Chemical Manure Co Ltd, Creekmouth, 1921	This image portrays the site area and its immediate surrounds from the south-east. A large warehouse structure defines the majority of the site footprint.
EPW006140 – Lawes Chemical Manure Co Ltd, Creekmouth, 1921	This image portrays the site area and its immediate surrounds from the south on the adjacent side of the Thames. The chemical works is shown to extend eastwards out of the site footprint. The area to the immediate north of the boundary is defined entirely by open ground.
EPW036779 – The Lawes Chemical Co Works, the Barking Guano Works and environs, Creekmouth, from the south-east, 1931	This image portrays the site area and its immediate surrounds from the south-east. The chemical works is shown to have been reduced in size; the section of the works formerly situated immediately east of the boundary is now occupied by open hard surfaced ground.
EPW036783 – The Lawes Chemical Co Works, pylons running across the Dagenham Marshes and environs, Creekmouth, from the south-west, 1931	This image portrays the site area and its immediate surrounds from the south-west.

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10. Introduction to German Aerial Delivered Ordnance

10.1. General

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

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

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

10.2. Generic Types of WWII German Aerial Delivered Ordnance

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

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

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10.3. Failure Rate of German Aerial Delivered Ordnance

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

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

From 1940 to 1945, bomb disposal teams reportedly dealt with a total of 50,000 explosive items of 50kg, over 7,000 anti-aircraft projectiles and 300,000 beach mines. Unexploded ordnance is still regularly encountered across the UK, see press articles in **Annex H1**.

10.4. UXB Ground Penetration

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

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

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

10.4.1. The J-Curve Effect

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

10.4.2. WWII UXB Ground Penetration Studies

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

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

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10.4.3. Site Specific Bomb Penetration Considerations

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

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

It has not been possible to determine maximum bomb penetration capabilities at this stage due to the limitations of site-specific geotechnical information currently available. 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.

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 1000kg warhead failed to explode, the weapons are so large that they would have been observed and dealt with at the time. Therefore, V-weapons are referenced in this report not as a viable risk factor, but primarily in order to help account for evidence of damage and clearance reported.

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11. The Likelihood of Contamination from German Aerial Delivered UXBs

11.1. World War I

During WWI Britain was targeted and bombed by Zeppelin Airships, as well as Gotha and Giant fixed-wing aircraft. An estimated 250 tons of ordnance (high explosive and incendiary bombs) was dropped on Greater London, more than half of which fell on the City of London (see **Annex I** for a WWI bomb plot map of London). This source does not record any WWI bombing incidents to have affected the site.

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

11.2. World War II Bombing of the Municipal Borough of Barking

The Luftwaffe's main objective for the attacks on London was to inhibit the capital's commercial output. To achieve this they targeted the docks, warehouses, wharves, railway lines, factories and power stations. As the war progressed this strategy gradually changed to the indiscriminate bombing of civilian areas in an attempt to subvert public morale.

During WWII the site was located within the Municipal Borough of Barking, which sustained a very high density of bombing, as represented by bomb density data figures and maps, see **Annex J**. This was mainly due to its location in London and its proximity to key Luftwaffe targets such as Barking Power station and the Beckon Gas Works (shown in Luftwaffe reconnaissance photography in **Annex K**).

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

Records of bombing incidents for Municipal Borough of Barking are presented in the following sections.

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11.3. WWII Home Office Bombing Statistics

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

Record of German Ordnance Dropped on the Municipal Borough of Barking		
Area Acreage		**3,877**
Weapons	High Explosive bombs (all types)	484
	Parachute mines	26
	Oil bombs	12
	Phosphorus bombs	11
	Fire pots	15
	Pilotless aircraft (V-1)	40
	Long range rocket bombs (V-2)	20
Total		**608**
Number of Items per 1,000 acres		**156.8**

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.

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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 **Annexes L-M**.

Consolidated London Bomb Census Maps – Annex L1	
Date Range	**Comments**
Night Bombing up to 7th October 1940	An incident is recorded within the site footprint. A further incident is plotted approximately 200m to the north-west.
7th October 1940 to 6th June 1941	An incident is plotted to the immediately north of the boundary in the confines of the chemical works. Several further incidents are recorded in the site's immediate and wider surrounds; the closest is plotted approximately 30m to the east of the boundary.

Weekly London Bomb Census Maps – Annex L2-L4	
Date Range	**Comments**
7th to 14th October 1940	A HE incident is recorded on the site's northern boundary. This incident is part of a stick which fell to the north-west of the boundary; however, it is not visible on the map.
25th November to 2nd December 1940	No incidents are recorded within the site footprint during this week. However, a UXB strike is plotted on the *Guano Works* approximately 200m east of the site footprint.
6th to 13th January 1941	An incendiary bomb 'shower' is recorded over the site footprint during this week.
17th to 23rd January 1944	No incidents are recorded within the site footprint during this week. However, a phosphorous bomb is recorded approximately 300m north-east of the boundary to the immediate north of the *Guano Works*.
24th to 30th January 1944	A 500kg HE bomb is recorded to the immediate south-easy of the site footprint in the River Thames.

V-1 Pilotless Aircraft Bomb Census Map – Annex M	
Date Range	**Comments**
1944-45	No V-1 incidents are recorded within the site boundary or its immediate surrounds. The closest recorded incident is plotted approximately 360m to the north-east of the site area.

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11.5. London Bomb Census Reports

Bomb census reports compiled by the Research and Experiments Branch of the Ministry of Home Security during WWII were consulted at The National Archives. These reports recorded information such as the date, time, type and damage caused by bomb incidents for a selected time period in the region and are therefore not often comprehensive. No relevant records for the site area could be identified during the production of this report.

11.6. Barking ARP Bomb Mapping

Bomb mapping for the Municipal Borough of Barking was obtained from the Barking and Dagenham Archives and Local Studies Service. These were mostly compiled by the Borough engineers and surveyors department, and were labelled as 'Bomb Investigation Record'. Other maps do not appear to be compiled by the Borough Engineers and this will be noted. The section of these map editions showing the area of the site is presented in **Annexes N-Q.**

Barking Bomb Maps	
Date	**Comments**
AA Shell mapping likely September 1939 – December 1940 (**Annex N**)	This map is noted to be a copy of a map sent to a Group Engineer on the 17th December 1940. The date range of this map is likely from the start of the war to December 1940. An anti-aircraft (AA) shell is recorded to the immediate north-west of the site area.
Consolidated up until October 1940 (**Annex O**)	This bomb census map is based on a 1938 Landmark map of the area, with bomb strikes overlaid. This map covers the area of the London Borough of Barking and Dagenham, and was apparently compiled for a school project that was not finished, and the map only covers strikes pre-October 1940. This map does not differentiate between exploded and unexploded bombs. This map records two HE bomb strikes to the immediate north and north-west of the site area. Several HE bomb strikes are recorded in the site's wider surrounds; however, these are considered too far removed to have been of note.
29th January 1944 (**Annex P)**	This map appears to be compiled by Group Engineers. It records a HE bomb strike to the immediate east of the boundary on the banks of the Thames. There are no incidents recorded within the site footprint during this time period.
V-1 Flying Bomb Map likely 1944-1945 (**Annex Q**)	This bomb map appears to be based on the same map as the AA Shell mapping, but there are no annotations as to the date or who compiled this map. The only annotation shows 'Fly Bombs' which means this bomb plot map corresponds to V1 weapon strikes within Barking. No incidents are recorded within the site footprint; the closest recorded incident is plotted approximately 350m to the north-east of the boundary.

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11.7. Barking Register of Air Raids

Bomb incident records were obtained from the Barking and Dagenham Archives. A transcript of the associated written records for bombs which fell in the site area is presented in the table below. It should be noted that that the locations of these strikes are approximate.

Barking Register of Air Raid Incidents		
Date Range	**Location**	**Type of bomb**
17th October 1940	East side River Road, Creekmouth End.	High Explosive Bomb
3rd March 1943	In River Thames (three incidents recorded)	High Explosive Bomb

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 Annexes R-S**).

WWII-Era Aerial Photography	
Date	**Description**
18th June 1941	This image shows the boundary to have been occupied by the premises of Lawes Chemical Works at the outset of WWII, consisting of the main works building, smaller outbuildings associated with the works and open hard surfaced ground. The River Thames occupied the southern area of the boundary. No obvious evidence of structural clearance or significant structural damage to properties within the land based area of the site and its immediate surrounds is visible in this image. A wider view of the image is presented in **Annex R2**. Potential bomb craters are visible approximately 100m east of the boundary in the vicinity of an access road off River Road and approximately 260m to the north of the boundary in open ground north of River Road.
1st May 1946	Whilst the image does not indicate any significant alterations to the general composition of the site area from the previous edition, there is evidence to suggest that the chemical works sustained structural damage during WWII. Areas of roofing appear to have undergone repair works. The exact extent of any damage sustained is unknown. Furthermore, the open area of land to immediate east of the works encompassed by the site boundary displays characteristics consistent with ground disturbance sustained by bombing incidents. Damage and structural clearance is also noted to the immediate north-west of the boundary; please see **Annex S2** for a wider view of the image.

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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.

An abandoned bomb is officially registered approximately 500m north of the site area in the vicinity of a coal dump at Barking Power Station. However, 1st Line Defence holds no records of officially registered abandoned bombs at 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 (EOD) (now 29 Regt) is currently facing considerable delay. It has therefore not been possible to include any updated official information regarding bomb disposal/clearance tasks with regards to this site. A database of known disposal/clearance tasks has been referred to which does not make reference to such instances occurring within the site of proposed works. If any relevant information is received at a later date, WML Consulting will be advised.

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11.11. Evaluation of German Aerial Delivered UXO Records

Factors	Conclusion
Density of Bombing *It is important to consider the bombing density when assessing the possibility that UXBs remain in an area. High bombing density could allow for error in record keeping due to extreme damage caused to the area.*	During WWII, the site area was situated within the Municipal Borough of Barking. A borough of 3,877 acres, Barking sustained an overall very high density bombing campaign; an average of 156.8 items of ordnance were recorded per 1,000 acres, according to Home Office statistics. This bombing density can be attributed to the presence of a number of Luftwaffe bombing targets in the vicinity, including the Beckton Gas Works and Barking Power Station. London bomb census mapping and local bomb plot mapping both record bombing incidents within and immediately adjacent to the site area; including HE bomb strikes in the centre of the boundary and to the immediate north and north-west and an AA shell on the north-western border. However, whilst analysing available written records, no references to incidents occurring within the site area were found. It should be noted that the available written records were often ambiguous in regards to locations of incidents.
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.*	Whilst the general composition of the site area does not alter significantly when comparing aerial photography taken in 1941 and 1946, there is evidence to suggest that the structures present on site sustained bomb damage; areas of roofing appear to have undergone repair works. However, the exact extent of any damage sustained is unknown. It should be noted that given the site's industrial nature, any damage may have been repaired swiftly and therefore is not visible in the photography. Due to the southern area of the site's occupation by the River Thames, it is not considered possible to accurately identify areas of damage from available sources. Evidence of damage and clearance is noted to the immediate north-west of the boundary in post-war aerial photography from 1946; this can be attributed to bombing incidents in the vicinity.
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 ground cover present in the land based area of the site is considered to have been largely conducive to the visual detection of UXO i.e. structures, hard surfaced ground, at the outset of WWII. However, following the recorded bombing incidents, there is the potential for conditions unconducive to the detection of UXO to have been created i.e. rubble and debris. UXO entry holes could be as small as 20cm in diameter and could easily go undetected in such conditions. During WWII, the southern section of the site was occupied by open water and an area of mud/foreshore. Whilst the site only encompasses a small portion of the river, it is still considered a risk that an item of UXO may have fallen unnoticed and unrecorded within the site area. It is considered very unlikely that any UXO falling within these areas would have been noted and reported at the time as there would have been little if any evidence of their presence left.

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Access Frequency *UXO in locations where access was irregular would have a greater chance of passing unnoticed than at those that were regularly occupied. The importance of a site to the war effort is also an important consideration as such sites are likely to have been both frequently visited and subject to post- raid checks for evidence of UXO.*	At the outset of WWII, the land based area of the site is likely to have experienced frequent and regular levels of access due to its occupation by an industrial feature. However, following bombing incidents and any subsequent damage occurring, the site area is likely to have experienced a decrease for a period. Items of UXO are more likely to fall unnoticed in infrequently accessed areas. Regarding the marine based area of the site, the possibility of UXO falling unnoticed within this part of the site cannot be discounted due to the inability to frequently access bodies of water.
Bomb Failure Rate	There is no evidence to suggest that the bomb failure rate in the locality of the site would have been dissimilar to the 10% normally used.
Abandoned Bombs	1st Line Defence holds no records of abandoned bombs at or within the site vicinity.
Bombing Decoy sites	1st Line Defence could find no evidence of bombing decoy sites within the site vicinity.
Bomb Disposal Tasks	1st Line Defence could find no evidence of bomb disposal tasks within the site boundary and immediate area.

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12. Introduction to Allied Explosive Ordnance

12.1. General

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

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

Chemical works were often requisitioned during WWII for military purposes and were often converted in order to produce munitions. However, in this case, 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.

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12.2.1. Anti-Aircraft Artillery (AAA)

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

Anti-Aircraft Artillery				
Item	**Description**			
HAA	These large calibre guns such as the 3.7" QF (Quick Firing) were used to engage high flying enemy bombers. They often fired large HE projectiles, which were usually initiated by integral fuzes, triggered by impact, area, time delay or a combination of aforementioned mechanisms.			
LAA	These mobile guns were intended to engage fast, low flying aircraft. They were typically rotated between locations on the perimeters of towns and strategically important industrial works. As they could be moved to new positions with relative ease when required, records of their locations are limited. The most numerous of these were the 40mm Bofors gun which could fire up to 120 x 40mm HE projectiles per minute to over 1,800m.			
Variations in HAA and LSA Ammunition	**Gun type**	**Calibre**	**Shell Weight**	**Shell Dimensions**
	3.0 Inch	76mm	7.3kg	76mm x 356mm
	3.7 Inch	94mm	12.7kg	94mm x 438mm
	4.5 Inch	114mm	24.7kg	114mm x 578mm
	40mm	40mm	0.9kg	40mm x 311mm
Z-AA	The three inch unrotated rocket/projectile known as the UP-3 had initially been developed for the Royal Navy. The UP-3 was also used in ground-based single and 128-round launchers known as ''Z'' batteries. The rocket, containing a high explosive warhead was often propelled by cordite.			

The closest recorded HAA to the site was located approximately 2km east of the site, however the range of a projectile can be up to 15km. The site would also have been in range of mobile light anti-aircraft guns.

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

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

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13. The Likelihood of Contamination from Allied Ordnance

13.1. Introduction

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

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

13.2. Evaluation of Contamination Risk from Allied UXO

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

Sources of Allied UXO Contamination	Conclusion
Military Camps *Military camps present an elevated risk from ordnance simply due to the large military presence and likelihood of associated live ordnance training.*	1st Line Defence could find no evidence of a military camp within the site.
Anti-Aircraft Defences *Anti-Aircraft defences were employed across the country. Proximity to anti-aircraft defences increases the chance of encountering AA projectiles.*	1st Line Defence could find no evidence of Anti-Aircraft defences such as a HAA or LAA gun emplacement occupying or bordering the site. The closest HAA was located approximately 2km east of the site, however the range of a projectile can be up to 15km. The conditions in which HAA or LAA projectiles may have fallen unnoticed within a site footprint are analogous to those regarding German aerial delivered ordnance.
Home Guard Activity *The Home Guard regularly undertook training and ordnance practice in open areas, as well as burying ordnance as part of anti-invasion defences.*	1st Line Defence has no evidence of any Home Guard activities on the site.
Defensive Positions *Defensive positions suggest the presence of military activity, which is often indicative of ordnance storage, usage or disposal.*	There is no evidence of any defensive features formerly located on or bordering the site footprint.
Training or firing ranges *Areas of ordnance training saw historical ordnance usage in large numbers, often with inadequate disposal of expended and live items. The presence of these ranges significantly impact on the risk of encountering items of ordnance in their vicinity.*	There is no evidence of such features affecting the site.

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Defensive Minefields *Minefields were placed in strategic areas to defend the country in the event of a German invasion. Minefields were not always cleared with an appropriate level of vigilance.*	There is no evidence of defensive minefields affecting the site.
Ordnance Manufacture *Ordnance manufacture indicates an increased chance that items of ordnance were stored, or disposed of, within a location.*	No information of ordnance being stored, produced, or disposed of within the proposed site could be found.
Military Related Airfields *Military airfields present an elevated risk from ordnance simply due to the large military presence and likelihood of associated live ordnance training or bombing practice.*	The site was not situated within the perimeters or vicinity of a military airfield.

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14. The Likelihood of UXO Contamination Summary

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

UXO Contamination Summary	
Quality of the Historical Record	The research has evaluated pre- and post-WWII Ordnance Survey maps, pre-WWII oblique imagery, Luftwaffe reconnaissance imagery, London bomb census mapping, London V-1 pilotless aircraft mapping, an AA shell map for Barking, bombing raid maps for Barking, V-1 pilotless aircraft mapping for Barking, 1941 & 1946 high-resolution RAF aerial photography, and relevant in-house data. The record set is of an adequate quality. A number of sources are available; however, they are not all corroborative of one another. For example, the location of bombing incidents on London bomb census mapping and local bomb plot mapping do not match one another. Furthermore, the incident records available are vague in terms of exact locations, meaning it has not proved possible to accurately establish the amount and extent of any bombing incidents within the site footprint and its immediate surrounds.
German Aerial Delivered Ordnance	• During WWII, the site area was situated within the Municipal Borough of Barking. A borough of 3,877 acres, Barking sustained an overall very high density bombing campaign; an average of 156.8 items of ordnance were recorded per 1,000 acres, according to Home Office statistics. This bombing density can be attributed to the presence of a number of Luftwaffe bombing targets in the vicinity, including the Beckton Gas Works and Barking Power Station. The site itself was an industrial facility in a prominent position on the banks of the Thames – it may in itself have constituted an obvious and viable target from the air. • The site was occupied by the Lawes Chemical Works and a section of the River Thames during WWII. The chemical works consisted of a large structure in the centre of the site area, several smaller structures, open hard surfaced ground and a wharf. • London bomb census mapping and local bomb plot mapping both record incidents within and immediately adjacent to the site area, including HE bomb strikes in the centre of the boundary and to the immediate north and north-west. An anti-aircraft shell is also recorded on the north-western border. However, whilst analysing available written records, no references to incidents occurring within the site area were found. It should be noted that the available written records were often ambiguous regarding the locations of incidents. • Aerial photography taken in 1941 does not identify any obvious areas of structural clearance or significant damage within the site footprint. However, when comparing with post-WWII photography taken in 1946, whilst the general composition of the site area does not alter, there is evidence suggesting that structures present on site sustained bomb damage i.e. repairs to roofing. However, given the limitations of the available record set, the exact extent of any damage is unknown. • At the outset of WWII, the land based area of the site is likely to have experienced frequent and regular levels of access due to its occupation by an industrial feature. Furthermore, the ground cover present should have been largely conducive to the visual detection of UXO i.e. structures, hard surfaced ground at the outset of WWII. However, following the recorded bombing incidents, there is the potential for conditions unconducive to the detection of UXO to have been created i.e. rubble and debris. This will also have potential resulted in a decrease in access levels for a period. Items of UXO are considered more likely to fall unnoticed in areas occupied by rubble and debris and poorly accessed areas such as the disturbed ground in the eastern section of the site

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	• During WWII, the southern section of the site was occupied by open water and an area of mud/foreshore. It is considered very unlikely that any UXO falling within these areas would have been noted and reported at the time as there would have been little if any evidence of their presence left. These sections of the site are considered to be at a somewhat greater risk of contamination. It is noted that some of this southern section of the site has been subject to infill post-war. Whilst there is not considered to be any significant risk of contamination within the levels of post-war fill, below these levels a risk of encountering UXO would still remain.
Allied Ordnance	• There is no evidence 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 aerial delivered ordnance.

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15. The Likelihood that UXO Remains

15.1. Introduction

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

15.2. UXO Clearance

1st Line Defence has found no evidence in the public domain or within internal records that any official ordnance clearance operations have taken place on site. Note however that we have not received confirmation of this fact from the 33 EOD Regiment Archive (now part of 29 Regt). It should also be noted that in addition to 29 Regt archival information, 1st Line Defence also do not currently have access to data that may be relevant including 5131(BD)SQN Archive, SD Training Technical Advisory Section (TAS) and MACA Records (bomb disposal callouts).

If such information is available at a later date, it is recommended that it be reviewed as it will assist with understanding both levels and types of contamination likely to be present, and may indicate risk reduction in certain areas.

15.3. Post-War Redevelopment

Post-war redevelopment has consisted of the clearance of all surviving post-war structures, the redevelopment of the Lawes Chemical Works as evidenced in post-war OS mapping and the later clearance of the redeveloped chemical works. The site is currently shown to be occupied by a metal recycling works. 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.

Within the footprints of post-WWII redevelopments, the risk from shallow-buried UXO (especially 1kg German incendiaries and British AA projectiles) should have been encountered/removed during initial excavations. However, the risk from deep-buried German UXBs will only have been mitigated within the volumes of any post-war pile foundations or deep excavations for basement levels. The risk will remain within virgin geology below and amongst these post-war works, down to the maximum bomb penetration depth.

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16. The Likelihood of UXO Encounter

16.1. Introduction

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

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

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

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

16.2. Encountering Aerial Delivered Ordnance

Since an aerial delivered bomb may come to rest at any depth between just below ground level and its maximum penetration depth, there is a chance that such an item (if present) could be encountered during shallow excavations (for services or site investigations) into the original WWII ground level as well as at depth.

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17. The Likelihood of UXO Initiation

17.1. Introduction

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

17.2. Initiating Aerial Delivered Ordnance

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

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

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

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

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18. Consequences of Initiation/Encounter

18.1. Introduction

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

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

18.2. Consequences of Detonation

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

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

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19. 1st Line Defence Risk Assessment

19.1. Risk Assessment Stages

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

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

19.2. Assessed Risk Level

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

Ordnance Type	Risk Level			
	Negligible	Low	Medium	High
German Unexploded HE Bombs			✓	
German 1kg Incendiary Bombs			✓	
Allied Anti-Aircraft Artillery Projectiles			✓	
Allied Land Service and Small Arms Ammunition	✓			

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

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

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20. Proposed Risk Mitigation Methodology

20.1. General

The following risk mitigation measures are recommended to support the proposed works at the S. Norton & Sons site in Barking:

Type of Work	Recommended Mitigation Measure
All Works	• **UXO Risk Management Plan** It is recommended that a site-specific plan for the management of UXO risk be written for this site. This plan should be kept on site and be referred to in the event that a suspect item of UXO is encountered at any stage of the project. It should detail the steps to be taken in the event of such a discovery, considering elements such as communication, raising the alarm, nominated responsible persons etc. Contact 1st Line Defence for help/more information. • **Site Specific UXO Awareness Briefings to all personnel conducting intrusive works.** As a minimum precaution, all personnel working on the site should be briefed on the basic identification of UXO and what to do in the event of encountering a suspect item. This should in the first instance be undertaken by a UXO Specialist. Posters and information on the risk of UXO can be held in the site office for reference.
Shallow Intrusive Works/Open Excavations	• **Unexploded Ordnance (UXO) Specialist Presence on Site to support shallow intrusive works** When on site the role of the UXO Specialist would include: • Monitoring works using visual recognition and instrumentation, including immediate response to reports of suspicious objects or suspected items of ordnance that have been recovered by the ground workers on site. • Providing UXO awareness briefings to any uninformed staff and advise staff of the need to modify working practices to take account of the ordnance risk. • To aid incident management which would involve liaison with the local authorities and police should ordnance be identified and present an explosive hazard.
Borehole/Piles	• **Intrusive Magnetometer Survey of all borehole and pile locations down to a maximum bomb penetration depth:** 1st Line Defence can deploy a range of intrusive magnetometer techniques to clear pile locations. The appropriate technique is influenced by a number of factors, but most importantly the site's ground conditions. The appropriate survey methodology would be confirmed once the enabling works have been completed.

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

1st Line Defence Limited **1st April 2020**

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

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Site Location Maps

Annex: **A**

1ST LINE DEFENCE

Unit 3, Maple Park
Essex Road, Hoddesdon,
Hertfordshire. EN11 0EX
Email: info@1stlinedefence.co.uk
Tel: +44 (0)1992 245 020

Client: **WML Consulting**

Project: **S. Norton & Sons, River Road, Barking**

Ref: **DA10683-00**

Source: Google Maps

Approximate site boundary

N

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Recent Aerial Photography

Annex: **B**

1ST LINE DEFENCE

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Ref: **DA10683-00**

Source: Google Earth ™ Mapping Services

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Client Provided Site Plan

Annex: **C**

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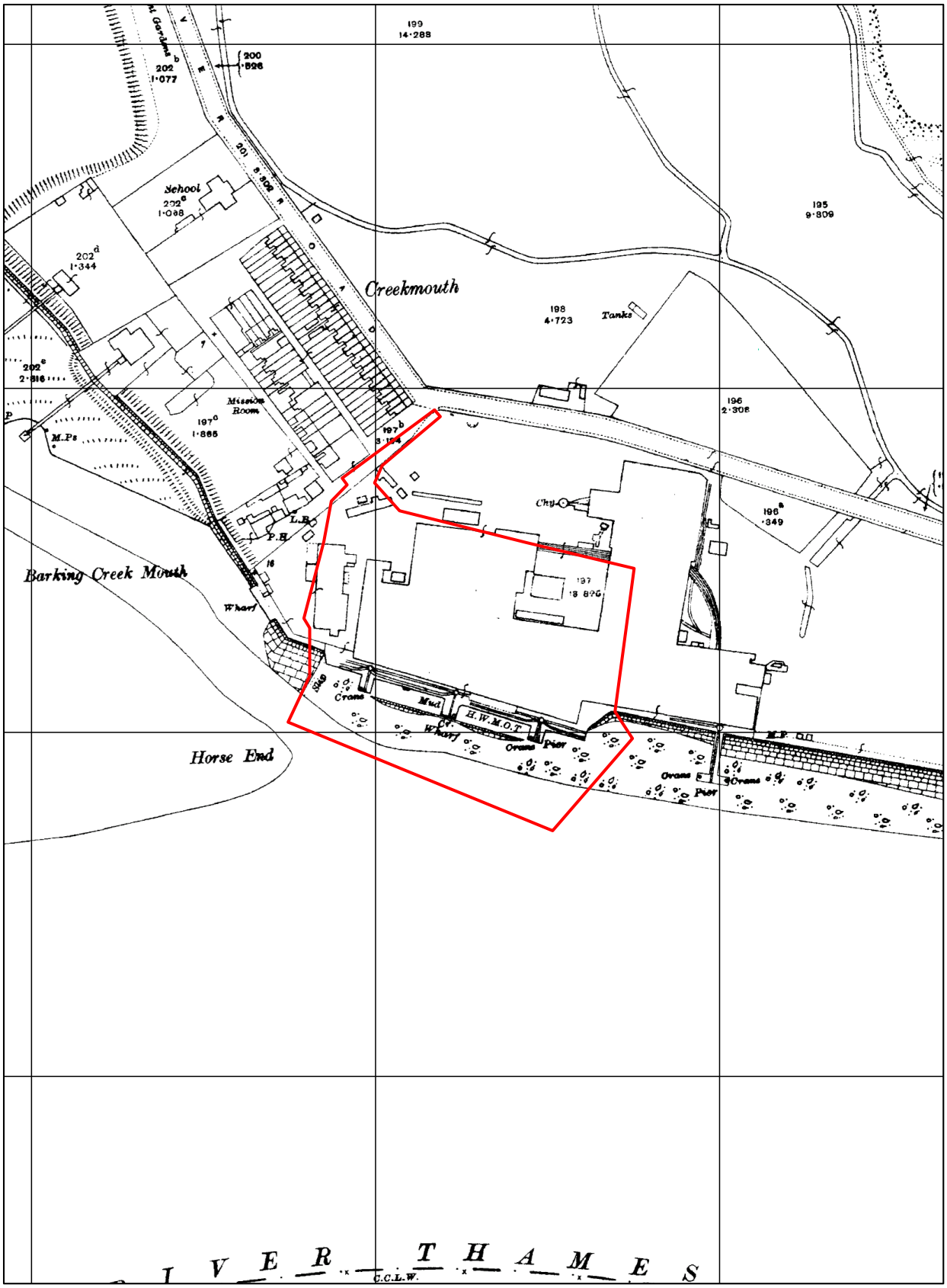
1916 Historical Map

Annex: D1



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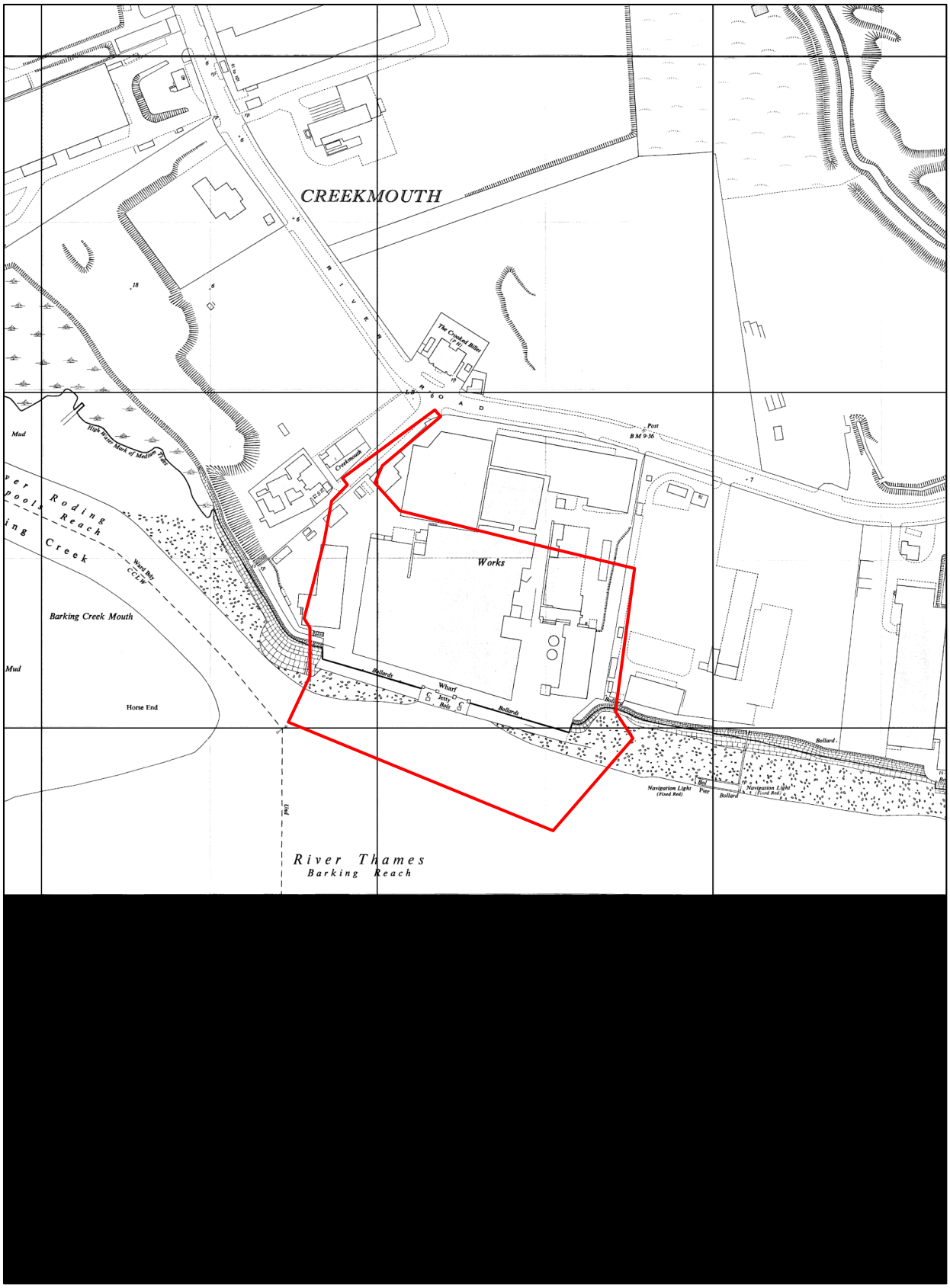
1958-1962 Historical Map

Annex: **D2**



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EPW006139 – Lawes Chemical Manure Co Ltd, Creekmouth, 1921

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EPW036779 – The Lawes Chemical Co Works, the Barking Guano Works and environs, Creekmouth, from the south-east, 1931

EPW036783 – The Lawes Chemical Co Works, pylons running across the Dagenham Marshes and environs, Creekmouth, from the south-west, 1931

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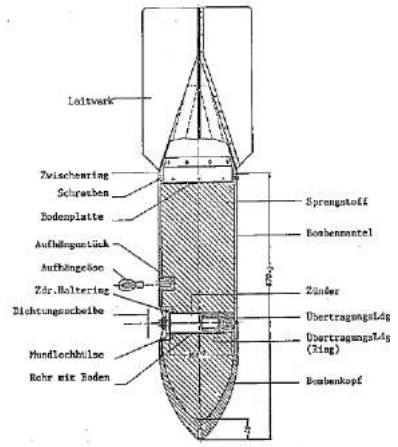
Examples of German Air-Delivered Ordnance

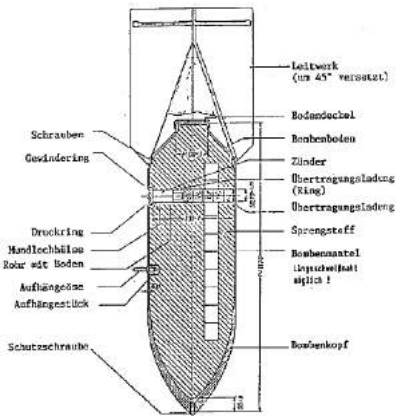
SC 50kg High Explosive Bomb

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



SC 250kg High Explosive Bomb

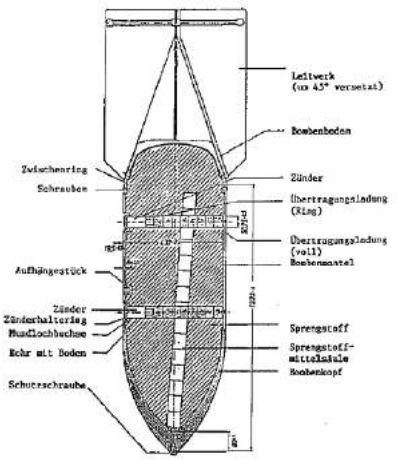
Bomb Weight	245-256kg (540-564lb)
Explosive Weight	125-130kg (276-287lb)
Fuze Type	Electrical impact/mechanical time delay fuze.
Bomb Dimensions	1640 x 512mm (64.57 x 20.16in)
Body Diameter	368mm (14.5in)
Use	Against railway installations, embankments, flyovers, underpasses, large buildings and below-ground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

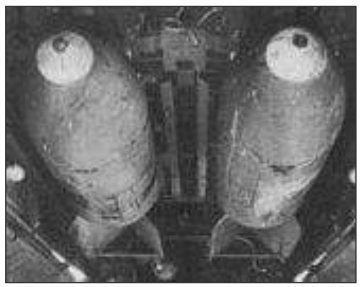


SC250 bomb being loaded onto German bomber

SC 500kg High Explosive Bomb

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





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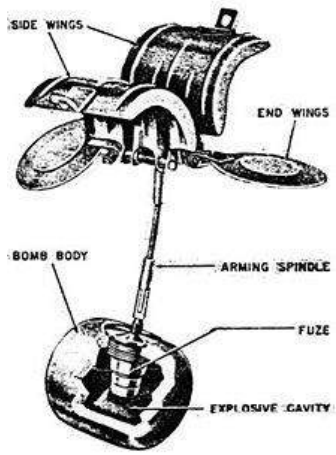
Examples of German Air-Delivered Ordnance

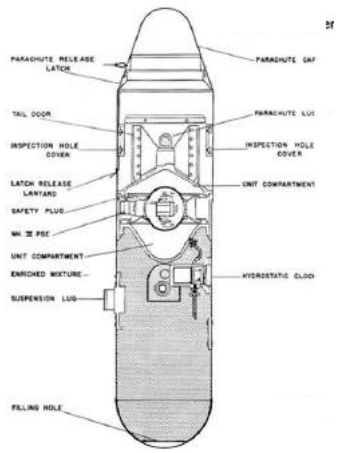
SD2 Anti-Personnel 'Butterfly Bomb'

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



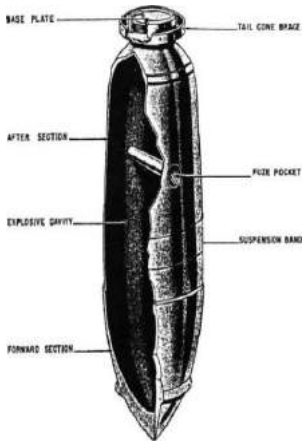
Parachute Mine (Luftmine B / LMB)

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



SC 1000kg

Bomb Weight	Approx. 993-1027kg (2,189-2,264lb)
Explosive Weight	Approx. 530-620kg (1168-1367lb)
Fuze Type	Electrical impact/mechanical time delay fuze.
Filling	Mixture of 40% amatol and 60% TNT, but when used as an anti-shipping bomb it was filled with Trialen 105, a mixture of 15% RDX, 70% TNT and 15% aluminium powder.
Bomb Dimensions	2800 x 654mm (110 x 25.8in)
Body Diameter	654mm (18.5in)
Use	SC type bombs are General Purpose Bombs used primarily for general demolition work. Constructed of parallel walls with comparatively heavy noses. They are usually of three piece welded construction



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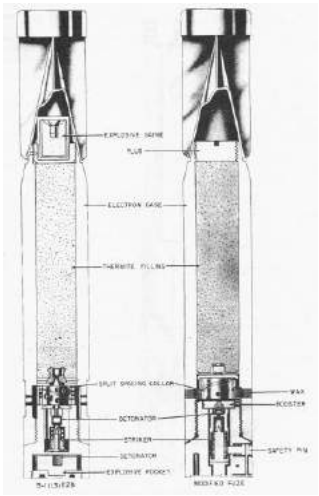
German Incendiary Bombs

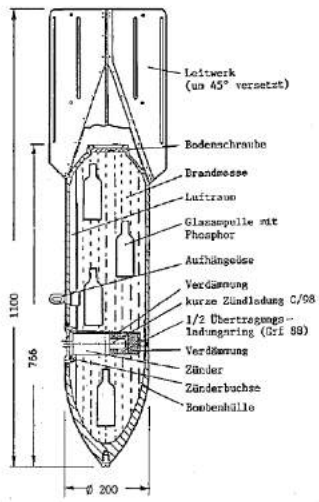
1kg Incendiary Bomb

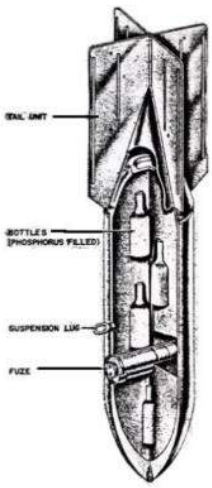
Bomb Weight	Approx. 1.0 - 1.3kg (2.2 and 2.9lb)
Explosive Weight	Approx. 680g (1.5lb) Thermite 8-15gm Explosive Nitropenta
Fuze Type	Impact fuze
Bomb Dimensions	350 x 50mm (13.8 x 1.97in)
Body Diameter	50mm (1.97in)
Use	As incendiary – dropped in clusters on towns and industrial complexes
Remarks	Magnesium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



C50 A Incendiary Bomb

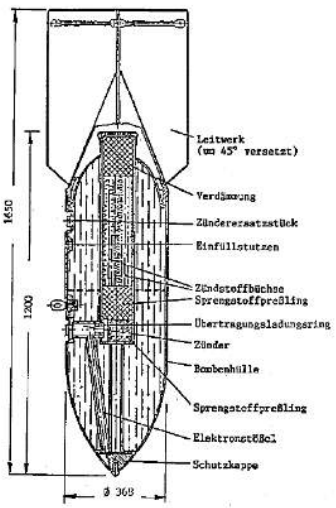
Bomb Weight	Approx. 41kg (90.4lb)
Explosive Weight	Approx. 0.03kg (0.066lb)
Incendiary Filling	12kg (25.5lb) liquid filling with phosphor igniters in glass phials. Benzine 85%; Phosphorus 4%; Pure Rubber 10%
Fuze Type	Electrical impact fuze
Bomb Dimensions	1,100 x 280mm (43.2 x 8in)
Use	Against any targets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





Flam C-250 Oil Bomb

Bomb Weight	Approx. 125kg (276lb)
Explosive Weight	Approx. 1kg (2.2lb)
Fuze Type	Super-fast electrical impact fuze
Filling	Mixture of 30% petrol and 70% crude oil
Bomb Dimensions	1,650 x 512.2mm (65 x 20.2in)
Body Diameter	368mm (14.5in)
Use	Often used for surprise attacks on ground troops, against troop barracks and industrial installations. Thin casing – not designed for ground penetration



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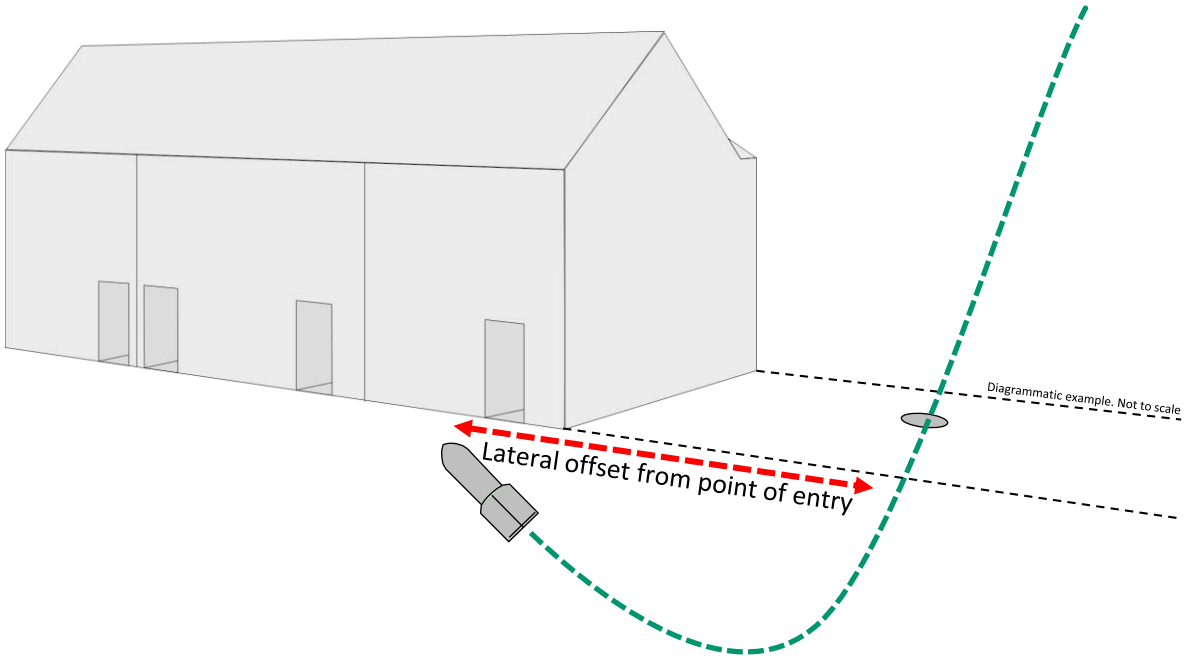

Top: J-curve Effect - Due to angle of entry, unexploded bombs would often end their trajectory at a lateral offset from point of entry, often ending up beneath adjacent extant structures/sites. The photograph above shows 250kg bomb found in Bermondsey pointing upwards, demonstrating ‘J-curve’

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

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BBC NEWS

Bermondsey bomb: World War Two device safely removed

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

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

March 2015

BBC NEWS

Bethnal Green WW2 bomb: Experts remove unexploded device

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

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

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

August 2016

BBC NEWS

Bath WW2 bomb scare: Device defused, police say

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

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

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

May 2016

BBC NEWS

London City Airport reopens after WW2 bomb moved

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

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

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

May 2015

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Ref: **DA10683-00**

Source: BBC News

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Examples of Unexpected Detonation of WWII Bombs

Annex: **H2**

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

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

BASF Provides Some Details

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

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

1st March 2013

SPIEGEL ONLINE

Blast Kills One

World War II Bomb Explodes on German Motorway

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

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

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

23rd October 2006

WWII bomb injures 17 at Hattingen construction site

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

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

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

19th September 2013

BBC NEWS

World War II bomb kills three in Germany

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

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

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

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

2nd June 2010

June 2006

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Source: Various news sources

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London City airport closed until Tuesday after WWII bomb found

theguardian.com/uk-news/2018/feb/12/london-city-airport-closed-after-wwii-bomb-found-in-thames

Patrick Greenfield February 12, 2018

London City airport will reopen on Tuesday after an unexploded second world war bomb that was found in the river Thames near the runway was safely removed.

An exclusion zone around George V dock in east London near the airport has been lifted after Royal Navy technicians and the Metropolitan police safely removed a 500kg tapered end shell measuring about 1.5 metres that was discovered on Sunday morning during pre-planned building work.

The airport was closed all day yesterday as authorities worked to remove the device. Police and navy divers had to wait for the tide to change on Monday evening before the bomb could be brought to the surface and moved out of the dock.

Evacuated residents have been told they can return to their homes, and normal services at London City airport will resume on Tuesday .

Specialist Met police officers and Royal Navy technicians confirmed the nature of the device after it was discovered just after 5am on Sunday. The exclusion zone was implemented at 10pm the same day to ensure public safety, police said.

"Following the discovery of a world war two ordnance in King George V dock as part of planned development works, a 214-metre exclusion zone has been implemented as a precaution by the Met police. As a result, London City airport is currently closed," a spokesperson for the airport said on Sunday..

In an updated statement on Monday, a spokesperson for the airport said: "The World War Two ordnance discovered in King George V Dock has been safely removed by the Royal Navy and Met Police. As a result, the exclusion zone has now been lifted and the airport will be open as normal on Tuesday."

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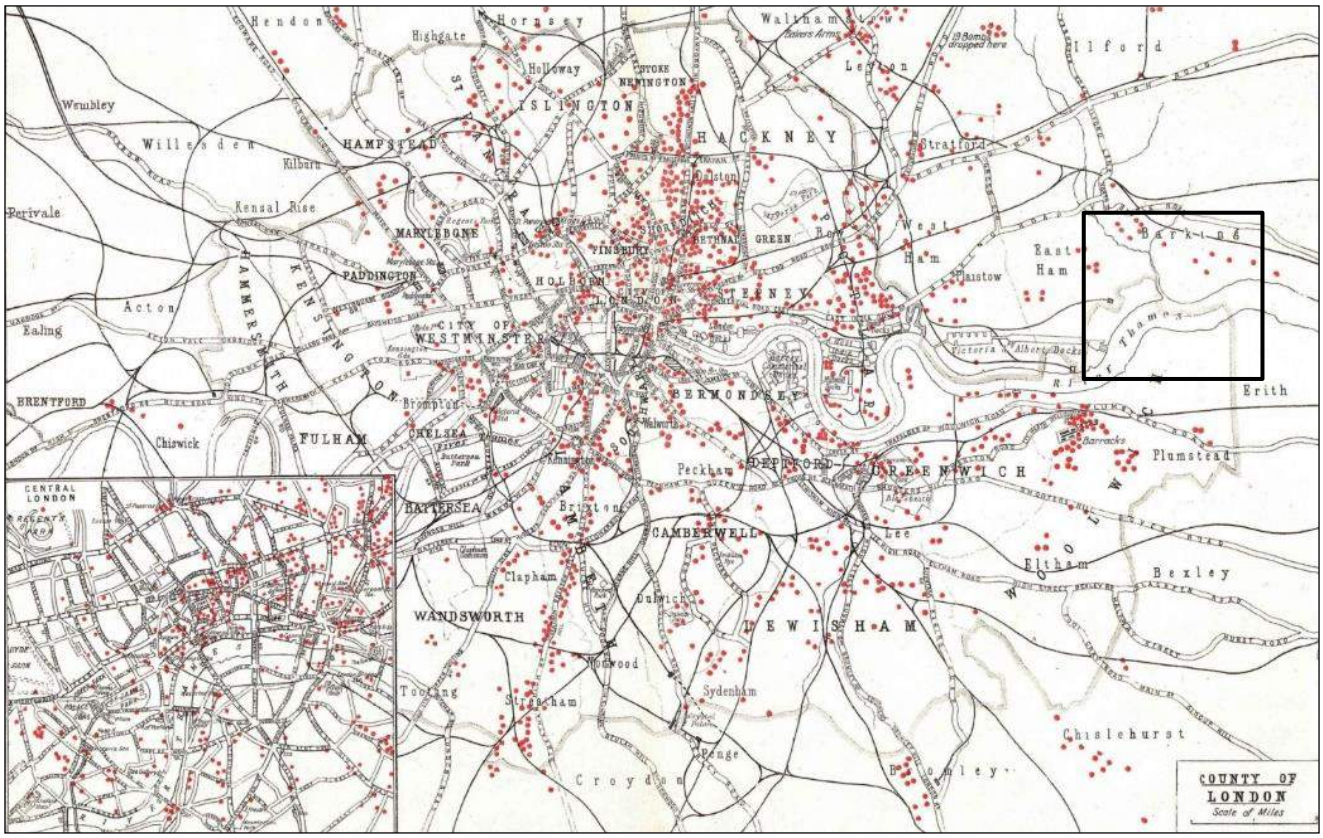
WWI Bomb Plot Map, London

Annex: I



Examples of 50 and 100kg German WWI bombs

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Source: The National Archives, Kew

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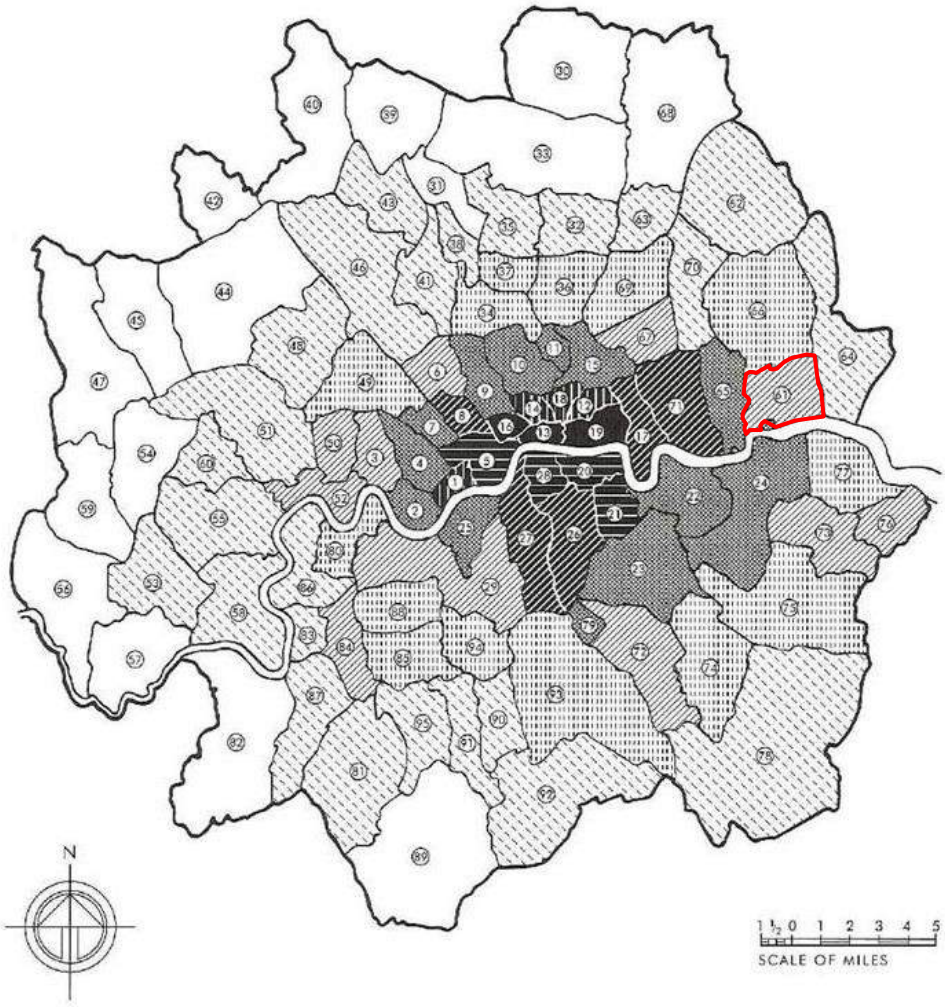
London WWII Bomb Density Map

Annex: J



No. OF BOMBS PER 1,000 ACRES

OVER 600	300 – 399	100 – 149
500 – 599	200 – 299	50 – 99
400 – 499	150 – 199	UNDER 50

1	Chelsea	25	Battersea	49	Willesden	72	Beckenham
2	Fulham	26	Camberwell	50	Acton	73	Bexley
3	Hammersmith	27	Lambeth	51	Ealing	74	Bromley
4	Kensington	28	Southwark	52	Brentford and Chiswick	75	Chislehurst and Sidcup
5	Westminster	29	Wandsworth	53	Feltham	76	Crayford
6	Hampstead	30	Cheshunt	54	Hayes and Harlington	77	Erith
7	Paddington	31	East Barnet	55	Heston and Isleworth	78	Orpington
8	St. Marylebone	32	Edmonton	56	Staines	79	Penge
9	St. Pancras	33	Enfield	57	Sunbury	80	Barnes
10	Islington	34	Hornsey	58	Twickenham	81	Epsom and Ewell
11	Stoke Newington	35	Southgate	59	Yiewsley and West Drayton	82	Esher
12	Bethnal Green	36	Tottenham	60	Southall and Norwood	83	Kingston on Thames
13	City of London	37	Wood Green	61	Barking	84	Malden and Coombe
14	Finsbury	38	Friern Barnet	62	Chigwell	85	Merton and Morden
15	Hackney	39	Potters Bar	63	Chingford	86	Richmond
16	Holborn	40	Elstree	64	Dagenham	87	Surbiton
17	Poplar	41	Finchley	65	East Ham	88	Wimbledon
18	Shoreditch	42	Bushey	66	Ilford	89	Banstead
19	Stepney	43	Barnet U.D.	67	Leyton	90	Beddington and Wallington
20	Bermondsey	44	Harrow	68	Waltham Holy Cross	91	Carshalton
21	Deptford	45	Ruislip and Northwood	69	Walthamstow	92	Coulsdon and Purley
22	Greenwich	46	Hendon	70	Wanstead and Woodford	93	Croydon
23	Lewisham	47	Uxbridge	71	West Ham	94	Mitcham
24	Woolwich	48	Wembley			95	Sutton and Cheam

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Source: The London Metropolitan Archives

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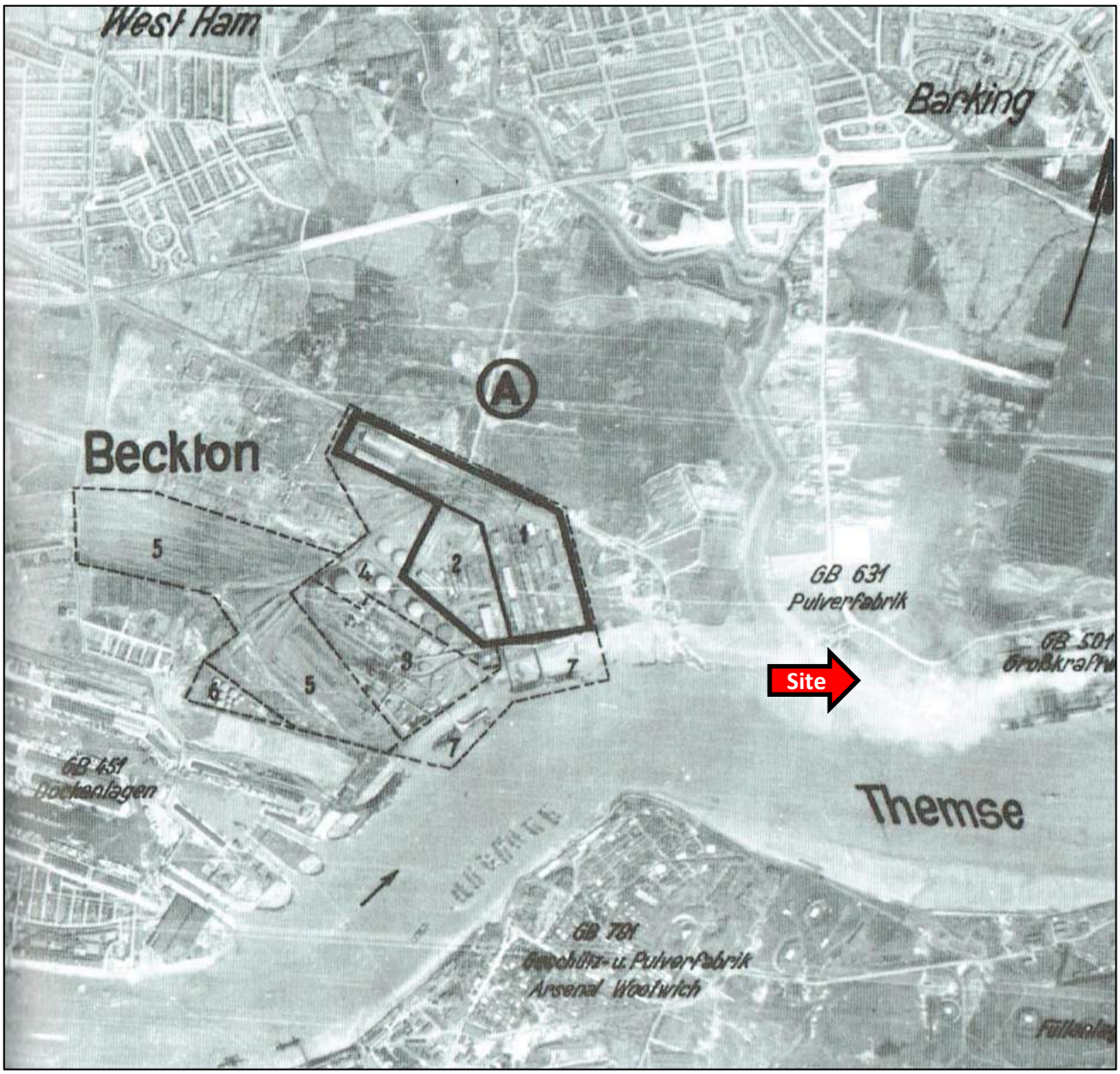
Luftwaffe Photograph, 24th May 1939



London – Beckton/Barking

A - The Beckon Gas Works

GB 451 – Dockenlagen – Docklands GB
GB 501 – Grobkraften – Power Station
631 – Pulberfabrik – Powder Factory
GB 781 – Geschuiz – u.Pulverfabrick – Woolwich Arsenal

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Source: Nigel J. Clarke, "Adolf Hitler's Home Counties Holiday Snaps"

N

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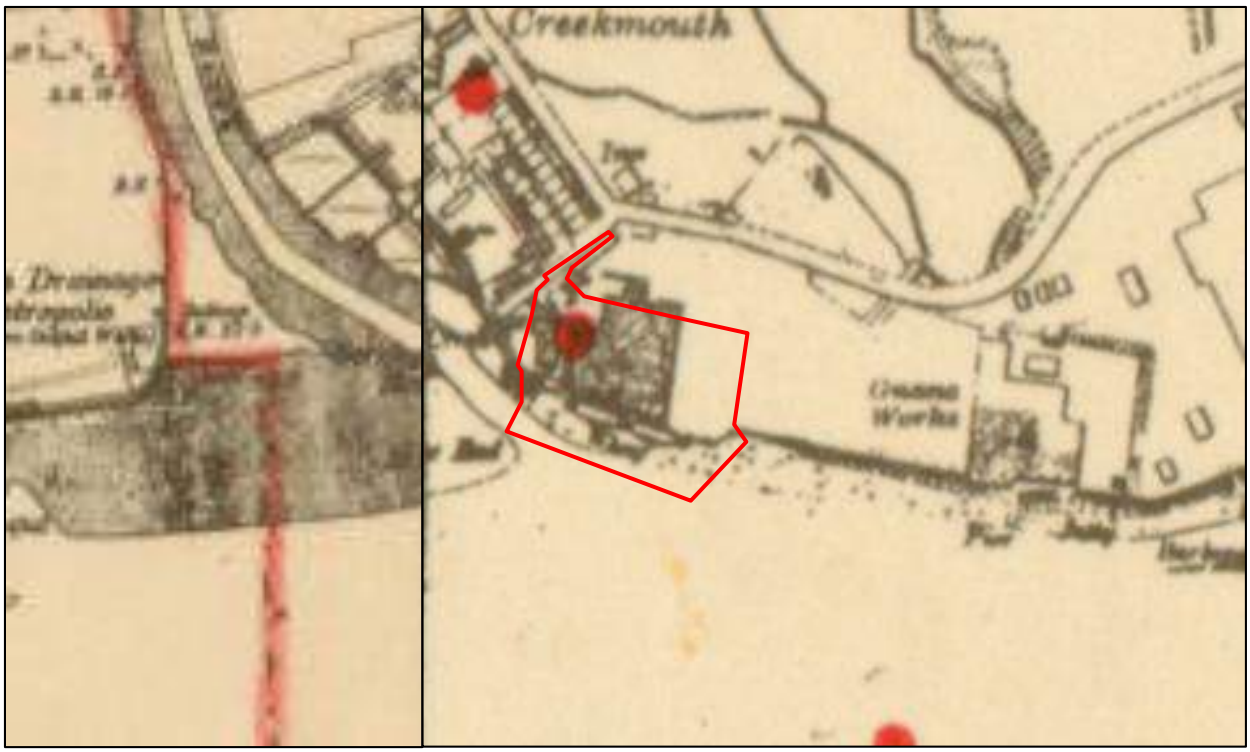
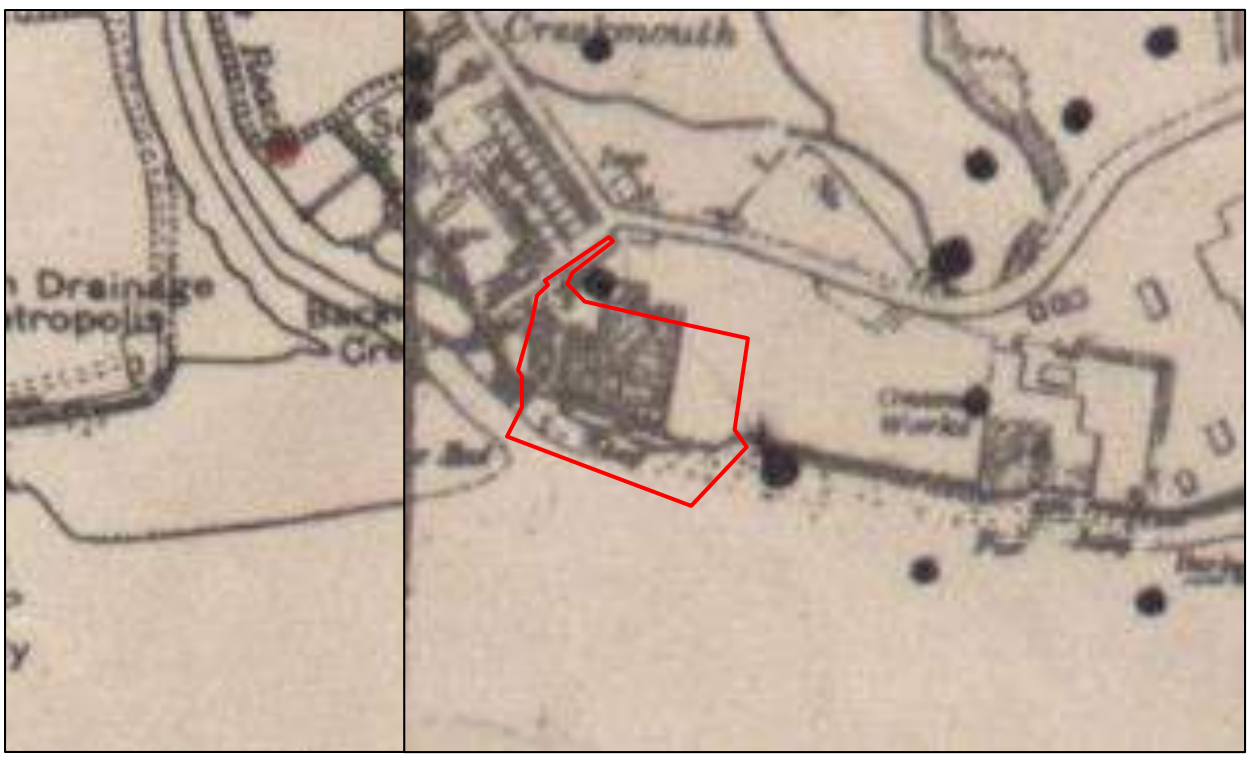
Consolidated London Bomb Census Mapping

Annex: **L1**

Night Bombing up to 7th October 1940



Night Bombing - 7th October 1940 to 6th June 1941



Recorded bomb strike

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Client: **WML Consulting**

Approximate site boundary

Project: **S. Norton & Sons, River Road, Barking**

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Ref: **DA10683-00**

Source: The National Archives, Kew

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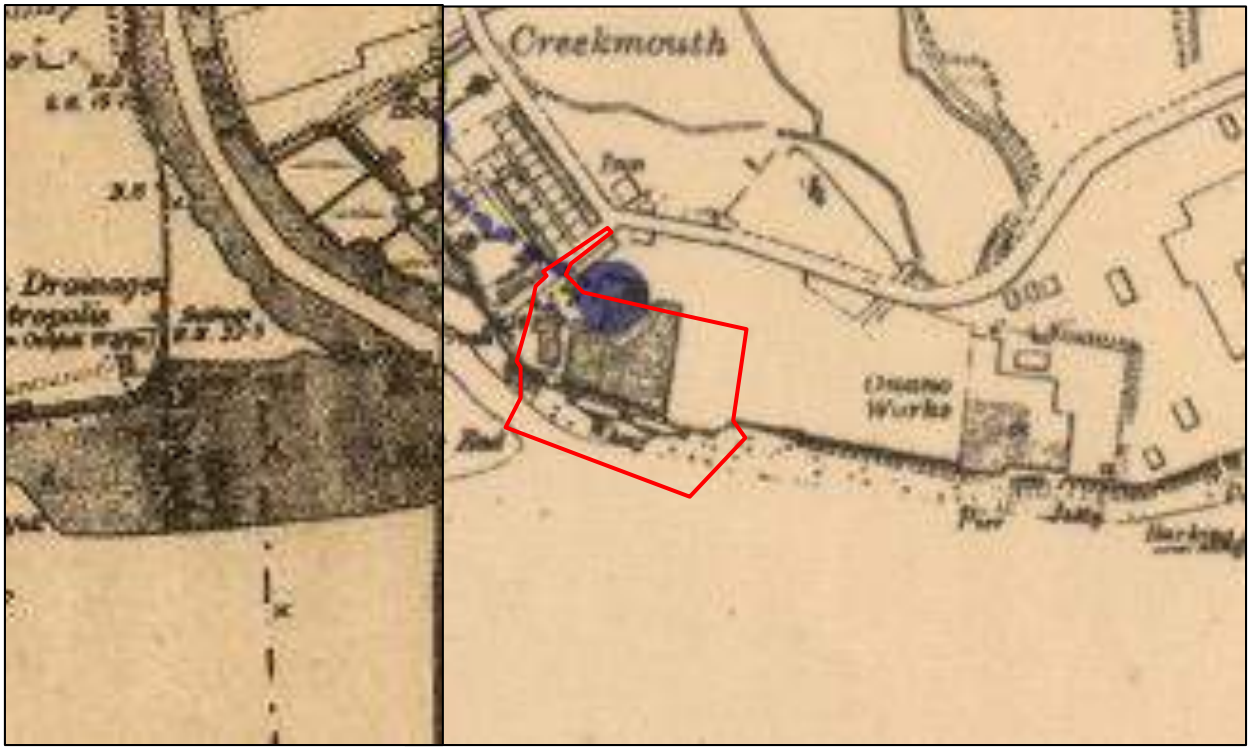
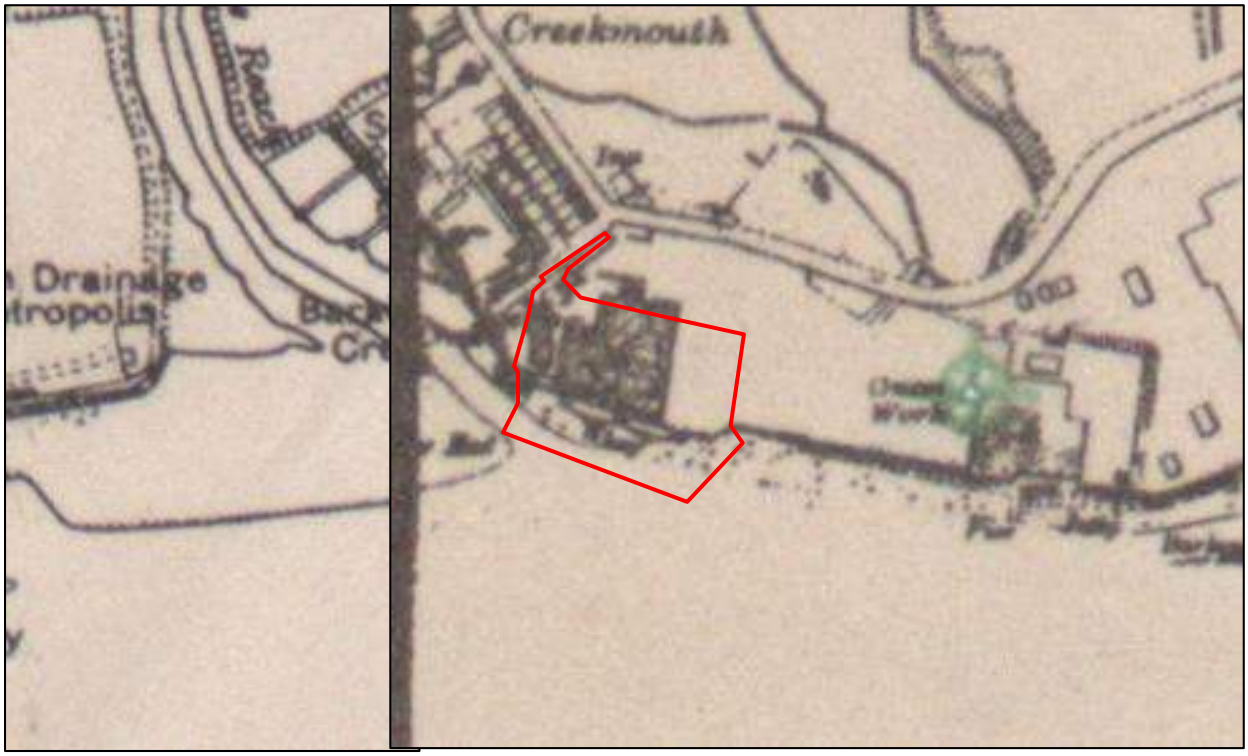
Weekly London Bomb Census Mapping

Annex: **L2**

Night Bombing – 7th to 14th October 1940



Night Bombing - 25th November to 2nd December 1940



Recorded HE bomb strike

Recorded UXB strike

Recorded incendiary bomb shower

Recorded oil bomb strike

Key to weekly map symbol colours

Monday - Brown	Friday - Green
Tuesday - Vermilion	Saturday - Violet
Wednesday - Blue	Sunday - Yellow
Thursday - Black	

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Approximate site boundary

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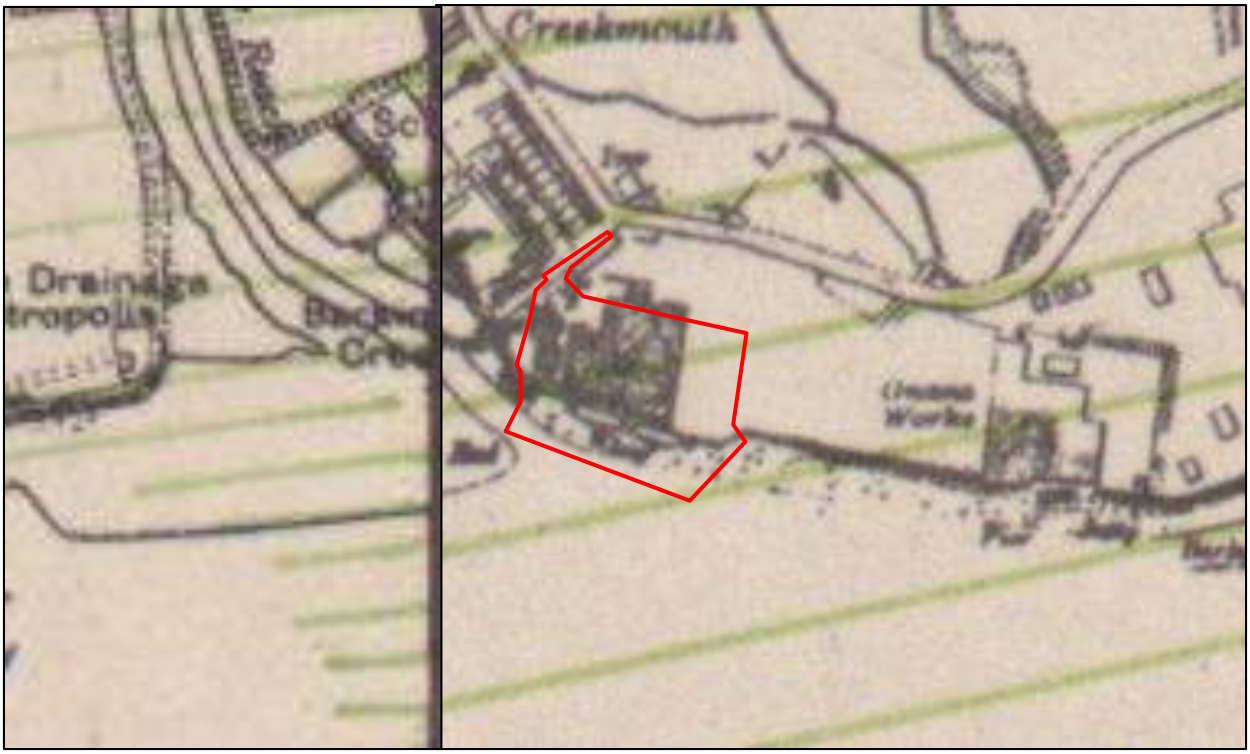
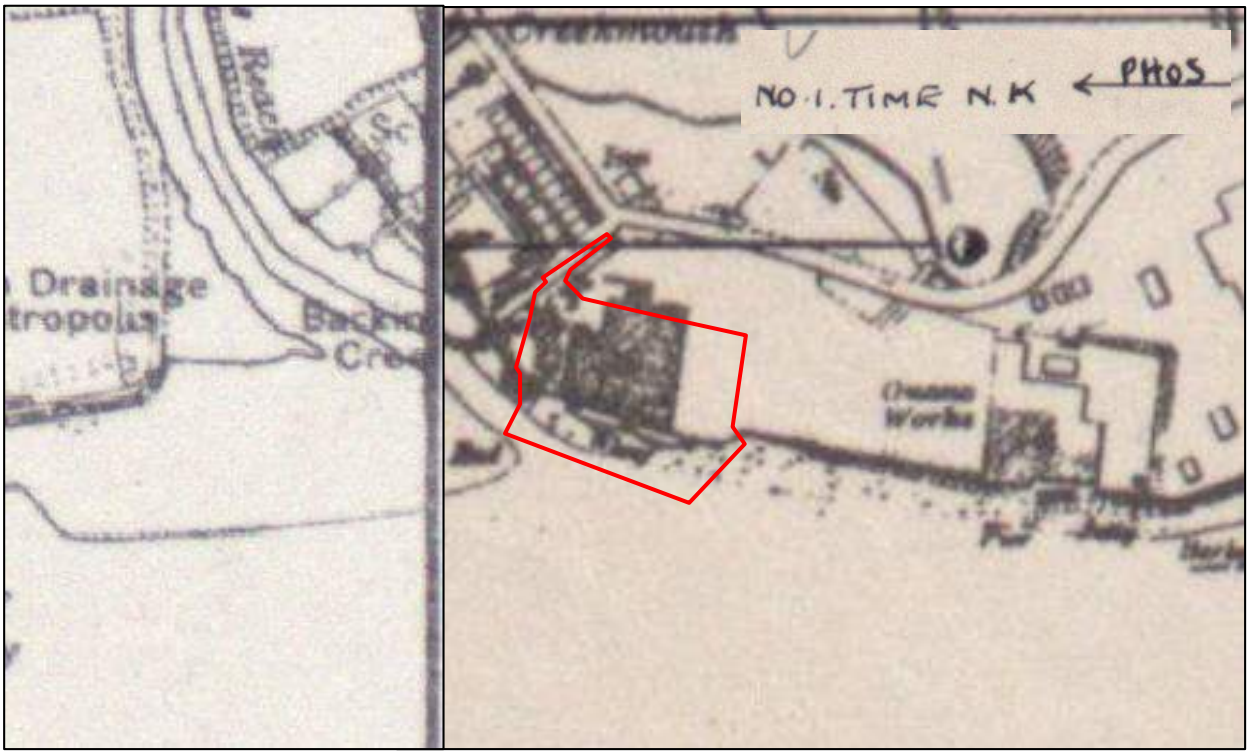
Weekly London Bomb Census Mapping

Annex: **L3**

Night Bombing – 6th to 13th January 1941



Night Bombing – 17th to 23rd January 1944



Recorded HE bomb strike

Recorded UXB strike

Recorded incendiary bomb shower

Recorded oil bomb strike

Key to weekly map symbol colours

Monday - Brown
Tuesday - Vermilion
Wednesday - Blue
Thursday - Black
Friday - Green
Saturday - Violet
Sunday - Yellow

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Approximate site boundary

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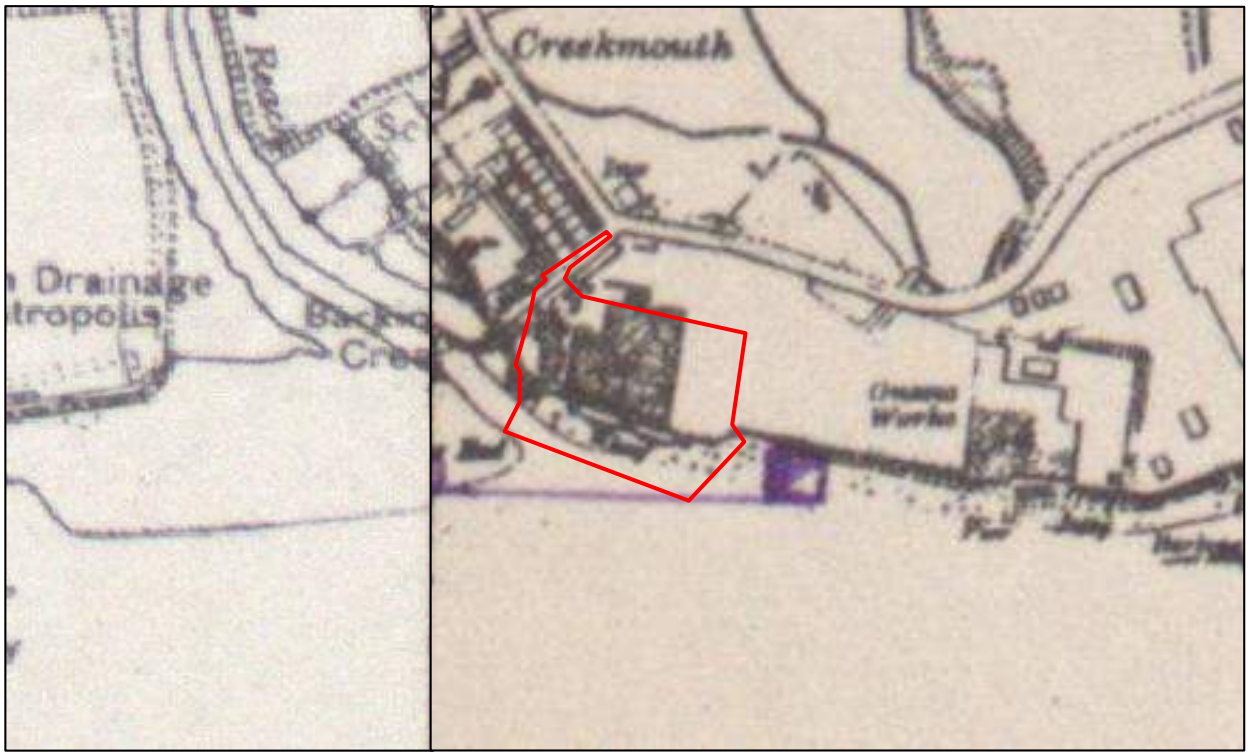
Weekly London Bomb Census Mapping

Annex: **L4**

Night Bombing – 24th to 30th January 1941



Recorded HE bomb strike

Recorded UXB strike

Recorded incendiary bomb shower

Recorded oil bomb strike

Key to weekly map symbol colours

Monday - Brown
Tuesday - Vermilion
Wednesday - Blue
Thursday - Black
Friday - Green
Saturday - Violet
Sunday - Yellow

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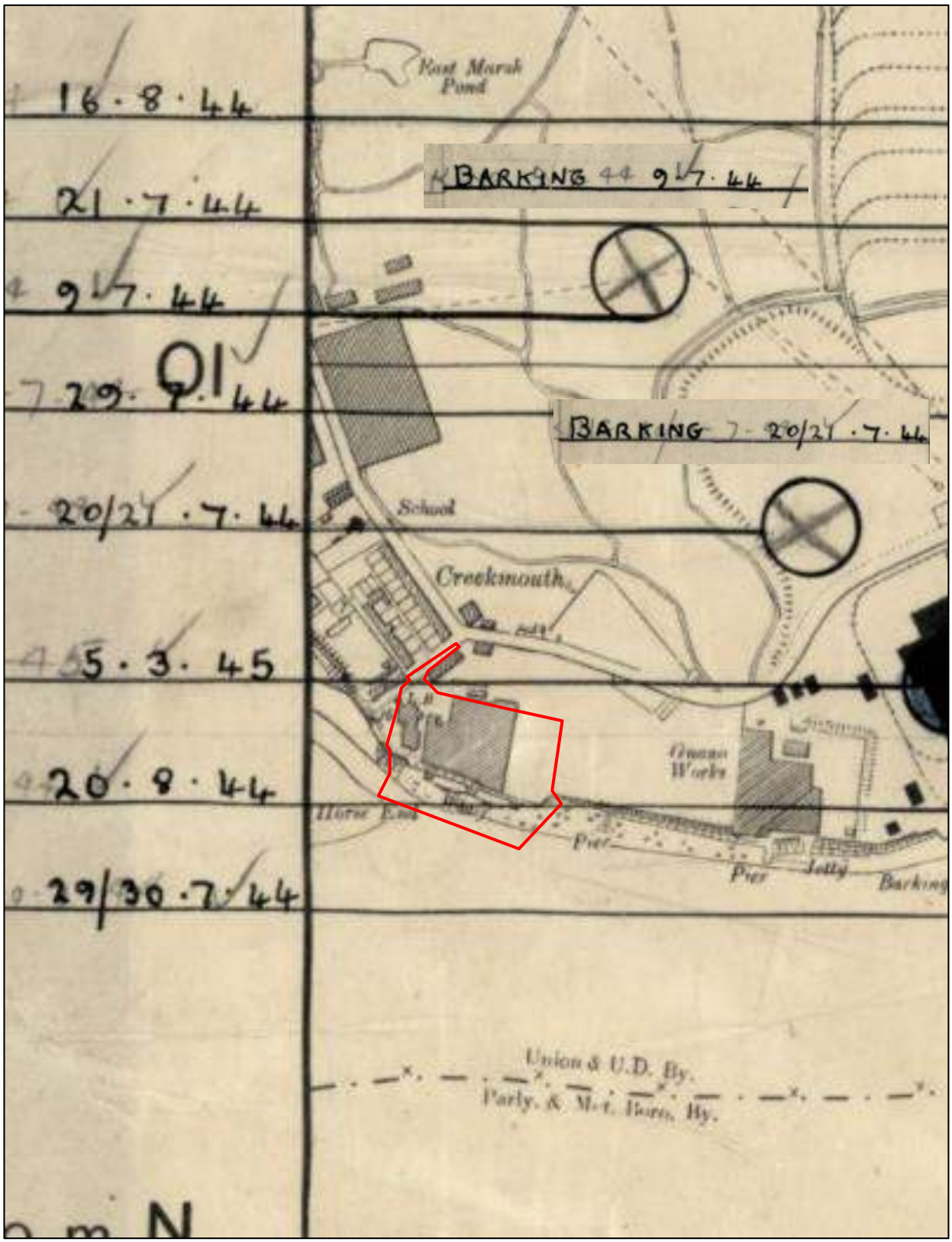
London V-1 Flying Bomb Map

Annex: **M**



V-1 flying bomb

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Ref: **DA10683-00**

Source: The National Archives, Kew

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Barking AA Shell Map

Annex: N

Recorded AA Shell

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Ref: **DA10683-00**

Source: Barking and Dagenham Archives

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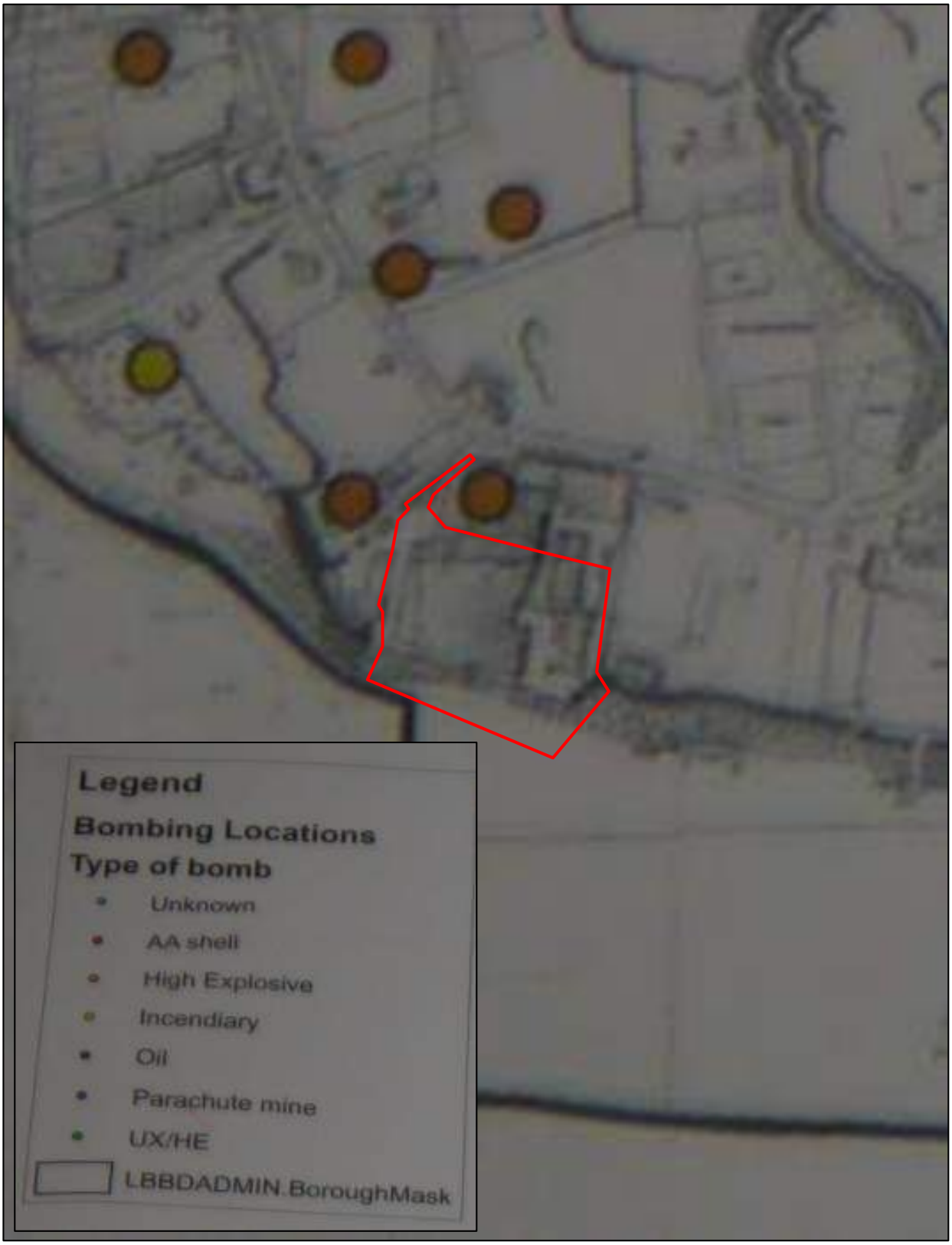
Incomplete Post-War Bomb Map

Annex: **O**



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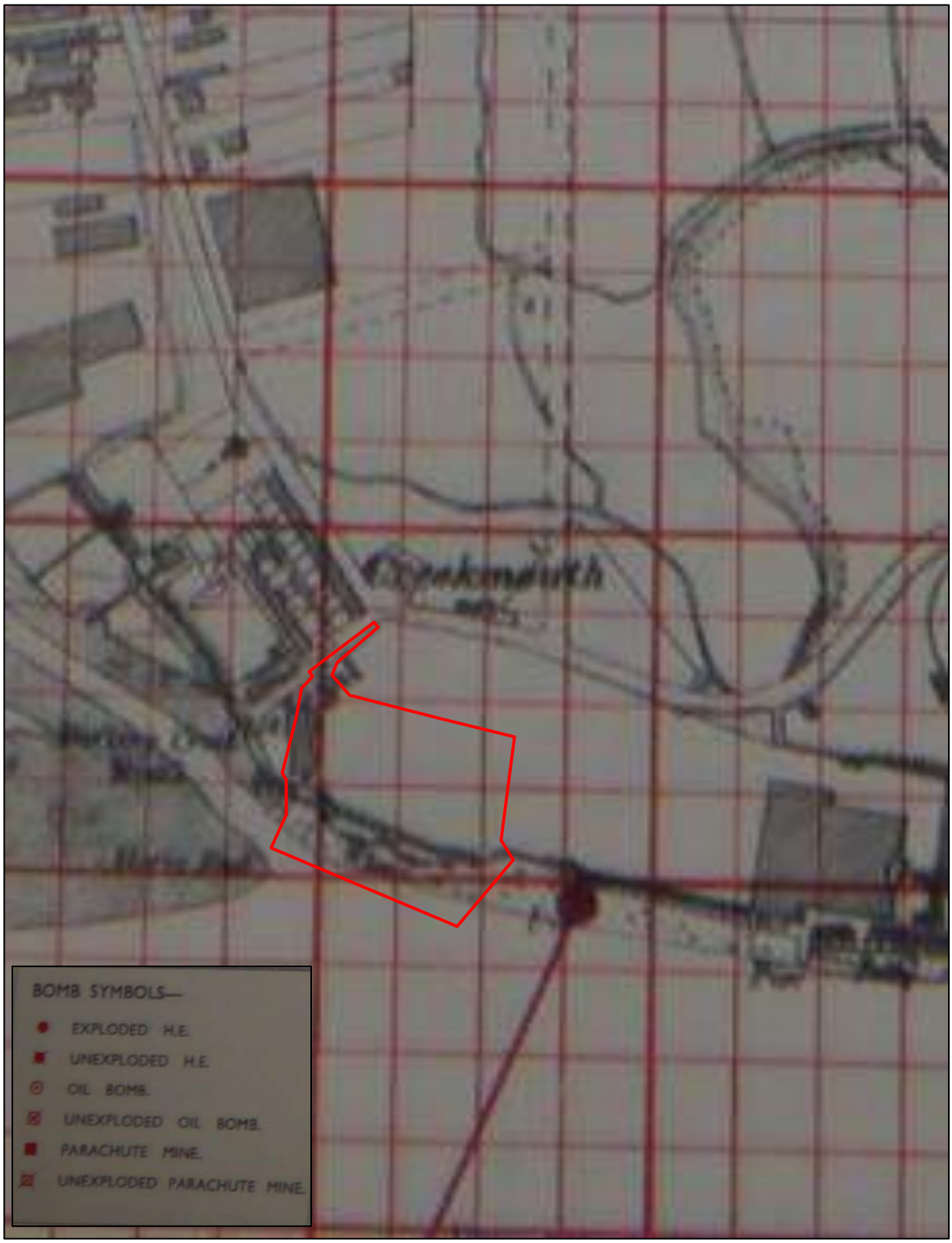
Barking Bombing Raid Map

Annex: **P**

29th January 1944



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Ref: **DA10683-00**

Source: Barking and Dagenham Archives

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Barking V-Weapon Map

Annex: Q

Recorded V-1 Pilotless Aircraft strike

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Ref: **DA10683-00**

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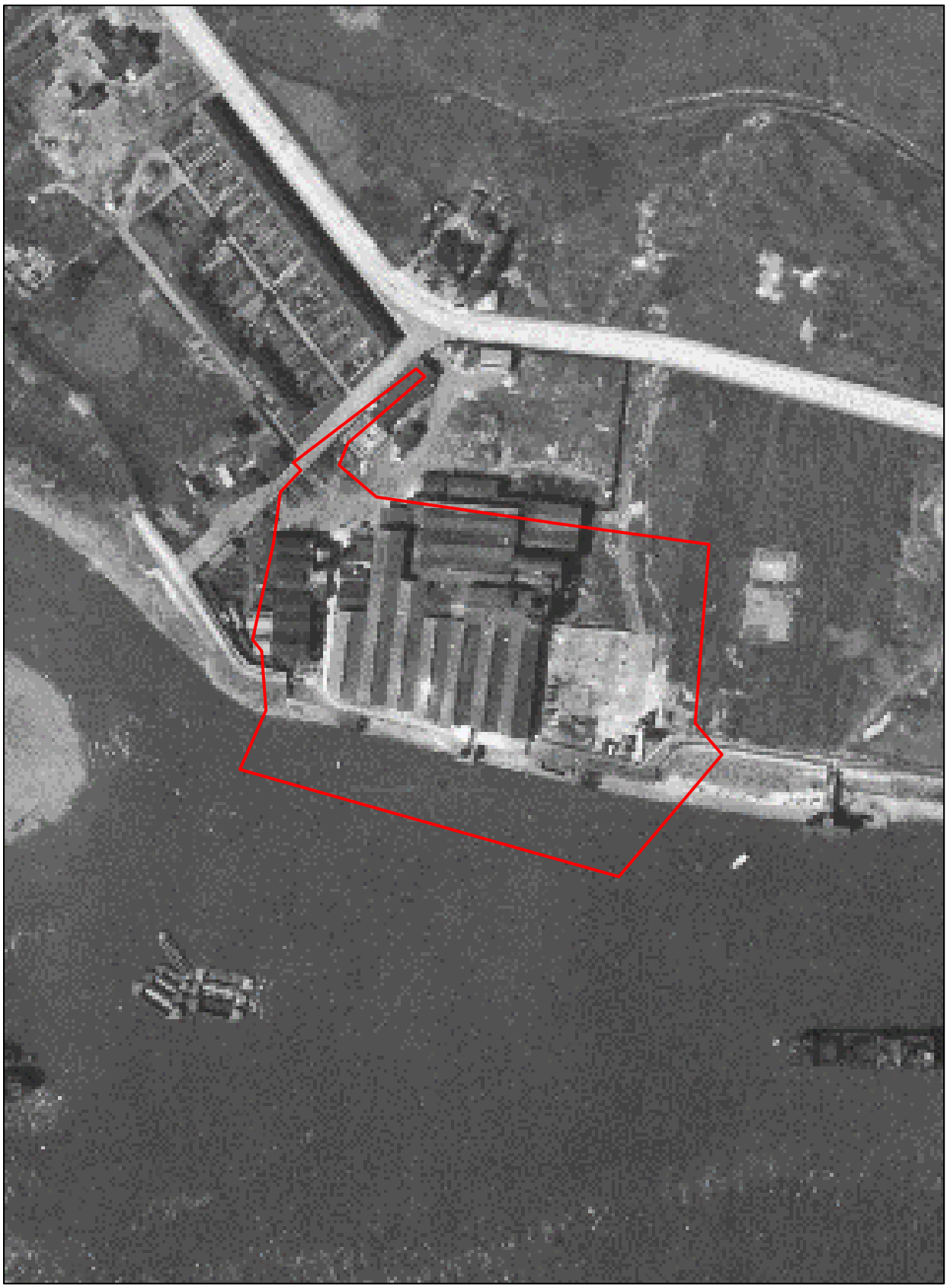
RAF Aerial Photography 18th June 1941

Annex: **R1**



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Client: **WML Consulting**

Approximate site boundary

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Ref: **DA10683-00**

Source: National Monuments Record Office (Historic England)

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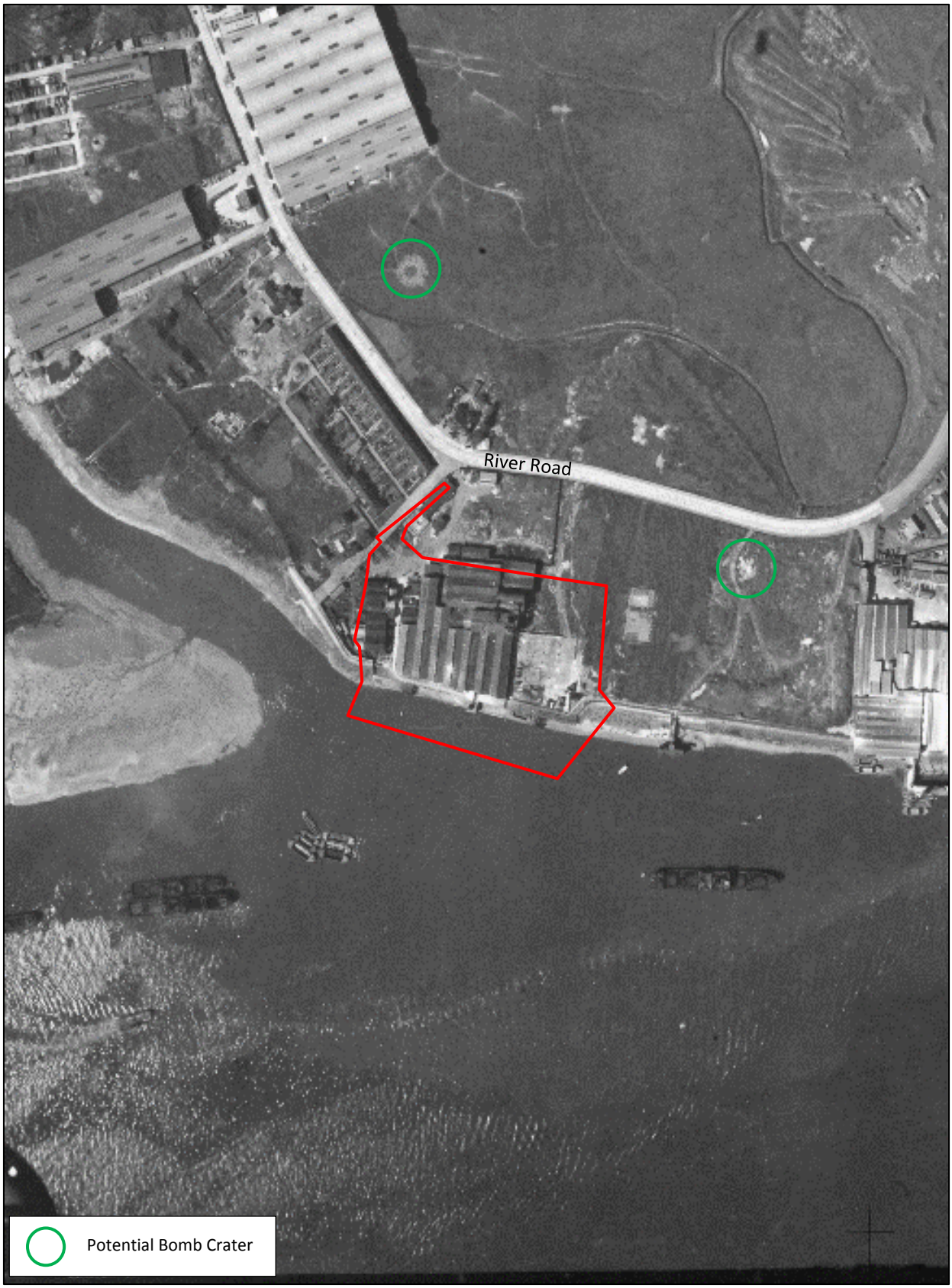
RAF Aerial Photography 18th June 1941

Annex: **R2**



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Ref: **DA10683-00**

Source: National Monuments Record Office (Historic England)

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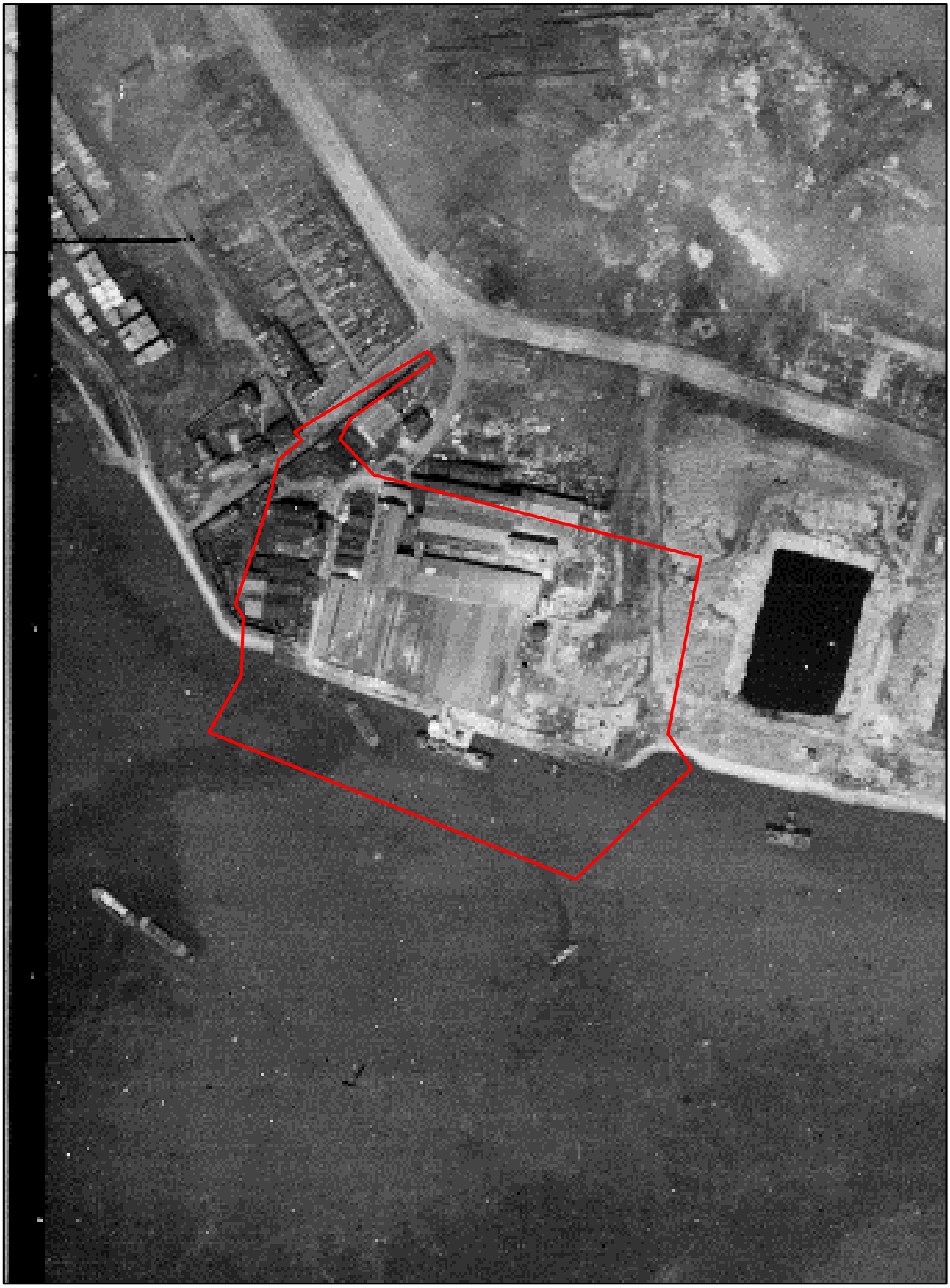
RAF Aerial Photography 1st May 1946

Annex: **S1**



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Ref: **DA10683-00**

Source: National Monuments Record Office (Historic England)

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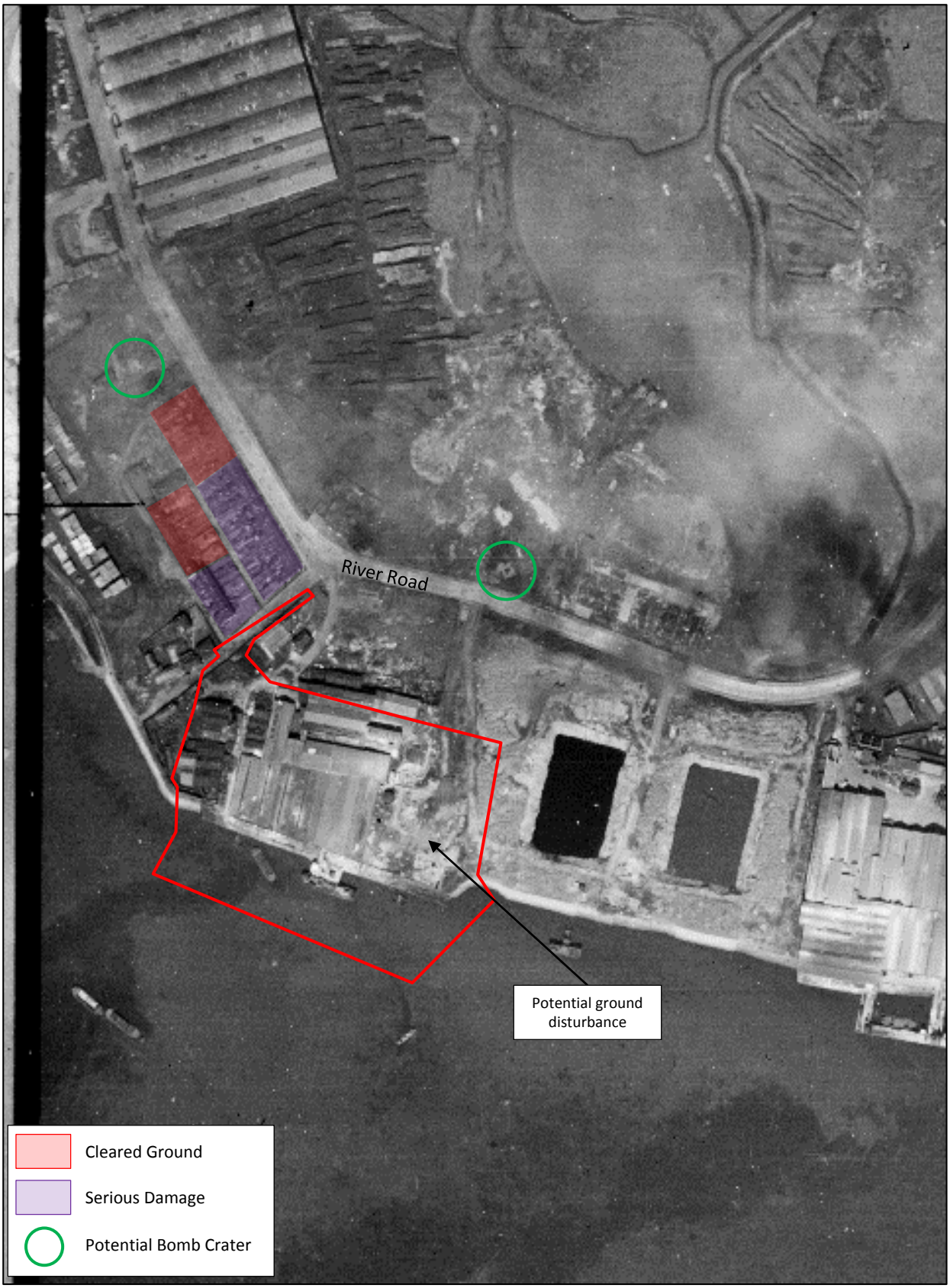
RAF Aerial Photography 1st May 1946

Annex: **S2**



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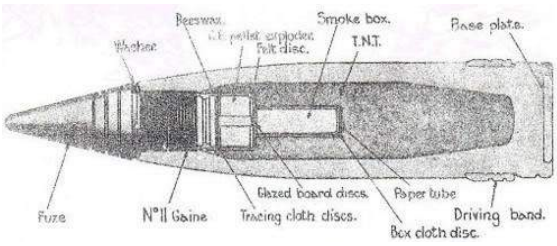
Examples of Anti-Aircraft Projectiles

Annex: T

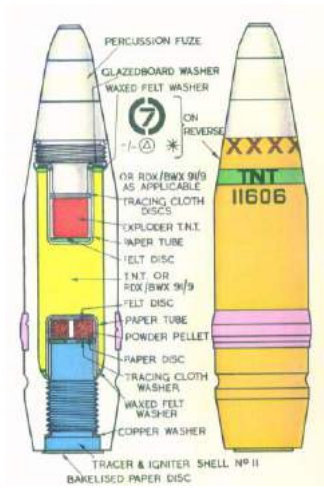
3.7 Inch QF Anti-Aircraft Projectile

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



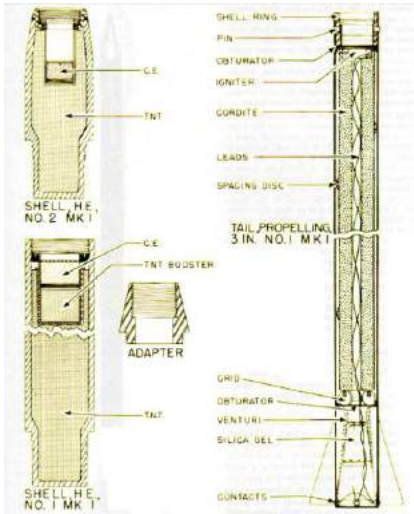
40mm Bofors Projectile

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



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

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



1ST LINE DEFENCE

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Client: **WML Consulting**

Project: **S. Norton & Sons, River Road, Barking**

Ref: **DA10683-00**

Source: Various sources

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APPENDIX 03

Herts & Essex Site Investigations

HERTS & ESSEX SITE INVESTIGATIONS

The Old Post Office, Wellpond Green, Standon,
Ware, Herts, SG11 1NJ

Telephone : Ware (01920) 822233
Fax: Ware (01920) 822200

28th September 2018

Our Ref:MRS/14927

S. Norton & Co Ltd
Bankfield House
Regent Road,
Liverpool
L20 8RQ

For The Attention Of M. Bennett Esq.:

Dear Sir,

Re: Norton & Sons, River Road, Barking, London IG11 0DS : Site Investigation

1.0 Introduction

1.01 In accordance with your instructions, we visited the above site during August & September 2018 .

1.02 The purpose of our visit was to carry out an investigation into the subsoil conditions with a view to piled foundation design.

1.03 The comments and opinions expressed are based purely on the conditions encountered and the subsequent laboratory testing.

1.04 Therefore, it is possible that some special conditions prevailing on site have not been encountered or taken into account.

1.05 All ground water recordings or their absence relate to short term observations and do not allow for fluctuations due to seasonal or other effects.

2.0 Description of Site

2.01 The site is situated at Norton & Sons, River Road, Barking, London IG11 0DS

2.02 At the time of our visit the site was generally flat.

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Warren House, Bells Hill, Bishop's Stortford, Herts. CM23 2NN
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Appendix No. 3
Sheet No. 4
Job No. 14927
Date Sept 2018

LOCATION Norton & Sons, River Road, Barking, London IG11 0DS

SULPHATE ANALYSIS TEST RESULTS

Borehole	Depth (m)	Sample	Concentrations of Soluble Sulphate			Classification	pH
			Soil		Groundwater		
			Total SO_4 (%)	SO_4 in 2:1 water:soil (g/l)			
DP2A	2.00	B		0.04			7.98
DP2A	5.00	B		0.28			8.18
DP2A	9.00	B		0.24			8.23
DP2A	14.50	B		0.16			7.61

3.0 Fieldwork

3.01 One borehole was sunk to a maximum depth of 20.00m by means of a shell and auger drilling rig along with a series of dynamic probes .

3.02 The location of the works is indicated on the site plan forming appendix one.

3.03 The various strata and details encountered were noted and are recorded on the borehole logs forming appendix two.

3.04 Insitu strength tests were carried out in the boreholes, the results of which can be seen on the aforementioned logs.

3.05 A full range of samples were recovered as noted and retained for subsequent laboratory testing.

3.06 The location, type and height of any trees should be taken from a survey for later use with NHBC Chapter 4.20, if required.

4.0 Laboratory Testing

4.01 All samples were tested in accordance with BS:1377:1990 Methods of Test for Soils for Civil Engineering purposes.

4.02 Selected samples were tested to determine their, atterberg limit, partical size distribution, soluble sulphate content and pH value.

4.03 The results of all laboratory testing are summarised in appendix three.

5.0 Conclusions and Recommendations

5.01 By inspection of the borehole logs it can be seen that the subsoil consists of a Concrete Slab cored to 0.40m above a Loose To Medium Dense Brick & Concrete FILL to 2.60m where a Soft Brown Silty Sandy CLAY overlies at 6.20m a Soft Fibrous Brown to Black PEAT to 7.40m above a Medium Dense Grey SAND & GRAVEL'S / Silty SANDS / Sandy Silty CLAYS to 16.00m which in turn overlies the White Weathered Weak CHALK With Some Flints which is encountered and present to the base of the excavation.

5.02 Water was encountered upon excavation of the borehole as described on the borehole logs, a moderate inflow at 7.40m standing at 3.40m However we had to case the borehole against collapse to 20.00m which masks the true water table position. .

5.03 Standard Penetration Tests in the subsoil gave N values of 5 - 60 .

5.04 No significant roots were encountered in the boreholes.

5.05 For your information Standard Penetration Test N values can be calculated from the dynamic probe by taking 3 consecutive blow counts for 10 cm and adding them together. I.E. N = DP 300.

5.06 Laboratory testing proved the granular material to contain less than 20% fines and as such can be considered as non shrinkable.

5.07 Laboratory testing proved the clays to be of intermediate to very high plasticity (PI=20 - 53%) which indicates a high susceptibility to movement associated with moisture content change.

5.08 Therefore when considering the information available we are of the opinion that a series of piles and ground beams would form the optimum foundation solution.

5.09 Further investigation may be required in order to locate existing foundations within the area of the site which may restrict any future works.

5.10 As the site contains less than 0.50g/L of soluble sulphate it can be categorised as a class 1 site in accordance with BRE Digest, and as such any concrete in contact with the subsoil needs no special precautions.

We hope that this is satisfactory, however if you should require any further information, please do not hesitate to contact us.
Yours faithfully,

M. R. Smith M.Sc
Principal Engineer

HERTS & ESSEX SITE INVESTIGATIONS

The Old Post Office, Wellpond Green, Standon, Ware, Herts SG11 1NJ
Telephone: Ware (01920) 822233
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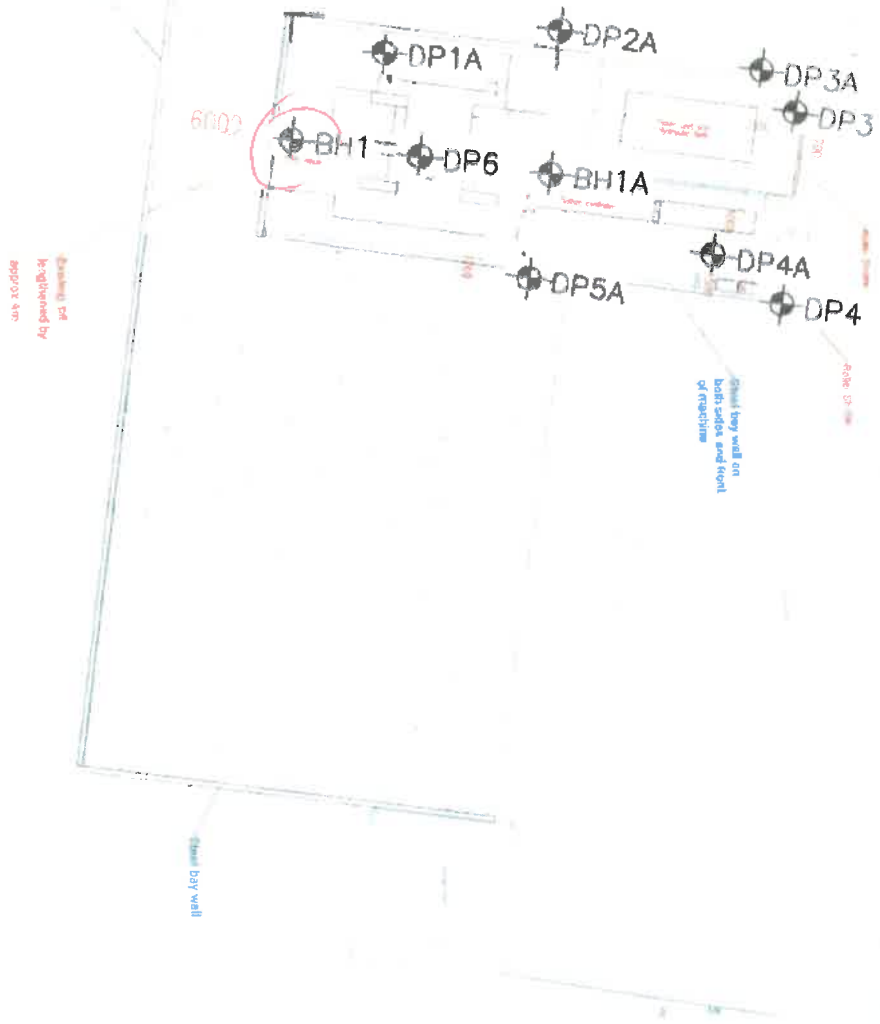
Appendix No.	1
Sheet No.	1
Job No.	14927
Date	Sept 2018

Norton & Sons, River Road, Barking, London IG11 0DS

Site Plan



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Appendix No. 2
Sheet No. 1
Job No. 14927
Date Sept 2018

Norton & Sons, River Road, Barking, London IG11 0DS

Borehole 1 in DP2A

Description of Strata	Depth	Reduced Level	Legend	Thickness (m)	Water Level	Samples No.	Samples Type	Samples Depth (m)	S.P.T N-Value or Vane Strength	Casing Depth (m)
Concrete (Cored)	0.40			0.40	Moderate inflow at 7.40m standing at 3.40m	1	B	0.20		
Loose To Medium Dense Crushed Brick & Concrete FILL	2.60			2.20		2	B	0.70		
						3	B	1.00	N=13	
						4	B	2.00	N=9	
Soft Brown Grey Silty Sandy CLAY	6.20			3.60		5	B	3.00	N=5	
						6	B	4.00	N=6	
						7	B	5.00	N=5	
Soft Fiberous Brown PEAT	7.40			1.20		8	B	6.50	N=7	
						9	B	7.40	N=34	
Medium Dense Grey SAND & GRAVEL				4.60		10	B	9.00	N=37	

Remarks:

Scale 1:50

Key : U-Undisturbed Sample (100mm diameter) B -Bulk Sample ▽ -Water Struck D -Disturbed Sample SZ-Water Standing W-Water Sample P-Piston Sample N-S.P.T. N-Value V-Vane Strength (kN/m²)

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Appendix No. 2
Sheet No. 2
Job No. 14927
Date Sept 2018

Norton & Sons, River Road, Barking, London IG11 0DS

Borehole 1 in DP2A ..... Continued

Description of Strata	Depth	Reduced Level	Legend	Thickness (m)	Water Level	Samples No.	Samples Type	Samples Depth (m)	S.P.T N-Value or Vane Strength	Casing Depth (m)
Medium Dense Grey SAND & GRAVEL				4.60	Moderate inflow at 7.40m standing at 3.40m	11	B	10.50	N=43	
	12.00					12	B	12.00	N=60	
Dense Grey Silty SAND				1.00						
	13.00					13	B	13.00	N=45	
Medium Dense Grey Brown SAND & GRAVEL				1.20						
	14.20									
Very Stiff To Hard Grey Sandy Silty CLAY				1.80		14	B	14.50	N=47	
	16.00					16	B	16.00	N=17	
White Moderatley Weathered Weak CHALK With Some Flints				4.00		17	B	17.50	N=24	
						18	B	19.00	N=32	
Borehole Complete At 20.00m	20.00									20.00

Remarks:

Scale 1:50

Key : U–Undisturbed Sample (100mm diameter) B –Bulk Sample ▽ –Water Struck D –Disturbed Sample ▽ –Water Standing W–Water Sample P–Piston Sample N–S.P.T. N–Value V–Vane Strength (kN/m²)

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Appendix No. 3
Sheet No. 1
Job No. 12960
Date Sept 2018

LOCATION Norton & Sons, River Road, Barking, London IG11 0DS

LIQUID AND PLASTIC LIMIT TEST RESULTS

Borehole	Depth (m)	Sample	Natural Moisture Content (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Group Symbol	Desiccation Profile	Percentage Retained 425 Micron Sieve (%)
DP2A	2.00	U	37	40	20	20	CI		63
DP2A	3.00	U	48	71	26	45	CV		2
DP2A	5.00	U	105	85	30	53	CV		3
DP2A	6.50	U	305					PEAT	
DP2A	14.00	U	32	43	21	22	CI		6

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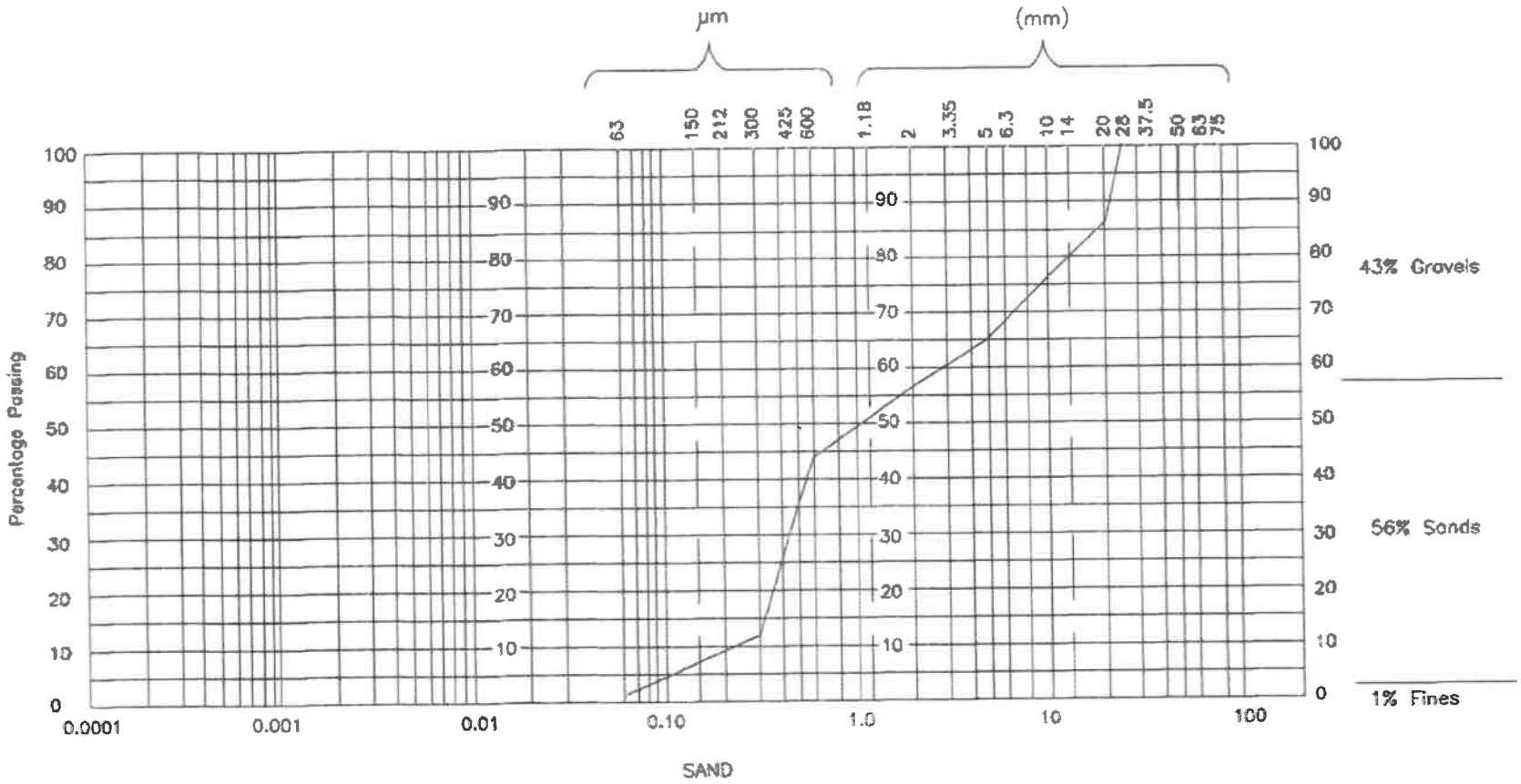
Appendix No. 3
Sheet No. 2
Job No. 12960
Date Sept 2018

PARTICLE SIZE DISTRIBUTION



Site Norton & Sons, River Road, Barking, London IG11 0DS

Borehole No DP2A

Sample No. B

Depth 9.00m

British Standard Sieve Test As Per Test (7a)

Description of Soil :

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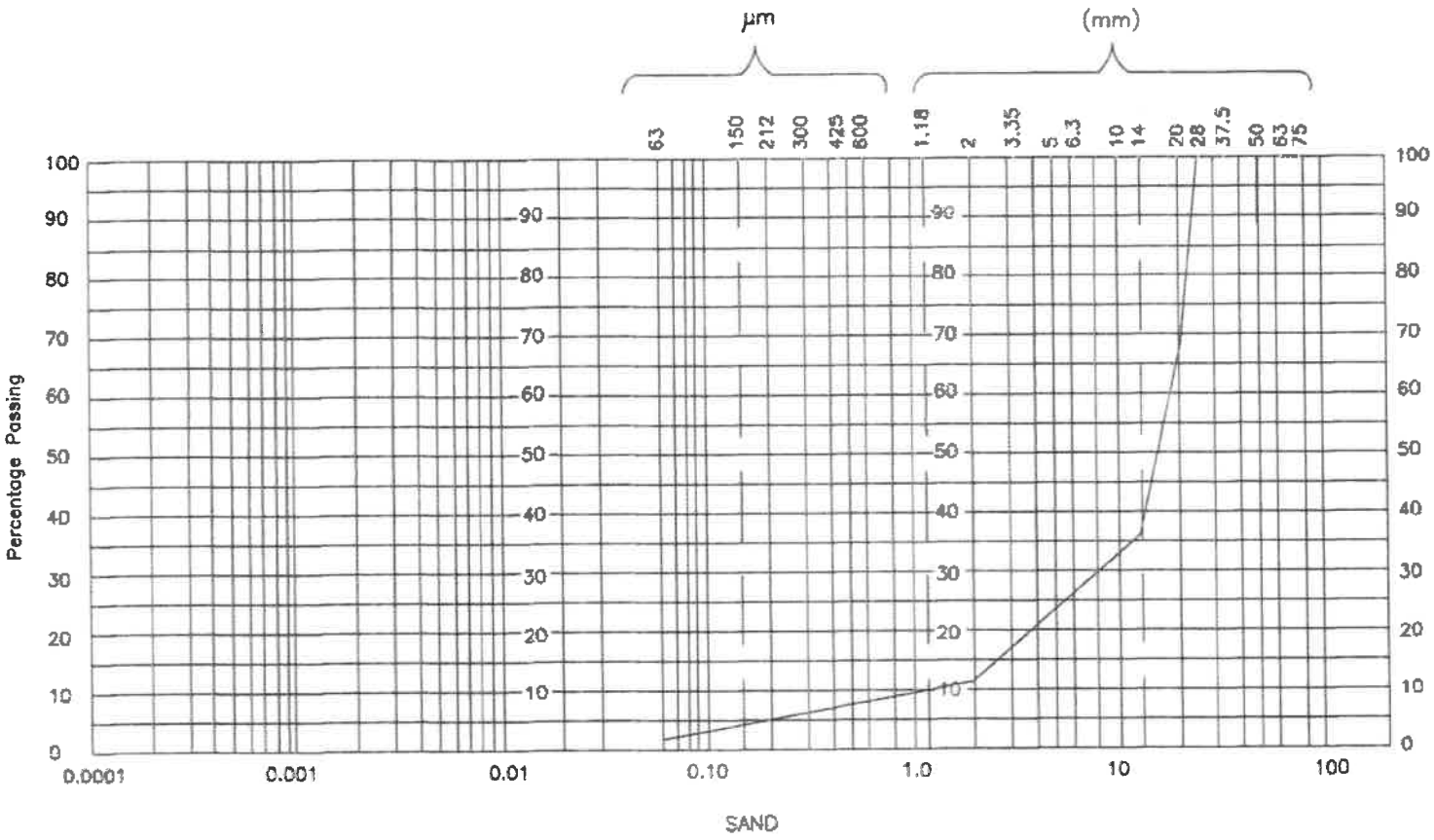
Appendix No. 3
Sheet No. 3
Job No. 12960
Date Sept 2018

PARTICLE SIZE DISTRIBUTION



89% Gravels

9% Sands

2% Fines

Particle Size Distribution (mm)

CLAY	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE	COBBLES
	SILT			SAND			GRAVEL			

Site Norton & Sons, River Road, Barking, London IG11 0DS

Borehole No DP2A

Sample No. B

Depth 13.00m

British Standard Sieve Test As Per Test (7a)

Description of Soil :

Dynamic Probe Plot **DP1A**

Site River Road Barking

Client

Date Sep-18

Depth (m)	Blows (No.)	S.P.T N - Value	Bearing Capacity kN/m²	Depth (m)	Blows (No.)	S.P.T N - Value	Bearing Capacity kN/m²
0.10				5.10			
0.20				5.20			
0.30				5.30			
0.40				5.40			
0.50	2			5.50			
0.60	3			5.60			
0.70	6			5.70			
0.80	12			5.80			
0.90	50+			5.90			
1.00				6.00			
1.10				6.10			
1.20				6.20			
1.30				6.30			
1.40				6.40			
1.50				6.50			
1.60				6.60			
1.70				6.70			
1.80				6.80			
1.90				6.90			
2.00				7.00			
2.10				7.10			
2.20				7.20			
2.30				7.30			
2.40				7.40			
2.50				7.50			
2.60				7.60			
2.70				7.70			
2.80				7.80			
2.90				7.90			
3.00				8.00			
3.10				8.10			
3.20				8.20			
3.30				8.30			
3.40				8.40			
3.50				8.50			
3.60				8.60			
3.70				8.70			
3.80				8.80			
3.90				8.90			
4.00				9.00			
4.10				9.10			
4.20				9.20			
4.30				9.30			
4.40				9.40			
4.50				9.50			
4.60				9.60			
4.70				9.70			
4.80				9.80			
4.90				9.90			
5.00							

Dynamic Probe Plot BH1

Site River Road Barking

Client

Date Sep-18

Depth (m)	Blows (No.)	S.P.T N - Value	Bearing Capacity kN/m²	Depth (m)	Blows (No.)	S.P.T N - Value	Bearing Capacity kN/m²
0.10				5.10			
0.20				5.20			
0.30				5.30			
0.40				5.40			
0.50				5.50			
0.60				5.60			
0.70				5.70			
0.80				5.80			
0.90				5.90			
1.00	3			6.00			
1.10	50+			6.10			
1.20				6.20			
1.30				6.30			
1.40				6.40			
1.50				6.50			
1.60				6.60			
1.70				6.70			
1.80				6.80			
1.90				6.90			
2.00				7.00			
2.10				7.10			
2.20				7.20			
2.30				7.30			
2.40				7.40			
2.50				7.50			
2.60				7.60			
2.70				7.70			
2.80				7.80			
2.90				7.90			
3.00				8.00			
3.10				8.10			
3.20				8.20			
3.30				8.30			
3.40				8.40			
3.50				8.50			
3.60				8.60			
3.70				8.70			
3.80				8.80			
3.90				8.90			
4.00				9.00			
4.10				9.10			
4.20				9.20			
4.30				9.30			
4.40				9.40			
4.50				9.50			
4.60				9.60			
4.70				9.70			
4.80				9.80			
4.90				9.90			
5.00							

Dynamic Probe Plot **BH1A**

Site **River Road Barking**

Client

Date Sep-18

Depth (m)	Blows (No.)	S.P.T N - Value	Bearing Capacity kN/m²	Depth (m)	Blows (No.)	S.P.T N - Value	Bearing Capacity kN/m²
0.10				5.10			
0.20				5.20			
0.30				5.30			
0.40	3			5.40			
0.50	8			5.50			
0.60	7			5.60			
0.70	9			5.70			
0.80	14			5.80			
0.90	17			5.90			
1.00	50+			6.00			
1.10				6.10			
1.20				6.20			
1.30				6.30			
1.40				6.40			
1.50				6.50			
1.60				6.60			
1.70				6.70			
1.80				6.80			
1.90				6.90			
2.00				7.00			
2.10				7.10			
2.20				7.20			
2.30				7.30			
2.40				7.40			
2.50				7.50			
2.60				7.60			
2.70				7.70			
2.80				7.80			
2.90				7.90			
3.00				8.00			
3.10				8.10			
3.20				8.20			
3.30				8.30			
3.40				8.40			
3.50				8.50			
3.60				8.60			
3.70				8.70			
3.80				8.80			
3.90				8.90			
4.00				9.00			
4.10				9.10			
4.20				9.20			
4.30				9.30			
4.40				9.40			
4.50				9.50			
4.60				9.60			
4.70				9.70			
4.80				9.80			
4.90				9.90			
5.00							

Dynamic Probe Plot DP2A

Site **River Road Barking**

Client

Date **Sep-18**

Depth (m)	Blows (No.)	S.P.T N - Value	Bearing Capacity kN/m²	Depth (m)	Blows (No.)	S.P.T N - Value	Bearing Capacity kN/m²
0.10				5.10			
0.20				5.20			
0.30				5.30			
0.40	8			5.40			
0.50	10			5.50			
0.60	10			5.60			
0.70	13			5.70			
0.80	11			5.80			
0.90	9			5.90			
1.00	12			6.00			
1.10	21			6.10			
1.20	17			6.20			
1.30	21			6.30			
1.40	35			6.40			
1.50	16			6.50			
1.60	6			6.60			
1.70	3			6.70			
1.80	1			6.80			
1.90	2			6.90			
2.00	1			7.00			
2.10	8			7.10			
2.20	9			7.20			
2.30	5			7.30			
2.40	2			7.40			
2.50	2			7.50			
2.60	2			7.60			
2.70	2			7.70			
2.80	3			7.80			
2.90	2			7.90			
3.00	2			8.00			
3.10	3			8.10			
3.20	2			8.20			
3.30	2			8.30			
3.40	3			8.40			
3.50	3			8.50			
3.60	3			8.60			
3.70	3			8.70			
3.80	4			8.80			
3.90	3			8.90			
4.00	4			9.00			
4.10	4			9.10			
4.20	3			9.20			
4.30	4			9.30			
4.40	3			9.40			
4.50	4			9.50			
4.60	4			9.60			
4.70	3			9.70			
4.80	4			9.80			
4.90	4			9.90			
5.00	4						

Dynamic Probe Plot DP3

Site River Road Barking

Client

Date Sep-18

Depth (m)	Blows (No.)	S.P.T N - Value	Bearing Capacity kN/m²
0.10			
0.20			
0.30			
0.40			
0.50			
0.60			
0.70	3		
0.80	6		
0.90	6		
1.00	5		
1.10	6		
1.20	7		
1.30	29		
1.40	5		
1.50	1		
1.60	0		
1.70	0		
1.80	2		
1.90	1		
2.00	0		
2.10	4		
2.20	4		
2.30	3		
2.40	2		
2.50	2		
2.60	1		
2.70	2		
2.80	2		
2.90	3		
3.00	2		
3.10	3		
3.20	2		
3.30	3		
3.40	4		
3.50	4		
3.60	4		
3.70	4		
3.80	4		
3.90	5		
4.00	5		
4.10	4		
4.20	5		
4.30	5		
4.40	5		
4.50	5		
4.60	5		
4.70	5		
4.80	5		
4.90	5		
5.00	5		

Depth (m)	Blows (No.)	S.P.T N - Value	Bearing Capacity kN/m²
5.10			
5.20			
5.30			
5.40			
5.50			
5.60			
5.70			
5.80			
5.90			
6.00			
6.10			
6.20			
6.30			
6.40			
6.50			
6.60			
6.70			
6.80			
6.90			
7.00			
7.10			
7.20			
7.30			
7.40			
7.50			
7.60			
7.70			
7.80			
7.90			
8.00			
8.10			
8.20			
8.30			
8.40			
8.50			
8.60			
8.70			
8.80			
8.90			
9.00			
9.10			
9.20			
9.30			
9.40			
9.50			
9.60			
9.70			
9.80			
9.90			

Dynamic Probe Plot DP3A

Site **River Road Barking**

Client

Date Sep-18

Depth (m)	Blows (No.)	S.P.T N - Value	Bearing Capacity kN/m²	Depth (m)	Blows (No.)	S.P.T N - Value	Bearing Capacity kN/m²
0.10				5.10			
0.20				5.20			
0.30				5.30			
0.40	8			5.40			
0.50	50+			5.50			
0.60				5.60			
0.70				5.70			
0.80				5.80			
0.90				5.90			
1.00				6.00			
1.10				6.10			
1.20				6.20			
1.30				6.30			
1.40				6.40			
1.50				6.50			
1.60				6.60			
1.70				6.70			
1.80				6.80			
1.90				6.90			
2.00				7.00			
2.10				7.10			
2.20				7.20			
2.30				7.30			
2.40				7.40			
2.50				7.50			
2.60				7.60			
2.70				7.70			
2.80				7.80			
2.90				7.90			
3.00				8.00			
3.10				8.10			
3.20				8.20			
3.30				8.30			
3.40				8.40			
3.50				8.50			
3.60				8.60			
3.70				8.70			
3.80				8.80			
3.90				8.90			
4.00				9.00			
4.10				9.10			
4.20				9.20			
4.30				9.30			
4.40				9.40			
4.50				9.50			
4.60				9.60			
4.70				9.70			
4.80				9.80			
4.90				9.90			
5.00							

Dynamic Probe Plot **DP4**

Site River Road Barking

Client

Date Sep-18

Depth (m)	Blows (No.)	S.P.T N - Value	Bearing Capacity kN/m²	Depth (m)	Blows (No.)	S.P.T N - Value	Bearing Capacity kN/m²
0.10				5.10			
0.20				5.20			
0.30				5.30			
0.40				5.40			
0.50				5.50			
0.60	1			5.60			
0.70	14			5.70			
0.80	11			5.80			
0.90	12			5.90			
1.00	13			6.00			
1.10	10			6.10			
1.20	17			6.20			
1.30	26			6.30			
1.40	37			6.40			
1.50	25			6.50			
1.60	19			6.60			
1.70	17			6.70			
1.80	15			6.80			
1.90	7			6.90			
2.00	5			7.00			
2.10	3			7.10			
2.20	3			7.20			
2.30	5			7.30			
2.40	4			7.40			
2.50	2			7.50			
2.60	3			7.60			
2.70	3			7.70			
2.80	4			7.80			
2.90	4			7.90			
3.00	5			8.00			
3.10	4			8.10			
3.20	4			8.20			
3.30	6			8.30			
3.40	6			8.40			
3.50	4			8.50			
3.60	4			8.60			
3.70	5			8.70			
3.80	6			8.80			
3.90	14			8.90			
4.00	13			9.00			
4.10	11			9.10			
4.20	9			9.20			
4.30	4			9.30			
4.40	3			9.40			
4.50	3			9.50			
4.60	3			9.60			
4.70	4			9.70			
4.80	4			9.80			
4.90	6			9.90			
5.00	5						

Dynamic Probe Plot DP4A

Site River Road Barking

Client

Date Sep-18

Depth (m)	Blows (No.)	S.P.T N - Value	Bearing Capacity kN/m²	Depth (m)	Blows (No.)	S.P.T N - Value	Bearing Capacity kN/m²
0.10				5.10			
0.20				5.20			
0.30				5.30			
0.40				5.40			
0.50				5.50			
0.60				5.60			
0.70				5.70			
0.80				5.80			
0.90	1			5.90			
1.00	6			6.00			
1.10	14			6.10			
1.20	6			6.20			
1.30	2			6.30			
1.40	0			6.40			
1.50	0			6.50			
1.60	0			6.60			
1.70	0			6.70			
1.80	0			6.80			
1.90	1			6.90			
2.00	0			7.00			
2.10	0			7.10			
2.20	0			7.20			
2.30	1			7.30			
2.40	1			7.40			
2.50	11			7.50			
2.60	27			7.60			
2.70	9			7.70			
2.80	3			7.80			
2.90	2			7.90			
3.00	2			8.00			
3.10	2			8.10			
3.20	2			8.20			
3.30	2			8.30			
3.40	1			8.40			
3.50	2			8.50			
3.60	1			8.60			
3.70	2			8.70			
3.80	1			8.80			
3.90	0			8.90			
4.00	1			9.00			
4.10	1			9.10			
4.20	2			9.20			
4.30	1			9.30			
4.40	1			9.40			
4.50	2			9.50			
4.60	1			9.60			
4.70	2			9.70			
4.80	2			9.80			
4.90	1			9.90			
5.00	2						

Dynamic Probe Plot DP5A

Site River Road Barking

Client

Date Sep-18

Depth (m)	Blows (No.)	S.P.T N - Value	Bearing Capacity kN/m²	Depth (m)	Blows (No.)	S.P.T N - Value	Bearing Capacity kN/m²
0.10				5.10			
0.20				5.20			
0.30				5.30			
0.40	5			5.40			
0.50	4			5.50			
0.60	9			5.60			
0.70	16			5.70			
0.80	12			5.80			
0.90	7			5.90			
1.00	6			6.00			
1.10	7			6.10			
1.20	3			6.20			
1.30	2			6.30			
1.40	2			6.40			
1.50	13			6.50			
1.60	5			6.60			
1.70	1			6.70			
1.80	15			6.80			
1.90	13			6.90			
2.00	6			7.00			
2.10	12			7.10			
2.20	18			7.20			
2.30	9			7.30			
2.40	3			7.40			
2.50	2			7.50			
2.60	2			7.60			
2.70	2			7.70			
2.80	2			7.80			
2.90	2			7.90			
3.00	3			8.00			
3.10	3			8.10			
3.20	2			8.20			
3.30	3			8.30			
3.40	2			8.40			
3.50	3			8.50			
3.60	2			8.60			
3.70	4			8.70			
3.80	3			8.80			
3.90	4			8.90			
4.00	5			9.00			
4.10	4			9.10			
4.20	5			9.20			
4.30	4			9.30			
4.40	5			9.40			
4.50	5			9.50			
4.60	4			9.60			
4.70	5			9.70			
4.80	5			9.80			
4.90	5			9.90			
5.00	5						

Dynamic Probe Plot **DP6**

Site River Road Barking

Client

Date Sep-18

Depth (m)	Blows (No.)	S.P.T N - Value	Bearing Capacity kN/m²	Depth (m)	Blows (No.)	S.P.T N - Value	Bearing Capacity kN/m²
0.10				5.10			
0.20				5.20			
0.30				5.30			
0.40	6			5.40			
0.50	6			5.50			
0.60	3			5.60			
0.70	5			5.70			
0.80	8			5.80			
0.90	13			5.90			
1.00	50+			6.00			
1.10				6.10			
1.20				6.20			
1.30				6.30			
1.40				6.40			
1.50				6.50			
1.60				6.60			
1.70				6.70			
1.80				6.80			
1.90				6.90			
2.00				7.00			
2.10				7.10			
2.20				7.20			
2.30				7.30			
2.40				7.40			
2.50				7.50			
2.60				7.60			
2.70				7.70			
2.80				7.80			
2.90				7.90			
3.00				8.00			
3.10				8.10			
3.20				8.20			
3.30				8.30			
3.40				8.40			
3.50				8.50			
3.60				8.60			
3.70				8.70			
3.80				8.80			
3.90				8.90			
4.00				9.00			
4.10				9.10			
4.20				9.20			
4.30				9.30			
4.40				9.40			
4.50				9.50			
4.60				9.60			
4.70				9.70			
4.80				9.80			
4.90				9.90			
5.00							

APPENDIX 04

Exploratory Hole Records

Borehole Log

GROUNDTECH CONSULTING

Borehole No. **BH01**

Sheet 1 of 3

Project Name: AXION	Project No. 20166	Co-ords: -	Hole Type CP
Location: BARKING		Level:	Scale 1:50
Client: WML		Dates: 04/06/2020 - 04/06/2020	Logged By BM

Well	Water Strikes	Samples and In Situ Testing			Depth (m)	Level (m)	Legend	Stratum Description
		Depth (m)	Type	Results				
								MADE GROUND: Pre-broken out concrete.
					1.00			NO RECOVERY.
		3.00		N=22 (3,3/4,5,5,8)				
					3.50			MADE GROUND: Very soft dark grey black slightly gravelly silty clay. Gravel is subangular fine to medium of brick and concrete.
		3.70	ES					
		4.00	D					
		4.00		N=13 (2,2/3,3,3,4)				
		4.80	ES					
		5.00	D					
		5.00		N=14 (1,2/3,3,3,5)				
		5.90	ES					
		6.00	D		6.00			Black slightly clayey silty pseudo fibrous PEAT. Wood common.
		6.50	ES					
		6.50		N=16 (2,2/3,4,4,5)				
		7.00	D		6.80			Very soft slightly gravelly silty CLAY. Gravel is subangular to rounded fine of mixed lithologies including quartzite and chert.
		7.50	ES					
	▼	8.00	D		8.00			Medium dense brown medium SAND and subangular to subrounded fine to coarse GRAVEL of mixed lithologies including chert and quartzite.
		8.00		N=26 (3,4/6,6,7,7)				
		8.50	ES					
		9.00	D					
		9.50		N=34 (4,6/7,7,9,11)				*Dense from 9.50m bgl.*
		10.00	D					

Continued on next sheet

Remarks

1. Area had been previously excavated with a mechanical excavator to a depth of c. 3.50m and loosely backfilled. 2. Water entry at 8.00m bgl. 3. Backfilled with arisings.

Borehole Log

GROUNDTECH CONSULTING

Borehole No. **BH01**

Sheet 2 of 3

Project Name: AXION	Project No. 20166	Co-ords: -	Hole Type CP
Location: BARKING		Level:	Scale 1:50
Client: WML		Dates: 04/06/2020 - 04/06/2020	Logged By BM

Well	Water Strikes	Samples and In Situ Testing			Depth (m)	Level (m)	Legend	Stratum Description	
		Depth (m)	Type	Results					
		10.00	ES						
		11.00	D						11
		11.00		N=41 (5,7/8,10,10,13)					
		12.00	D						12
		12.00	ES						
		12.50		N=42 (6,7/8,10,11,13)					
		13.00	D		13.00			Dense grey green slightly clayey silty fine SAND. Locally clayey.	13
		14.00	D						14
		14.00		N=48 (7,8/10,12,12,14)					
		15.00	D						15
		15.50		N=50 (8,10/50 for 260mm)				*Very dense from 15.50m bgl.*	
		16.00	D						16
		17.00	D						17
		17.00		N=50 (10,12/50 for 205mm)					
		18.00	D						18
		18.50		N=50 (25 for 135mm/50 for 195mm)					
		19.00	D						19
		20.00	D		20.00				20

Continued on next sheet

Remarks

1. Area had been previously excavated with a mechanical excavator to a depth of c. 3.50m and loosely backfilled. 2. Water entry at 8.00m bgl. 3. Backfilled with arisings.

GROUNDTECH CONSULTING

Borehole Log

Borehole No. **BH01**

Sheet 3 of 3

Project Name: AXION	Project No. 20166	Co-ords: -	Hole Type CP
Location: BARKING		Level:	Scale 1:50
Client: WML		Dates: 04/06/2020 - 04/06/2020	Logged By BM

Well	Water Strikes	Samples and In Situ Testing			Depth (m)	Level (m)	Legend	Stratum Description
		Depth (m)	Type	Results				
		20.00		N=50 (25 for 120mm/50 for 185mm)				End of borehole at 20.00 m

21
22
23
24
25
26
27
28
29
30

Remarks

1. Area had been previously excavated with a mechanical excavator to a depth of c. 3.50m and loosely backfilled. 2. Water entry at 8.00m bgl. 3. Backfilled with arisings.

GROUNDTECH CONSULTING

Borehole Log

Borehole No. **BH01A** Sheet 1 of 1

Project Name: AXION	Project No. 20166	Co-ords: -	Hole Type CP
Location: BARKING		Level:	Scale 1:50
Client: WML		Dates: 04/06/2020 - 04/06/2020	Logged By BM

Well	Water Strikes	Samples and In Situ Testing			Depth (m)	Level (m)	Legend	Stratum Description
		Depth (m)	Type	Results				
		0.50	ES		0.30			MADE GROUND: Concrete with rebar reinforcement.
		0.80	ES					MADE GROUND: Black sandy angular to subrounded fine to coarse gravel of ash, clinker and slag. *Asbestos cement ACM material present at 0.70m bgl.*
					0.90			MADE GROUND: Concrete slab.
					0.90			End of borehole at 0.90 m

Remarks
1. Hand dug pit to 0.90m bgl. 2. No groundwater encountered. 3. Terminated on concrete obstruction at 0.90m bgl.

GROUNDTECH CONSULTING

Borehole Log

Borehole No. **BH02**

Sheet 1 of 3

Project Name: AXION	Project No. 20166	Co-ords: -	Hole Type CP
Location: BARKING		Level:	Scale 1:50
Client: WML		Dates: 05/06/2020 - 05/06/2020	Logged By BM

Well	Water Strikes	Samples and In Situ Testing: Depth (m)	Type	Results	Depth (m)	Level (m)	Legend	Stratum Description
								MADE GROUND: Concrete with rebar reinforcement.
		0.45	D		0.45			
		0.50	ES					MADE GROUND: Brown very gravelly sand. Gravel is angular to subrounded fine to coarse of mixed lithologies including brick, concrete and ash.
		0.50 - 1.00	B		0.70			
		0.90	ES					MADE GROUND: Dark brown slightly clayey gravelly silty fine sand. Gravel is angular to subrounded fine to coarse of mixed lithologies including brick, concrete, chert and ash.
		1.20		N=12 (5,8/4,3,3,2)				*Concrete obstruction at 0.95m bgl.*
		1.20 - 1.70	B					*Locally clayey from 1.30m bgl.*
		2.00	D					
		2.00	ES					
		2.00		N=14 (2,2/3,4,4,3)				
		2.00 - 2.50	B					*From 2.50m becoming slightly gravelly of subangular fine to medium brick.*
		3.00	D					
		3.00	ES					*Locally sandy silty clay at 3.00m bgl.*
		3.00		N=15 (2,3/3,3,5,4)				
		3.00 - 3.50	B					
					3.70			Medium dense grey slightly clayey silty fine SAND.
		4.00	D					
		4.00	ES					
		5.00	D					
		5.00	ES					
		5.00		N=10 (3,4/2,3,2,3)				
					5.90			Black slightly clayey silty pseudo fibrous PEAT.
		6.00	D					
		6.00	ES					
		6.50		N=29 (4,5/5,7,8,9)	6.50			Medium dense grey silty fine SAND.
	▼	7.00	ES					
		7.10	D					
					7.40			Medium dense brown medium SAND and subangular to subrounded fine to coarse GRAVEL of mixed lithologies including chert and quartzite.
		8.00	D					
		8.00	ES					
		8.00		N=29 (3,5/5,7,7,10)				
		9.00	D					
		9.00	ES					
		9.50		N=32 (5,7/7,8,8,9)				*Dense from 9.50m bgl.*
		10.00	D					

Continued on next sheet

Remarks

1. Hand dug pit to 1.20m bgl. 2. Water entry at 7.00m bgl. 3. Backfilled with arisings.

GROUNDTECH CONSULTING

Borehole Log

Borehole No. **BH02**

Sheet 2 of 3

Project Name: AXION	Project No. 20166	Co-ords: -	Hole Type CP
Location: BARKING		Level:	Scale 1:50
Client: WML		Dates: 05/06/2020 - 05/06/2020	Logged By BM

Well	Water Strikes	Samples and In Situ Testing			Depth (m)	Level (m)	Legend	Stratum Description	
		Depth (m)	Type	Results					
		11.00 11.00	D	N=28 (4,5/6,7,7,8)				*Medium dense at 11.00m bgl.*	11
		12.00	D						12
		12.50		N=37 (5,7/7,8,10,12)					
		13.00	D						13
		14.00 14.00	D	N=44 (4,7/9,11,12,12)	14.00			Dense grey green slightly clayey silty fine SAND. Locally clayey.	14
		15.00	D						15
		15.50		N=40 (5,6/8,9,11,12)					
		16.00	D						16
		17.00 17.00	D	N=50 (11,13/50 for 194mm)				*Very dense from 17.00m bgl.*	17
		18.00	D						18
		18.50		N=50 (10,12/50 for 234mm)					
		19.00	D						19
		20.00	D		20.00				20

Continued on next sheet

Remarks

1. Hand dug pit to 1.20m bgl. 2. Water entry at 7.00m bgl. 3. Backfilled with arisings.

GROUNDTECH CONSULTING

Borehole Log

Borehole No. **BH02**

Sheet 3 of 3

Project Name: AXION	Project No. 20166	Co-ords: -	Hole Type CP
Location: BARKING		Level:	Scale 1:50
Client: WML		Dates: 05/06/2020 - 05/06/2020	Logged By BM

Well	Water Strikes	Samples and In Situ Testing			Depth (m)	Level (m)	Legend	Stratum Description
		Depth (m)	Type	Results				
		20.00		N=50 (12,13/50 for 156mm)				End of borehole at 20.00 m

21
22
23
24
25
26
27
28
29
30

Remarks
1. Hand dug pit to 1.20m bgl. 2. Water entry at 7.00m bgl. 3. Backfilled with arisings.

Borehole Log

GROUNDTECH CONSULTING

Borehole No. **WS01**

Sheet 1 of 1

Project Name: AXION	Project No. 20166	Co-ords: -	Hole Type WS
Location: BARKING		Level:	Scale 1:25
Client: WML		Dates: 04/06/2020 - 04/06/2020	Logged By BM

Well	Water Strikes	Samples and In Situ Testing			Depth (m)	Level (m)	Legend	Stratum Description
		Depth (m)	Type	Results				
					0.30			MADE GROUND: Concrete with rebar reinforcement.
		0.55	ES					MADE GROUND: Black sandy angular to subrounded fine to coarse gravel of ash, clinker and slag.
		0.90		N=50 (25 for 0mm/50 for 0mm)	0.90			MADE GROUND: Concrete obstruction.
					0.90			End of borehole at 0.90 m

1 2 3 4 5

Remarks

1. Hand dug pit to 0.90m bgl. 2. No groundwater encountered. 3. Terminated on concrete obstruction at 0.90m bgl.

GROUNDTECH CONSULTING

Borehole Log

Borehole No. **WS02**

Sheet 1 of 1

Project Name: AXION	Project No. 20166	Co-ords: -	Hole Type WS
Location: BARKING		Level:	Scale 1:25
Client: WML		Dates: 04/06/2020 - 04/06/2020	Logged By BM

Well	Water Strikes	Samples and In Situ Testing			Depth (m)	Level (m)	Legend	Stratum Description
		Depth (m)	Type	Results				
		0.30	ES		0.25			MADE GROUND: Concrete with rebar reinforcement.
								MADE GROUND: Black sandy angular to subrounded fine to coarse gravel of ash, clinker and slag.
		0.80		N=50 (25 for 0mm/50 for 0mm)	0.80			MADE GROUND: Concrete obstruction.
					0.80			End of borehole at 0.80 m

1
2
3
4
5

Remarks

1. Hand dug pit to 0.80m bgl. 2. Terminated on concrete obstruction at 0.80m bgl. 3. No groundwater encountered. 4. Backfilled with arisings.

Borehole Log

GROUNDTECH CONSULTING

Borehole No. **WS03**

Sheet 1 of 1

Project Name: AXION	Project No. 20166	Co-ords: -	Hole Type WS
Location: BARKING		Level:	Scale 1:25
Client: WML		Dates: 04/06/2020 - 04/06/2020	Logged By BM

Well	Water Strikes	Samples and In Situ Testing			Depth (m)	Level (m)	Legend	Stratum Description
		Depth (m)	Type	Results				
		0.40	ES		0.30			MADE GROUND: Concrete with rebar reinforcement.
					0.60			MADE GROUND: Black sandy angular to subrounded fine to coarse gravel of ash, clinker and slag.
		0.90	ES					MADE GROUND: Dark red brown slightly clayey very gravelly sand. Gravel is angular to subrounded fine to medium of mixed lithologies including ash, clinker, chert, brick and concrete. Damp.
		1.20		N=61 (5,5/61 for 150mm)	1.35			MADE GROUND: Concrete obstruction.
					1.35			End of borehole at 1.35 m

1 2 3 4 5

Remarks

1. Hand dug pit to 1.20m bgl. 2. No groundwater encountered. 3. Terminated on concrete obstruction at 1.35m bgl. 4. Backfilled with arisings.

Borehole Log

GROUNDTECH CONSULTING

Borehole No. **WS04**

Sheet 1 of 1

Project Name: AXION	Project No. 20166	Co-ords: -	Hole Type WS
Location: BARKING		Level:	Scale 1:25
Client: WML		Dates: 04/06/2020 - 04/06/2020	Logged By BM

Well	Water Strikes	Samples and In Situ Testing			Depth (m)	Level (m)	Legend	Stratum Description
		Depth (m)	Type	Results				
					0.45			MADE GROUND: Concrete with rebar reinforcement.
		0.65	ES		0.75			MADE GROUND: Brown very gravelly sand. Gravel is angular to subrounded fine to coarse of mixed lithologies including brick, concrete and ash.
		0.90 0.90	ES	N=50 (25 for 0mm/50 for 0mm)	1.00 1.00			MADE GROUND: Dark brown slightly clayey gravelly silty fine sand. Gravel is angular to subrounded fine to coarse of mixed lithologies including brick, concrete, chert and ash. MADE GROUND: Concrete obstruction. End of borehole at 1.00 m

Remarks

1. Hand dug pit to 1.00m bgl. 2. Terminated on concrete obstruction at 1.00m bgl. 3. No groundwater encountered. 4. Backfilled with arisings.

GROUNDTECH CONSULTING

Borehole Log

Borehole No. **WS05**

Sheet 1 of 1

Project Name: AXION	Project No. 20166	Co-ords: -	Hole Type WS
Location: BARKING		Level:	Scale 1:25
Client: WML		Dates: 04/06/2020 - 04/06/2020	Logged By BM

Well	Water Strikes	Samples and In Situ Testing			Depth (m)	Level (m)	Legend	Stratum Description	
		Depth (m)	Type	Results					
								MADE GROUND: Pre-broken out concrete.	
					1.00			NO RECOVERY.	1
					2.00			MADE GROUND: Brown medium to coarse sand and subangular to subrounded fine to coarse gravel of mixed lithologies including brick, ash, quartzite and chert. Wet.	2
		2.30	ES					*Light brown from 2.65m bgl.*	
		3.00		N=50 (10,14/50 for 150mm)					3
		3.20	ES						
		3.80	ES		3.75			Grey slightly clayey silty fine SAND.	
		3.90	D						
					4.00			End of borehole at 4.00 m	4
									5

Remarks

1. Area had been previously excavated with a mechanical excavator to a depth of c. 2.50m and loosely backfilled. 2. No groundwater encountered. 3. Terminated at 4.0m bgl due to collapse at 4.00m to 2.00m bgl. 4. Backfilled with arisings.

APPENDIX 05

Geotechnical Testing Results

LABORATORY REPORT

4043

Contract Number: PSL20/2854

Report Date: 03 July 2020

Client's Reference: 8860G

Client Name: WML Consulting
No 8 Oak Green Earl Road
Stanley Green Business Park
Cheadle Hulme
Cheshire
SK8 6QL

For the attention of: Sam Seddon

Contract Title: 20166 Axion Barking

Date Received: 11/6/2020
Date Commenced: 11/6/2020
Date Completed: 3/7/2020

Notes: Opinions and Interpretations are outside the UKAS Accreditation

A copy of the Laboratory Schedule of accredited tests as issued by UKAS is attached to this report. This certificate is issued in accordance with the accreditation requirements of the United Kingdom Accreditation Service. The results reported herein relate only to the material supplied to the laboratory. This certificate shall not be reproduced other than in full, without the prior written approval of the laboratory.

Checked and Approved Signatories:

R Gunson (Director)	A Watkins (Director)	R Berriman (Quality Manager)
L Knight (Senior Technician)	S Eyre (Senior Technician)	S Royle (Laboratory Manager)

5 – 7 Hexthorpe Road, Hexthorpe,
Doncaster DN4 0AR
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fax: +44 (0)844 815 6642
e-mail: rgunson@prosoils.co.uk
awatkins@prosoils.co.uk

SUMMARY OF LABORATORY SOIL DESCRIPTIONS

Hole Number	Sample Number	Sample Type	Top Depth m	Base Depth m	Description of Sample
BH01		D	4.00		Brown slightly gravelly CLAY with some organic material.
BH01		D	7.00		Dark brown slightly gravelly very sandy CLAY.
BH01		D	9.00		Dark brown very sandy clayey GRAVEL.
BH01		D	16.00		Dark brown slightly gravelly very sandy CLAY.
BH02		B	0.50		MADE GROUND brown very sandy silty gravel.
BH02		B	1.20		MADE GROUND brown very gravelly very sandy clay.
BH02		B	2.00		Brown gravelly very sandy CLAY.
BH02		D	0.45		MADE GROUND brown very sandy silty gravel.
BH02		D	4.00		Brown sandy silty CLAY with some organic material.
BH02		D	8.00		Brown sandy silty GRAVEL.
BH02		D	14.00		Dark brown slightly clayey very silty SAND.
BH02		D	19.00		Dark brown very gravelly sandy very silty CLAY.
WS01		D	3.90		Brown slightly sandy very silty CLAY with some organic material.

SUMMARY OF SOIL CLASSIFICATION TESTS

(BS1377 : PART 2 : 1990)

Hole Number	Sample Number	Sample Type	Top Depth m	Base Depth m	Moisture Content % Clause 3.2	Linear Shrinkage % Clause 6.5	Particle Density Mg/m^3 Clause 8.2	Liquid Limit % Clause 4.3/4	Plastic Limit % Clause 5.3	Plasticity Index % Clause 5.4	Passing .425mm %	Remarks
BH01		D	4.00		46			84	37	47	98	Very high plasticity CV.
BH01		D	7.00		28			33	16	17	95	Low plasticity CL.
BH01		D	9.00		11							
BH01		D	16.00		39							
BH02		D	0.45		28							
BH02		D	4.00		43							
BH02		D	8.00		2.4							
BH02		D	14.00		30							
BH02		D	19.00		18							
WS01		D	3.90		66							

SYMBOLS : **NP : Non Plastic** *** : Liquid Limit and Plastic Limit Wet Sieved.**

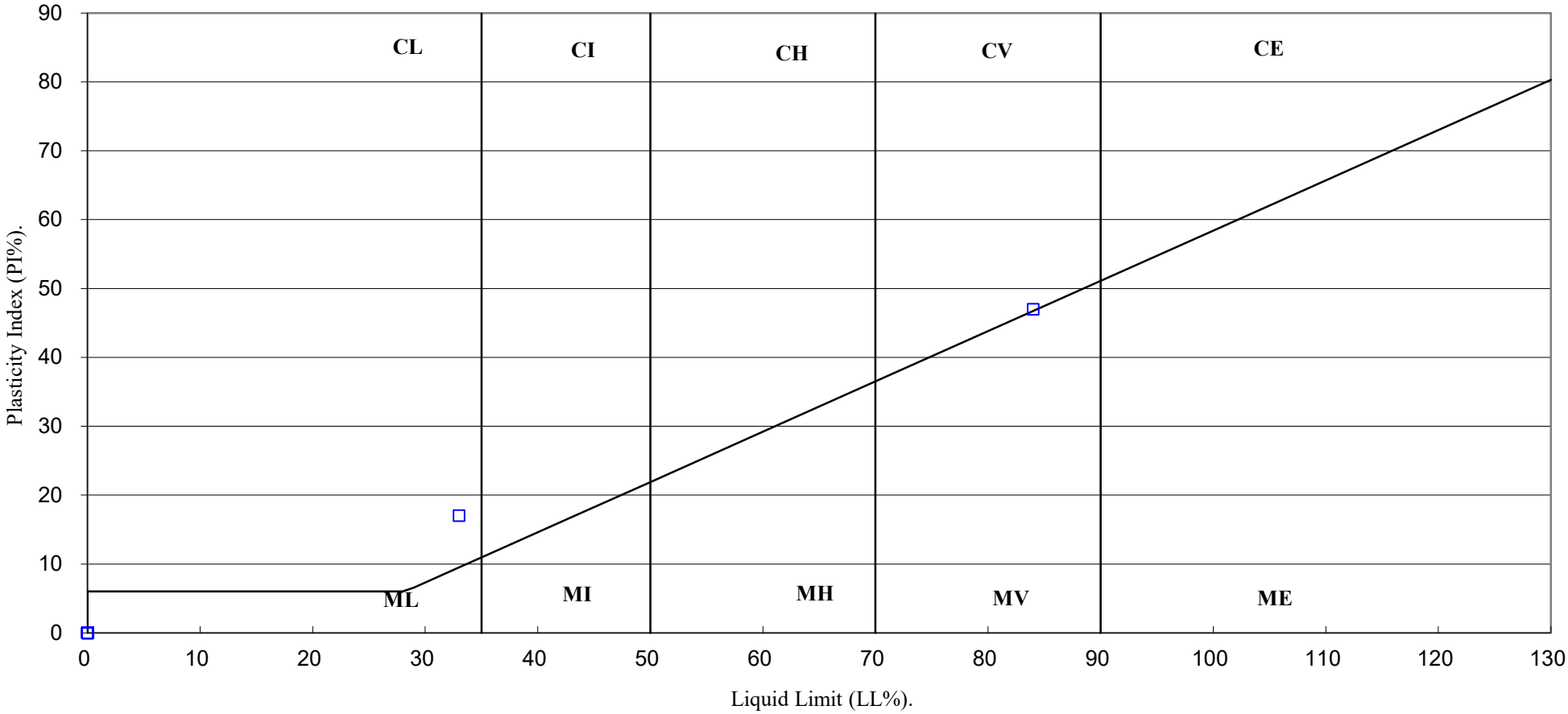
UKAS TESTING 4043

PSL Professional Soils Laboratory

20166- Axion Barking

Contract No:
PSL20/2854
Client Ref:
8860G

PLASTICITY CHART FOR CASAGRANDE CLASSIFICATION.



UKAS TESTING 4043	PSL Professional Soils Laboratory	20166- Axion Barking	Contract No: PSL20/2854 Client Ref: 8860G

PARTICLE SIZE DISTRIBUTION TEST

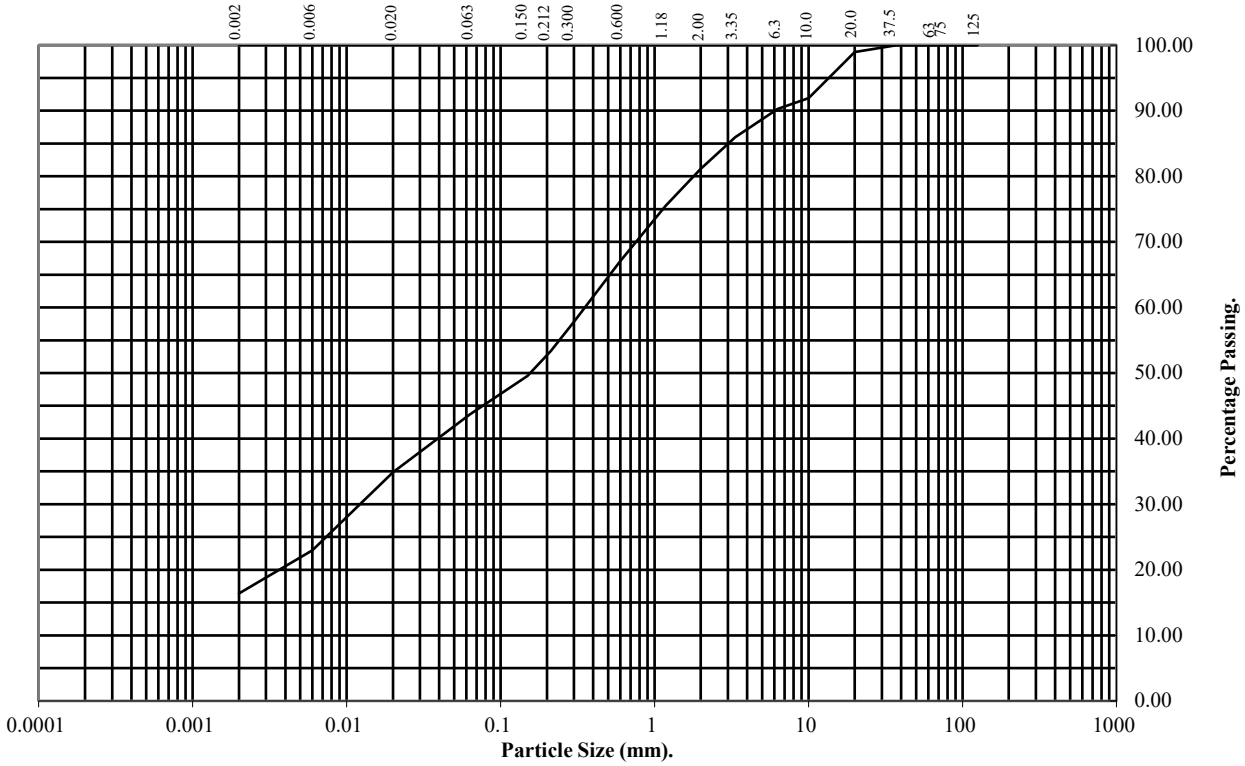
BS1377 : Part 2 : 1990

Wet Sieve & Pipette Analysis, Clause 9.2 & 9.4

Hole Number: **BH02** **Top Depth (m):** **2.00**

Sample Number: **Base Depth(m):**

Sample Type: **B**



BS Test Sieve (mm)	Percentage Passing
125	100
75	100
63	100
37.5	100
20	99
10	92
6.3	90
3.35	86
2	81
1.18	75
0.6	67
0.3	58
0.212	53
0.15	50
0.063	44

Particle Diameter	Percentage Passing
0.02	35
0.006	23
0.002	16

Soil Fraction	Total Percentage
Cobbles	0
Gravel	19
Sand	37
Silt	28
Clay	16

Remarks:

See Summary of Soil Descriptions

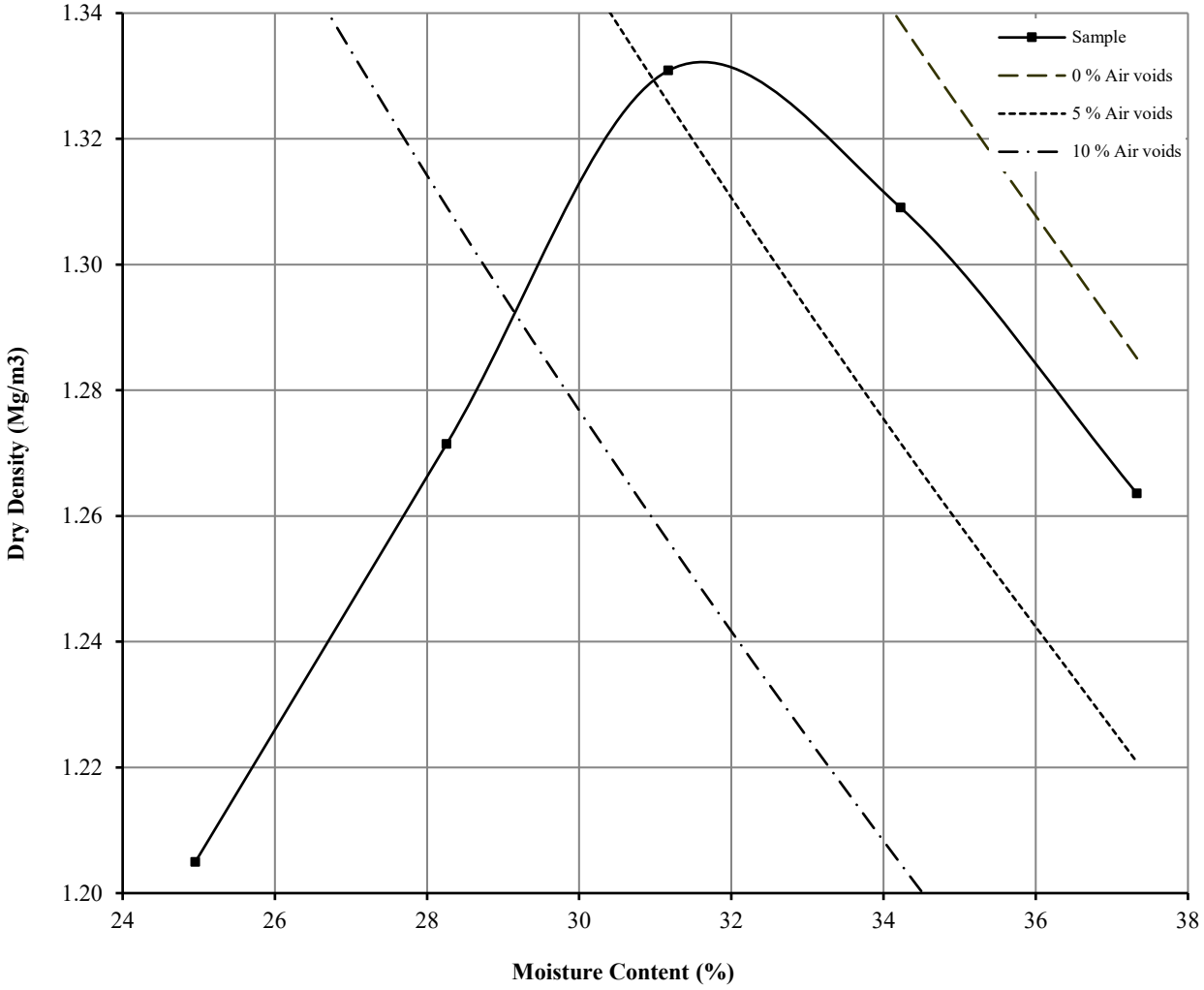
DRY DENSITY / MOISTURE CONTENT RELATIONSHIP

BS 1377 : Part 4 : Clause 3.4 : 1990

Hole Number: BH02 **Top Depth (m) :** 1.20

Sample Number: **Base Depth (m) :**

Sample Type: B



Initial Moisture Content:		41	Method of Compaction:	2.5kg	Separate Samples
Particle Density (Mg/m3):	2.47	Assumed	Material Retained on 37.5 mm Test Sieve (%):		3
Maximum Dry Density (Mg/m3):		1.33	Material Retained on 20.0 mm Test Sieve (%):		13
Optimum Moisture Content (%):		31			
Remarks See summary of soil descriptions.					

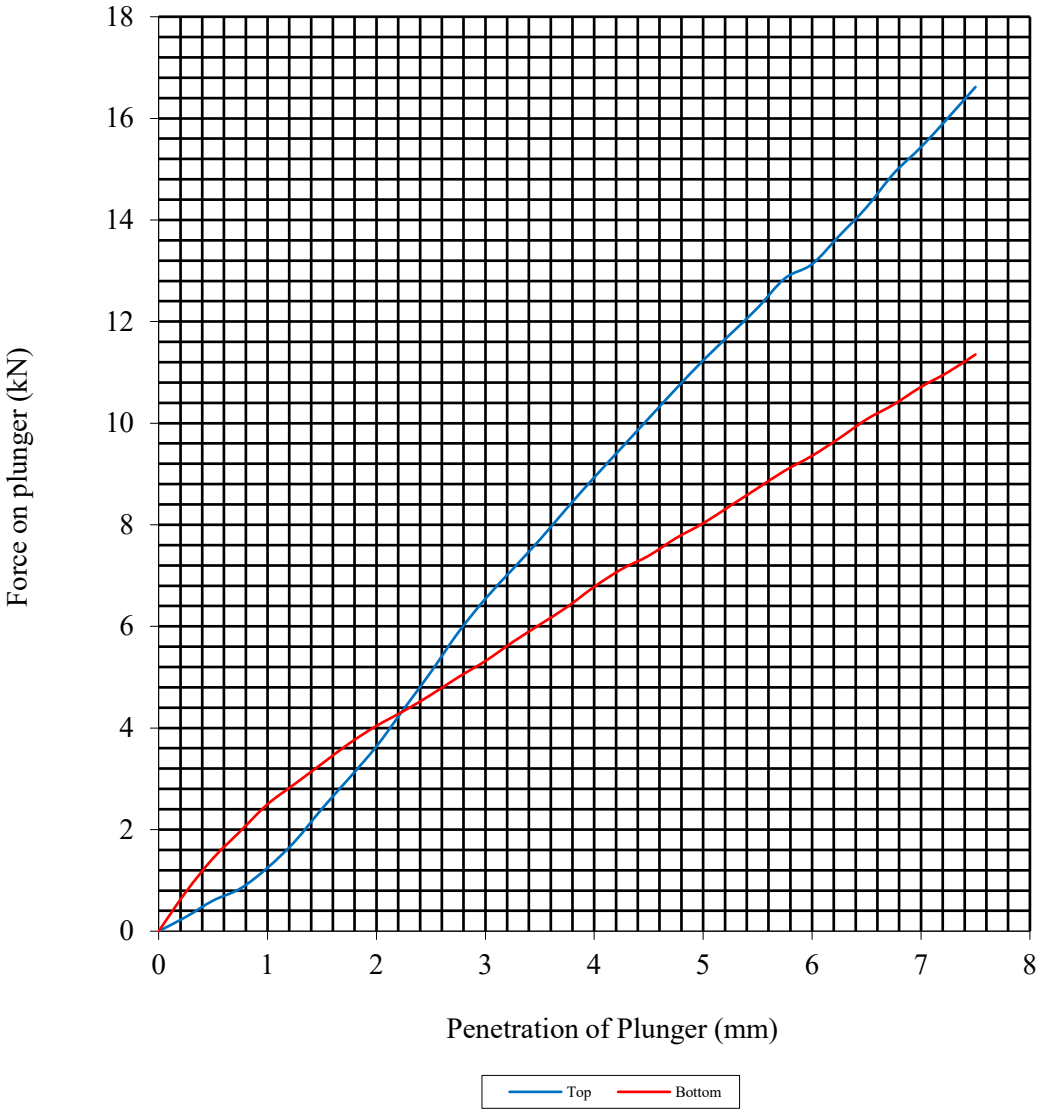
CALIFORNIA BEARING RATIO TEST

BS 1377 : Part 4 : 1990

Hole Number: BH02 **Top Depth (m):** 0.50

Sample Number: **Base Depth (m):**

Sample Type: B



Initial Sample Conditions		Sample Preparation		Final Moisture Content %		C.B.R. Value %	
Moisture Content:	17	Surcharge Kg:	4.20	Sample Top	17	Sample Top	56.2
Bulk Density Mg/m3:	1.86	Soaking Time hrs	0	Sample Bottom	17	Sample Bottom	40.1
Dry Density Mg/m3:	1.59	Swelling mm:	0	Remarks : See Summary of Soil Descriptions.			
Percentage retained on 20mm BS test sieve:			11				
Compaction Conditions		2.5kg					

UKAS TESTING 4043

PSL Professional Soils Laboratory

20166 - Axion Barking

Contract No: PSL20/2854

Client Ref: 8860G

Certificate of Analysis

Certificate Number 20-10809

03-Jul-20

Client Professional Soils Laboratory Ltd
5/7 Hexthorpe Road
Hexthorpe
DN4 0AR

Our Reference 20-10809

Client Reference PSL20/2854

Order No (not supplied)

Contract Title 20166 - Axion Barking

Description 13 Soil samples.

Date Received 19-Jun-20

Date Started 19-Jun-20

Date Completed 03-Jul-20

Test Procedures Identified by prefix DETSn (details on request).

Notes Opinions and interpretations are outside the laboratory's scope of ISO 17025 accreditation. This certificate is issued in accordance with the accreditation requirements of the United Kingdom Accreditation Service. The results reported herein relate only to the material supplied to the laboratory. This certificate shall not be reproduced except in full, without the prior written approval of the laboratory.

Approved By

Adam Fenwick
Contracts Manager

UKAS TESTING
2139

Summary of Chemical Analysis

Soil Samples

Our Ref 20-10809
Client Ref PSL20/2854
Contract Title 20166 - Axion Barking

			Lab No	1686180	1686181	1686182	1686183	1686184	1686185	1686186	1686187	1686188	1686189	1686190
			Sample ID	BH01	BH01	BH01	BH01	BH01	BH01	BH02	BH02	BH02	BH02	BH02
			Depth	5.00	6.00	10.00	14.00	19.00	20.00	3.00	6.00	7.10	9.00	12.00
			Other ID											
			Sample Type	D	D	D	D	D	D	D	D	D	D	D
			Sampling Date	n/s	n/s	n/s	n/s	n/s	n/s	n/s	n/s	n/s	n/s	n/s
			Sampling Time	n/s	n/s	n/s	n/s	n/s	n/s	n/s	n/s	n/s	n/s	n/s
Test	**Method**	**LOD**	**Units**											
Metals														
Magnesium Aqueous Extract	DETSC 2076*	10	mg/l		340	31	19	23	15	50			17	18
Inorganics														
Loss on Ignition at 440oC	DETSC 2003#	0.01	%								54			
pH	DETSC 2008#		pH		7.2	8.1	9.0	8.0	8.2	8.3			5.6	7.3
Organic matter	DETSC 2002#	0.1	%	4.8							> 25	4.4		
Chloride Aqueous Extract	DETSC 2055	1	mg/l		560	140	380	370	410	530			140	34
Nitrate Aqueous Extract as NO3	DETSC 2055	1	mg/l		< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	820			31	6.7
Sulphate Aqueous Extract as SO4	DETSC 2076#	10	mg/l		4100	950	430	320	240	2700			15000	870
Sulphur as S, Total	DETSC 2320	0.01	%		2.2	0.21	0.30	0.46	0.49	1.6			0.19	0.10
Sulphate as SO4, Total	DETSC 2321#	0.01	%		2.1	0.20	0.11	0.11	0.09	4.9			0.47	0.18

Key: * -not accredited. # -MCERTS (accreditation only applies if report carries the MCERTS logo). n/s -not supplied.

Summary of Chemical Analysis

Soil Samples

Our Ref 20-10809
Client Ref PSL20/2854
Contract Title 20166 - Axion Barking

			Lab No	1686191	1686192
			Sample ID	BH02	BH02
			Depth	17.00	20.00
			Other ID		
			Sample Type	D	D
			Sampling Date	n/s	n/s
			Sampling Time	n/s	n/s
Test	**Method**	**LOD**	**Units**		
Metals					
Magnesium Aqueous Extract	DETSC 2076*	10	mg/l	35	28
Inorganics					
Loss on Ignition at 440oC	DETSC 2003#	0.01	%		
pH	DETSC 2008#		pH	6.9	7.4
Organic matter	DETSC 2002#	0.1	%		
Chloride Aqueous Extract	DETSC 2055	1	mg/l	340	98
Nitrate Aqueous Extract as NO3	DETSC 2055	1	mg/l	4.4	1.7
Sulphate Aqueous Extract as SO4	DETSC 2076#	10	mg/l	710	700
Sulphur as S, Total	DETSC 2320	0.01	%	0.82	0.48
Sulphate as SO4, Total	DETSC 2321#	0.01	%	0.29	0.24

Key: * -not accredited. # -MCERTS (accreditation only applies if report carries the MCERTS logo). n/s -not supplied.

Information in Support of the Analytical Results

Our Ref 20-10809
Client Ref PSL20/2854
Contract 20166 - Axion Barking

Containers Received & Deviating Samples

Lab No	Sample ID	Date Sampled	Containers Received	Holding time exceeded for tests	Inappropriate container for tests
1686180	BH01 5.00 SOIL		PG	Sample date not supplied, Organic Matter (Manual) (28 days)	
1686181	BH01 6.00 SOIL		PG	Sample date not supplied, Anions 2:1 (30 days), Total Sulphur ICP (7 days), Total Sulphate ICP (30 days), Metals ICP Prep (182 days), pH + Conductivity (7 days)	
1686182	BH01 10.00 SOIL		PG	Sample date not supplied, Anions 2:1 (30 days), Total Sulphur ICP (7 days), Total Sulphate ICP (30 days), Metals ICP Prep (182 days), pH + Conductivity (7 days)	
1686183	BH01 14.00 SOIL		PG	Sample date not supplied, Anions 2:1 (30 days), Total Sulphur ICP (7 days), Total Sulphate ICP (30 days), Metals ICP Prep (182 days), pH + Conductivity (7 days)	
1686184	BH01 19.00 SOIL		PG	Sample date not supplied, Anions 2:1 (30 days), Total Sulphur ICP (7 days), Total Sulphate ICP (30 days), Metals ICP Prep (182 days), pH + Conductivity (7 days)	
1686185	BH01 20.00 SOIL		PG	Sample date not supplied, Anions 2:1 (30 days), Total Sulphur ICP (7 days), Total Sulphate ICP (30 days), Metals ICP Prep (182 days), pH + Conductivity (7 days)	
1686186	BH02 3.00 SOIL		PG	Sample date not supplied, Anions 2:1 (30 days), Total Sulphur ICP (7 days), Total Sulphate ICP (30 days), Metals ICP Prep (182 days), pH + Conductivity (7 days)	
1686187	BH02 6.00 SOIL		PG	Sample date not supplied, Loss on Ignition (730 days), Organic Matter (Manual) (28 days)	
1686188	BH02 7.10 SOIL		PG	Sample date not supplied, Organic Matter (Manual) (28 days)	
1686189	BH02 9.00 SOIL		PG	Sample date not supplied, Anions 2:1 (30 days), Total Sulphur ICP (7 days), Total Sulphate ICP (30 days), Metals ICP Prep (182 days), pH + Conductivity (7 days)	
1686190	BH02 12.00 SOIL		PG	Sample date not supplied, Anions 2:1 (30 days), Total Sulphur ICP (7 days), Total Sulphate ICP (30 days), Metals ICP Prep (182 days), pH + Conductivity (7 days)	
1686191	BH02 17.00 SOIL		PG	Sample date not supplied, Anions 2:1 (30 days), Total Sulphur ICP (7 days), Total Sulphate ICP (30 days), Metals ICP Prep (182 days), pH + Conductivity (7 days)	
1686192	BH02 20.00 SOIL		PG	Sample date not supplied, Anions 2:1 (30 days), Total Sulphur ICP (7 days), Total Sulphate ICP (30 days), Metals ICP Prep (182 days), pH + Conductivity (7 days)	

Information in Support of the Analytical Results

Our Ref 20-10809
Client Ref PSL20/2854
Contract 20166 - Axion Barking

Key: P-Plastic G-Bag
DETS cannot be held responsible for the integrity of samples received whereby the laboratory did not undertake the sampling. In this instance samples received may be deviating. Deviating Sample criteria are based on British and International standards and laboratory trials in conjunction with the UKAS note 'Guidance on Deviating Samples'. All samples received are listed above. However, those samples that have additional comments in relation to hold time, inappropriate containers etc are deviating due to the reasons stated. This means that the analysis is accredited where applicable, but results may be compromised due to sample deviations. If no sampled date (soils) or date+time (waters) has been supplied then samples are deviating. However, if you are able to supply a sampled date (and time for waters) this will prevent samples being reported as deviating where specific hold times are not exceeded and where the container supplied is suitable.

Soil Analysis Notes

Inorganic soil analysis was carried out on a dried sample, crushed to pass a 425µm sieve, in accordance with BS1377.
Organic soil analysis was carried out on an 'as received' sample. Organics results are corrected for moisture and expressed on a dry weight basis.
The Loss on Drying, used to express organics analysis on an air dried basis, is carried out at a temperature of 28°C +/-2°C.

Disposal

From the issue date of this test certificate, samples will be held for the following times prior to disposal :-
Soils - 1 month, Liquids - 2 weeks, Asbestos (test portion) - 6 months

APPENDIX 06

Chemical Analytical Results

Certificate of Analysis

Certificate Number	20-10212
	23-Jun-20
Client	WML Consulting Ltd No 8 Oak Green Earl Road Cheadle Hulme Cheshire S FAO Adam Fenwick SK8 6QL
Our Reference	20-10212
Client Reference	(not supplied)
Order No	8860G
Contract Title	Axion Barking
Description	12 Soil samples, 3 Leachate samples, 1 Misc sample.
Date Received	10-Jun-20
Date Started	10-Jun-20
Date Completed	23-Jun-20
Test Procedures	Identified by prefix DETSn (details on request).
Notes	Opinions and interpretations are outside the laboratory's scope of ISO 17025 accreditation. This certificate is issued in accordance with the accreditation requirements of the United Kingdom Accreditation Service. The results reported herein relate only to the material supplied to the laboratory. This certificate shall not be reproduced except in full, without the prior written approval of the laboratory.

Approved By

Adam Fenwick
Contracts Manager

UKAS TESTING
2139

Summary of Chemical Analysis
Soil/Misc Samples

Our Ref 20-10212
Client Ref
Contract Title Axion Barking

	Lab No	1681916	1681917	1681918	1681919	1681921	1681923	1681924
	Sample ID	BH01	BH01	BH01	BH01A	BH02	BH02	BH02
	Depth	3.70	4.80	5.90	0.50	0.50	2.00	3.00
	Other ID							
	Sample Type	ES	ES	ES	ES	ES	ES	ES
	Sampling Date	05/06/2020	05/06/2020	05/06/2020	05/06/2020	04/06/2020	04/06/2020	04/06/2020
	Sampling Time	n/s	n/s	n/s	n/s	n/s	n/s	n/s
Test	**Method**	**LOD**	**Units**					
Metals								
Arsenic	DETSC 2301#	0.2	mg/kg	390			9.1	19		93
Boron, Water Soluble	DETSC 2311#	0.2	mg/kg	3.7			1.6	1.0		2.0
Cadmium	DETSC 2301#	0.1	mg/kg	20			0.3	0.3		1.1
Chromium, Hexavalent	DETSC 2204*	1	mg/kg	< 1.0			< 1.0	< 1.0		< 1.0
Copper	DETSC 2301#	0.2	mg/kg	62			83	43		26
Lead	DETSC 2301#	0.3	mg/kg	960			28	98		1300
Mercury	DETSC 2325#	0.05	mg/kg	0.18			< 0.05	0.12		0.89
Nickel	DETSC 2301#	1	mg/kg	34			56	13		19
Selenium	DETSC 2301#	0.5	mg/kg	< 0.5			0.5	< 0.5		0.8
Vanadium	DETSC 2301#	0.8	mg/kg	62			88	29		47
Zinc	DETSC 2301#	1	mg/kg	1300			88	140		180
Inorganics										
pH	DETSC 2008#		pH	8.3		8.1	10.8	11.6	8.5	8.4
Cyanide, Total	DETSC 2130#	0.1	mg/kg	1.7			0.1	0.2		3.9
Sulphate Aqueous Extract as SO4	DETSC 2076#	10	mg/l	3900		1400	290	430	2400	4300
Sulphur as S, Total	DETSC 2320	0.01	%	1.1		0.45	0.11	0.25	0.68	0.03
Petroleum Hydrocarbons										
Aliphatic C5-C6	DETSC 3321*	0.01	mg/kg		< 0.01					
Aliphatic C6-C8	DETSC 3321*	0.01	mg/kg		< 0.01					
Aliphatic C8-C10	DETSC 3321*	0.01	mg/kg		< 0.01					
Aliphatic C10-C12	DETSC 3072#	1.5	mg/kg		< 1.5					
Aliphatic C12-C16	DETSC 3072#	1.2	mg/kg		< 1.2					
Aliphatic C16-C21	DETSC 3072#	1.5	mg/kg		< 1.5					
Aliphatic C21-C35	DETSC 3072#	3.4	mg/kg		< 3.4					
Aliphatic C5-C35	DETSC 3072*	10	mg/kg		< 10					
Aromatic C5-C7	DETSC 3321*	0.01	mg/kg		< 0.01					
Aromatic C7-C8	DETSC 3321*	0.01	mg/kg		< 0.01					
Aromatic C8-C10	DETSC 3321*	0.01	mg/kg		< 0.01					
Aromatic C10-C12	DETSC 3072#	0.9	mg/kg		< 0.9					
Aromatic C12-C16	DETSC 3072#	0.5	mg/kg		< 0.5					
Aromatic C16-C21	DETSC 3072#	0.6	mg/kg		< 0.6					
Aromatic C21-C35	DETSC 3072#	1.4	mg/kg		< 1.4					
Aromatic C5-C35	DETSC 3072*	10	mg/kg		< 10					
TPH Ali/Aro Total	DETSC 3072*	10	mg/kg		< 10					
Benzene	DETSC 3321#	0.01	mg/kg		< 0.01					
Ethylbenzene	DETSC 3321#	0.01	mg/kg		< 0.01					
Toluene	DETSC 3321#	0.01	mg/kg		< 0.01					
Xylene	DETSC 3321#	0.01	mg/kg		< 0.01					
MTBE	DETSC 3321	0.01	mg/kg		< 0.01					
Phenols										
Phenol - Monohydric	DETSC 2130#	0.3	mg/kg	1.1			6.8	< 0.3		< 0.3

Key: * -not accredited. # -MCERTS (accreditation only applies if report carries the MCERTS logo). n/s -not supplied.

Summary of Chemical Analysis
Soil/Misc Samples

Our Ref 20-10212
Client Ref
Contract Title Axion Barking

			Lab No	1681925	1681926	1681928	1681930
			Sample ID	BH02	WS01	WS03	WS04
			Depth	4.00	0.55	0.40	0.65
			Other ID				
			Sample Type	ES	ES	ES	ES
			Sampling Date	04/06/2020	04/06/2020	04/06/2020	04/06/2020
			Sampling Time	n/s	n/s	n/s	n/s
Test	**Method**	**LOD**	**Units**				
Metals							
Arsenic	DETSC 2301#	0.2	mg/kg		32		53
Boron, Water Soluble	DETSC 2311#	0.2	mg/kg		2.1		0.4
Cadmium	DETSC 2301#	0.1	mg/kg		0.2		0.4
Chromium, Hexavalent	DETSC 2204*	1	mg/kg		< 1.0		< 1.0
Copper	DETSC 2301#	0.2	mg/kg		89		60
Lead	DETSC 2301#	0.3	mg/kg		51		250
Mercury	DETSC 2325#	0.05	mg/kg		< 0.05		1.1
Nickel	DETSC 2301#	1	mg/kg		80		9.5
Selenium	DETSC 2301#	0.5	mg/kg		0.5		0.8
Vanadium	DETSC 2301#	0.8	mg/kg		120		18
Zinc	DETSC 2301#	1	mg/kg		81		110
Inorganics							
pH	DETSC 2008#		pH	8.0	8.1		12.4
Cyanide, Total	DETSC 2130#	0.1	mg/kg		0.2		3.7
Sulphate Aqueous Extract as SO4	DETSC 2076#	10	mg/l	3500	380		1200
Sulphur as S, Total	DETSC 2320	0.01	%	1.1	0.27		0.52
Petroleum Hydrocarbons							
Aliphatic C5-C6	DETSC 3321*	0.01	mg/kg			< 0.01	
Aliphatic C6-C8	DETSC 3321*	0.01	mg/kg			< 0.01	
Aliphatic C8-C10	DETSC 3321*	0.01	mg/kg			< 0.01	
Aliphatic C10-C12	DETSC 3072#	1.5	mg/kg			< 1.5	
Aliphatic C12-C16	DETSC 3072#	1.2	mg/kg			< 1.2	
Aliphatic C16-C21	DETSC 3072#	1.5	mg/kg			< 1.5	
Aliphatic C21-C35	DETSC 3072#	3.4	mg/kg			< 3.4	
Aliphatic C5-C35	DETSC 3072*	10	mg/kg			< 10	
Aromatic C5-C7	DETSC 3321*	0.01	mg/kg			< 0.01	
Aromatic C7-C8	DETSC 3321*	0.01	mg/kg			< 0.01	
Aromatic C8-C10	DETSC 3321*	0.01	mg/kg			< 0.01	
Aromatic C10-C12	DETSC 3072#	0.9	mg/kg			< 0.9	
Aromatic C12-C16	DETSC 3072#	0.5	mg/kg			< 0.5	
Aromatic C16-C21	DETSC 3072#	0.6	mg/kg			< 0.6	
Aromatic C21-C35	DETSC 3072#	1.4	mg/kg			< 1.4	
Aromatic C5-C35	DETSC 3072*	10	mg/kg			< 10	
TPH Ali/Aro Total	DETSC 3072*	10	mg/kg			< 10	
Benzene	DETSC 3321#	0.01	mg/kg			< 0.01	
Ethylbenzene	DETSC 3321#	0.01	mg/kg			< 0.01	
Toluene	DETSC 3321#	0.01	mg/kg			< 0.01	
Xylene	DETSC 3321#	0.01	mg/kg			< 0.01	
MTBE	DETSC 3321	0.01	mg/kg			< 0.01	
Phenols							
Phenol - Monohydric	DETSC 2130#	0.3	mg/kg		< 0.3		< 0.3

Key: * -not accredited. # -MCERTS (accreditation only applies if report carries the MCERTS logo). n/s -not supplied.

Summary of Chemical Analysis
Soil VOC/SVOC Samples

Our Ref 20-10212
Client Ref
Contract Title Axion Barking

Lab No	1681922
Sample ID	BH02
Depth	0.90
Other ID	
Sample Type	ES
Sampling Date	04/06/2020
Sampling Time	n/s

Test	Method	LOD	Units	
SVOCs				
Phenol	DETSC 3433	0.1	mg/kg	< 0.1
Aniline	DETSC 3433*	0.1	mg/kg	< 0.1
2-Chlorophenol	DETSC 3433	0.1	mg/kg	< 0.1
Benzyl Alcohol	DETSC 3433	0.1	mg/kg	< 0.1
2-Methylphenol	DETSC 3433	0.1	mg/kg	< 0.1
Bis(2-chloroisopropyl)ether	DETSC 3433	0.1	mg/kg	< 0.1
3&4-Methylphenol	DETSC 3433	0.1	mg/kg	< 0.1
2,4-Dimethylphenol	DETSC 3433	0.1	mg/kg	< 0.1
Bis-(dichloroethoxy)methane	DETSC 3433	0.1	mg/kg	< 0.1
2,4-Dichlorophenol	DETSC 3433	0.1	mg/kg	< 0.1
1,2,4-Trichlorobenzene	DETSC 3433	0.1	mg/kg	< 0.1
Naphthalene	DETSC 3433	0.1	mg/kg	< 0.1
4-Chloro-3-methylphenol	DETSC 3433	0.1	mg/kg	< 0.1
2-Methylnaphthalene	DETSC 3433	0.1	mg/kg	< 0.1
Hexachlorocyclopentadiene	DETSC 3433*	0.1	mg/kg	< 0.1
2,4,6-Trichlorophenol	DETSC 3433	0.1	mg/kg	< 0.1
2,4,5-Trichlorophenol	DETSC 3433*	0.1	mg/kg	< 0.1
2-Chloronaphthalene	DETSC 3433	0.1	mg/kg	< 0.1
2-Nitroaniline	DETSC 3433*	0.1	mg/kg	< 0.1
2,4-Dinitrotoluene	DETSC 3433*	0.1	mg/kg	< 0.1
Acenaphthylene	DETSC 3433	0.1	mg/kg	< 0.1
3-Nitroaniline	DETSC 3433*	0.1	mg/kg	< 0.1
Acenaphthene	DETSC 3433	0.1	mg/kg	< 0.1
4-Nitrophenol	DETSC 3433*	0.1	mg/kg	< 0.1
Dibenzofuran	DETSC 3433	0.1	mg/kg	< 0.1
2,6-Dinitrotoluene	DETSC 3433	0.1	mg/kg	< 0.1
2,3,4,6-Tetrachlorophenol	DETSC 3433*	0.1	mg/kg	< 0.1
Diethylphthalate	DETSC 3433	0.1	mg/kg	< 0.1
4-Chlorophenylphenylether	DETSC 3433*	0.1	mg/kg	< 0.1
Fluorene	DETSC 3433	0.1	mg/kg	< 0.1
4-Nitroaniline	DETSC 3433*	0.1	mg/kg	< 0.1
2-Methyl-4,6-Dinitrophenol	DETSC 3433*	0.1	mg/kg	< 0.1
Diphenylamine	DETSC 3433	0.1	mg/kg	< 0.1
4-Bromophenylphenylether	DETSC 3433	0.1	mg/kg	< 0.1
Hexachlorobenzene	DETSC 3433	0.1	mg/kg	< 0.1
Pentachlorophenol	DETSC 3433*	0.1	mg/kg	< 0.1
Phenanthrene	DETSC 3433	0.1	mg/kg	0.5
Anthracene	DETSC 3433	0.1	mg/kg	0.2
Di-n-butylphthalate	DETSC 3433	0.1	mg/kg	< 0.1
Fluoranthene	DETSC 3433	0.1	mg/kg	0.7
Pyrene	DETSC 3433	0.1	mg/kg	0.6

Key: * -not accredited. n/s -not supplied.

Summary of Chemical Analysis
Soil VOC/SVOC Samples

Our Ref 20-10212
Client Ref
Contract Title Axion Barking

Lab No	1681922
Sample ID	BH02
Depth	0.90
Other ID	
Sample Type	ES
Sampling Date	04/06/2020
Sampling Time	n/s

Test	Method	LOD	Units	
Butylbenzylphthalate	DETSC 3433*	0.1	mg/kg	< 0.1
Benzo(a)anthracene	DETSC 3433	0.1	mg/kg	0.4
Chrysene	DETSC 3433	0.1	mg/kg	0.3
Bis(2-ethylhexyl)phthalate	DETSC 3433	0.1	mg/kg	< 0.1
Di-n-octylphthalate	DETSC 3433	0.1	mg/kg	< 0.1
Benzo(b)fluoranthene	DETSC 3433	0.1	mg/kg	0.3
Benzo(k)fluoranthene	DETSC 3433	0.1	mg/kg	< 0.1
Benzo(a)pyrene	DETSC 3433	0.1	mg/kg	0.3
Indeno(123cd)pyrene	DETSC 3433	0.1	mg/kg	< 0.1
Dibenzo(ah)anthracene	DETSC 3433	0.1	mg/kg	< 0.1
Benzo(ghi)perylene	DETSC 3433	0.1	mg/kg	< 0.1
1,4-Dinitrobenzene	DETSC 3433*	0.1	mg/kg	< 0.1
Dimethylphthalate	DETSC 3433	0.1	mg/kg	< 0.1
1,3-Dinitrobenzene	DETSC 3433*	0.1	mg/kg	< 0.1
1,2-Dinitrobenzene	DETSC 3433*	0.1	mg/kg	< 0.1
2,3,5,6-Tetrachlorophenol	DETSC 3433*	0.1	mg/kg	< 0.1
Azobenzene	DETSC 3433	0.1	mg/kg	< 0.1
Carbazole	DETSC 3433*	0.1	mg/kg	< 0.1

Key: * -not accredited. n/s -not supplied.

Summary of Chemical Analysis
Leachate Samples

Our Ref 20-10212
Client Ref
Contract Title Axion Barking

			Lab No	1681927	1681929	1681931
			Sample ID	WS02	WS03	WS04
			Depth	0.30	0.90	0.90
			Other ID			
			Sample Type	ES	ES	ES
			Sampling Date	04/06/2020	04/06/2020	04/06/2020
			Sampling Time	n/s	n/s	n/s
Test	**Method**	**LOD**	**Units**			
Preparation						
NRA Leachate Preparation	DETSC 1009*			Y	Y	Y
Metals						
Arsenic, Dissolved	DETSC 2306	0.16	ug/l	0.81	610	54
Boron, Dissolved	DETSC 2306*	12	ug/l	< 12	33	< 12
Cadmium, Dissolved	DETSC 2306	0.03	ug/l	< 0.03	2.1	0.05
Chromium, Hexavalent	DETSC 2203	7	ug/l	< 7.0	< 7.0	< 7.0
Copper, Dissolved	DETSC 2306	0.4	ug/l	1.1	2.9	6.2
Lead, Dissolved	DETSC 2306	0.09	ug/l	0.57	0.56	0.45
Mercury, Dissolved	DETSC 2306	0.01	ug/l	2.0	0.07	0.15
Nickel, Dissolved	DETSC 2306	0.5	ug/l	1.5	8.7	1.6
Selenium, Dissolved	DETSC 2306	0.25	ug/l	< 0.25	3.8	1.4
Vanadium, Dissolved	DETSC 2306	0.6	ug/l	0.8	1.5	3.8
Zinc, Dissolved	DETSC 2306	1.3	ug/l	5.2	74	5.3
Inorganics						
pH	DETSC 2008		pH	7.5	6.4	9.3
Cyanide, Total	DETSC 2130	40	ug/l	< 40	< 40	< 40
Hardness	DETSC 2303	0.1	mg/l	34.1	1320	391
Sulphate as SO4	DETSC 2055	0.1	mg/l	2.3	630	150
Sulphur as S, Total	DETSC 2320*	10	mg/l	< 10	340	46
Petroleum Hydrocarbons						
EPH (C10-C40)	DETSC 3311	10	ug/l	< 10	< 10	46
PAHs						
Naphthalene	DETSC 3304	0.05	ug/l	< 0.05	< 0.05	0.05
Acenaphthylene	DETSC 3304	0.01	ug/l	< 0.01	0.03	< 0.01
Acenaphthene	DETSC 3304	0.01	ug/l	< 0.01	< 0.01	0.02
Fluorene	DETSC 3304	0.01	ug/l	< 0.01	0.02	< 0.01
Phenanthrene	DETSC 3304	0.01	ug/l	0.02	0.24	0.03
Anthracene	DETSC 3304	0.01	ug/l	< 0.01	0.12	0.01
Fluoranthene	DETSC 3304	0.01	ug/l	0.02	0.49	0.02
Pyrene	DETSC 3304	0.01	ug/l	0.03	0.42	0.03
Benzo(a)anthracene	DETSC 3304	0.01	ug/l	< 0.01	0.40	< 0.01
Chrysene	DETSC 3304	0.01	ug/l	< 0.01	0.59	< 0.01
Benzo(b)fluoranthene	DETSC 3304	0.01	ug/l	0.02	0.54	0.02
Benzo(k)fluoranthene	DETSC 3304	0.01	ug/l	< 0.01	0.24	< 0.01
Benzo(a)pyrene	DETSC 3304	0.01	ug/l	0.02	0.37	< 0.01
Indeno(1,2,3-c,d)pyrene	DETSC 3304	0.01	ug/l	< 0.01	0.30	< 0.01
Dibenzo(a,h)anthracene	DETSC 3304	0.01	ug/l	< 0.01	< 0.01	< 0.01
Benzo(g,h,i)perylene	DETSC 3304	0.01	ug/l	0.03	0.35	< 0.01
PAH Total	DETSC 3304	0.2	ug/l	< 0.20	4.1	< 0.20
Phenols						
Phenol - Monohydric	DETSC 2130	100	ug/l	< 100	< 100	< 100

Key: * -not accredited. n/s -not supplied.

Summary of Asbestos Analysis
Soil Samples

Our Ref 20-10212
Client Ref
Contract Title Axion Barking

Lab No	Sample ID	Sample Location	Material Type*	Result	Comment*	Analyst
1681916	BH01 3.70		SOIL	Chrysotile	Small bundle of Chrysotile	Michael Kay
1681919	BH01A 0.50		SOIL	NAD	none	Michael Kay
1681920	BH01A 0.80		Cement	Chrysotile	none	Michael Kay
1681921	BH02 0.50		SOIL	NAD	none	Michael Kay
1681924	BH02 3.00		SOIL	NAD	none	Michael Kay
1681926	WS01 0.55		SOIL	Amosite Chrysotile	Amosite and Chrysotile present in microscopic loose fibrous asbestos debris and as loose bundles	Michael Kay
1681930	WS04 0.65		SOIL	NAD	none	Michael Kay

Crocidolite = Blue Asbestos, Amosite = Brown Asbestos, Chrysotile = White Asbestos. Anthophyllite, Actinolite and Tremolite are other forms of Asbestos. Samples are analysed by DETSC 1101 using polarised light microscopy in accordance with HSG248 and documented in-house methods. NAD = No Asbestos Detected. Where a sample is NAD, the result is based on analysis of at least 2 sub-samples and should be taken to mean 'no asbestos detected in sample'. Key: * -not included in laboratory scope of accreditation.

Information in Support of the Analytical Results

Our Ref 20-10212
Client Ref
Contract Axion Barking

Containers Received & Deviating Samples

Lab No	Sample ID	Date Sampled	Containers Received	Holding time exceeded for tests	Inappropriate container for tests
1681916	BH01 3.70 SOIL	05/06/20	GJ 250ml, GJ 60ml, PT 1L		
1681917	BH01 4.80 SOIL	05/06/20	GJ 250ml, GJ 60ml, PT 1L		
1681918	BH01 5.90 SOIL	05/06/20	GJ 250ml, GJ 60ml, PT 1L		
1681919	BH01A 0.50 SOIL	05/06/20	GJ 250ml, GJ 60ml, PT 1L		
1681920	BH01A 0.80 MISC	05/06/20	PT 1L		
1681921	BH02 0.50 SOIL	04/06/20	GJ 60ml, PT 1L		
1681922	BH02 0.90 SOIL	04/06/20	GJ 250ml, GJ 60ml, PT 1L		
1681923	BH02 2.00 SOIL	04/06/20	GJ 250ml, GJ 60ml, PT 1L		
1681924	BH02 3.00 SOIL	04/06/20	GJ 250ml, GJ 60ml, PT 1L		
1681925	BH02 4.00 SOIL	04/06/20	GJ 250ml, GJ 60ml, PT 1L		
1681926	WS01 0.55 SOIL	04/06/20	GJ 60ml, PT 1L		
1681927	WS02 0.30 LEACHATE	04/06/20	GJ 250ml, GJ 60ml, PT 1L		
1681928	WS03 0.40 SOIL	04/06/20	GJ 250ml, GJ 60ml, PT 1L		
1681929	WS03 0.90 LEACHATE	04/06/20	GJ 250ml, GJ 60ml, PT 1L		
1681930	WS04 0.65 SOIL	04/06/20	GJ 250ml, GJ 60ml, PT 1L		
1681931	WS04 0.90 LEACHATE	04/06/20	GJ 250ml		

Key: G-Glass P-Plastic J-Jar T-Tub

DETS cannot be held responsible for the integrity of samples received whereby the laboratory did not undertake the sampling. In this instance samples received may be deviating. Deviating Sample criteria are based on British and International standards and laboratory trials in conjunction with the UKAS note 'Guidance on Deviating Samples'. All samples received are listed above. However, those samples that have additional comments in relation to hold time, inappropriate containers etc are deviating due to the reasons stated. This means that the analysis is accredited where applicable, but results may be compromised due to sample deviations. If no sampled date (soils) or date+time (waters) has been supplied then samples are deviating. However, if you are able to supply a sampled date (and time for waters) this will prevent samples being reported as deviating where specific hold times are not exceeded and where the container supplied is suitable.

Soil Analysis Notes

Inorganic soil analysis was carried out on a dried sample, crushed to pass a 425µm sieve, in accordance with BS1377.

Organic soil analysis was carried out on an 'as received' sample. Organics results are corrected for moisture and expressed on a dry weight basis.

The Loss on Drying, used to express organics analysis on an air dried basis, is carried out at a temperature of 28°C +/-2°C.

Disposal

From the issue date of this test certificate, samples will be held for the following times prior to disposal :-

Soils - 1 month, Liquids - 2 weeks, Asbestos (test portion) - 6 months

APPENDIX 07

Site Specific Acceptance Criteria

Screening Levels for "Commercial" end use assuming a 1% SOM for Hydrocarbons.

Contaminant	Screening Levels for Commercial End Use (mg/kg)
Metals	
Arsenic	640
Boron	240,000
Cadmium	190
Chromium III	8,600
Chromium VI	33
Copper	68,000
Lead*	2330
Mercury	58
Nickel	980
Selenium	12,000
Vanadium	9,000
Zinc	730,000
Non Metals	
Phenol	440
Polyaromatic Hydrocarbons (PAHs)	
Benz[a]anthracene	170
Benzo[a]pyrene	35
Benzo[b]fluoranthene	44
Benzo[ghi]perylene	3,900
Benzo[k]fluoranthene	1,200
Chrysene	350
Dibenz[ah]anthracene	3.5
Fluoranthene	23,000
Indeno[123-cd]pyrene	500
Naphthalene	190
Pyrene	54,000

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* Where not included in the S4UL's criteria for a limited number of contaminants, namely lead, have been derived by DEFRA in their document entitled SP1010: Development of Category 4 Screening Levels for Assessment of Land Affected by Contamination, April 2014.

Contaminant	Screening Levels for Commercial End Use (mg/kg)
Volatile Organic Compounds	
Benzene	27
Ethylbenzene	5,700
Toluene	56,000
M - Xylene	6,200
O - Xylene	6,600
P - Xylene	5,900
Total Petroleum Hydrocarbons	
Aliphatic C5-6	3,200
Aliphatic C6-8	7,800
Aliphatic C8-10	2,000
Aliphatic C10-12	9,700
Aliphatic C12-16	59,000
Aliphatic C16-35	1,600,000
Aliphatic C35 - 44	1,600,000
Aromatic C5 - 7	26,000
Aromatic C7 - 8	56,000
Aromatic C8-10	3,500
Aromatic C10-12	16,000
Aromatic C12-16	36,000
Aromatic C16-21	28,000
Aromatic C21-35	28,000
Aromatic C35 - 44	28,000

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* Where not included in the S4UL's criteria for a limited number of contaminants, namely lead, have been derived by DEFRA in their document entitled SP1010: Development of Category 4 Screening Levels for Assessment of Land Affected by Contamination, April 2014.

The GAC's for the assessment of potential groundwater contamination have been derived from very conservative guidelines protective of drinking water and environmental quality, namely:

- UK Environmental Quality Standards (EQS) for Freshwater, 2000;
- Petroleum Products in Drinking-water, Background document for development of WHO Guidelines for Drinking-water Quality, 2011.

Table 1: Inorganic Tier 1 Water Environment Screening Criteria

Contaminant	Units	Hardness Banding ($CaCO_3$ mg/l)	EQS /WFD (Freshwater)	UK DWS
Arsenic	µg/l	-	50	10
Ammonia	mg/l	-	0.2	0.5
Boron	µg/l	-	2000	1000
Cadmium	µg/l	-	5	5
Chromium	µg/l	0-50	2	50
		50-100	10	
		100-150	10	
		150-200	20	
		200-250	20	
Copper	µg/l	0-10	0.5	2000
		10-50	0.5	
		50-200	3	
		200-250	8	
		>250	12	
Cyanide (Free)	µg/l	-	1	-
Cyanide		-	-	50
Iron	µg/l	-	1000	200
Lead	µg/l	0-50	4	10
		50-150	10	
		150-250	20	
		>250	20	
Mercury	µg/l	-	1	1
Nickel	µg/l	0-50	8	20
		50-100	20	
		100-150	20	
		150-250	40	
		>250	40	
Selenium	µg/l	-	-	10
Sulphate (SO_4)	mg/l	-	400	250
Zinc	µg/l	0-50	8	5000
		50-150	15	
		150-250	50	
		>250	50	
pH	-	-	6-9	-

Table 2: Organic Tier 1 Water Environment Screening Criteria

Contaminant	Units	UK DWS	WHO
PAHs - The sum of • **Benzo(b)fluoranthene,** • **Benzo(ghi)perylene,** • **Benzo(k)fluoranthene,** • **indeno(1,2,3-c,d)pyrene)**	µg/l	0.1	-
Phenol (total)	µg/l	0.5	-
MTBE	µg/l	-	15
Aliphatic C5-C6	µg/l	-	15,000
Aliphatic C6-C8	µg/l	-	15,000
Aliphatic C8-C10	µg/l	-	300
Aliphatic C10-C12	µg/l	-	300
Aliphatic C12-C16	µg/l	-	300
Aliphatic C16-21	µg/l	-	(300) *
Aliphatic C21-35	µg/l	-	(300)*
Aromatic C6-C7	µg/l	1 (benzene)	10 (benzene)
Aromatic C7-C8	µg/l	-	700 (toluene)
Aromatic C8-C10	µg/l	-	300 (ethylbenzene)
Aromatic C10-12	µg/l	-	100
Aromatic C12-C16	µg/l	-	100
Aromatic C16-C21	µg/l	-	90
Aromatic C21-C35	µg/l	-	90

Notes

The WHO Guideline Values for petroleum products in drinking water have been applied in the absence of current TPH water quality standards. However, for the aromatic TPH bandings of C6-C7, C7-C8 and C8-C10, the more conservative UK specific WQS for benzene, toluene and ethylbenzene have been used.

In the absence of specific WHO Guideline Values for the aliphatic ranges C16-C21 and C21-C35, the guideline values for the aliphatic C8-C10 through to C12-C16 ranges of 300µg/l have been used. This is however considered conservative due to the increased stability and lower volatility of the longer chain aliphatics.

APPENDIX 08

Qualitative Risk Assessment Guidance

Qualitative Risk Assessment Guidance

The Preliminary Contamination Risk Assessment methodology within the Phase 1 Desk Study Report is undertaken with reference to the following CIRIA guidance.

- Contaminated Land Risk Assessment - A Guide to Good Practice CIRIA C552:2001.

In practical terms, risk evaluation is undertaken in order to ascertain if potential risks are considered to be acceptable via classification following factors.

- The magnitude of the potential **consequences** (severity) of the risk occurring.
- The magnitude of the **probability** (likelihood) of the risks occurring.

The potential consequences of contamination risks occurring at the Site should be classified in accordance with the following table which is adapted from Table 6.3 in the CIRIA guidance.

Table 1 Classification of Consequence

Classification	Definition
Severe	Short term (acute) risk to human health likely to result in 'significant harm' as defined by the *Environment Protection Act 1990*, Part IIA. Short term risk of (significant) pollution of sensitive water resource or ecosystem. Catastrophic damage to building/property. Short term risk to a particular ecosystem, or organism forming part of such an ecosystem.
Medium	Chronic damage to human health (significant harm). Pollution of sensitive water resources. A significant change in a particular ecosystem, or an organism forming part of such an ecosystem.
Mild	Pollution of non-sensitive water resources. Significant damage to crops, buildings, structures and services. Damage to sensitive buildings/structures/services or the environment.
Minor	Harm, although not necessarily significant harm, which may results in a financial loss, or expenditure to resolve. Non-permanent, easily preventable effects to human health. Easily repairable damage to buildings, structures and services.

The probability or likelihood of a risk occurring is then classified in accordance with Table 6.4 in the CIRIA Guidance which is also reproduced in Table 2 below.

Table 2 Classification of Probability

Classification / Likelihood	Definition
High	There is a pollution linkage and an event that either appears very likely in the short term and almost inevitable over the long term or there is evidence at the receptor of harm or pollution.
Likely	There is a pollutant linkage and all the elements are present and in the right place, which means that it is probable that an event will occur. Circumstances are such that an event is not inevitable, but possible in the short term and likely over the long term.
Low	There is a pollution linkage and circumstances are possible under which an event could occur. However, it is by no means certain that even over a longer period that such an event would take place and is even less likely in the shorter term.
Unlikely	There is a pollution linkage but circumstances are such that it is improbable that an event would occur even in the very long term.

These classifications are then compared to indicate the risk to each pollution linkage. For each likelihood scenario, it will be assumed that a pollution linkage exists between the source and any potential receptors. The classification is not applied if no active pollution linkage is perceived to exist.

Upon classification of both the consequences and probability, the two can be compared in Table 6.5 within the guidance, in order to produce a risk category rating. The risk categories range from 'Very High Risk' to 'Very Low Risk' and should be determined for each potential pollutant linkage as oppose to each receptor or hazard as indicated above.

The matrix table is reproduced in Table 3 below.

Table 3 Consequence Vs Probability Matrix

		Consequence			
		Severe	**Medium**	**Mild**	**Minor**
Probability	**High Likelihood**	Very High Risk	High Risk	Moderate Risk	Moderate / Low Risk
	Likely	High Risk	Moderate Risk	Moderate / Low Risk	Low Risk
	Low Likelihood	Moderate Risk	Moderate / Low Risk	Low Risk	Very Low Risk
	Unlikely	Moderate / Low Risk	Low Risk	Very Low Risk	Very Low Risk

The outcome of the Consequence vs Probability matrix should be compared to the risk definitions and likely actions required in Table 4 (Table 6.6 in CIRIA C552).

The outcome will then determine the overall risk category for the site and should form the basis for any proposed investigation work and remedial actions to be determined. The assessment is based on a qualitative approach at the initial Phase 1 Desk Study, and should be updated following the results of any subsequent ground investigation results.

Table 4 Definitions of Classified Risks and Likely Required Actions

Risk Category	Definition
Very High	There is a high probability that severe harm could arise to a designated receptor from an identified hazard OR, there is evidence that severe harm to a designated receptor is currently happening. This risk (if realised) is likely to result in a substantial liability. *Required Actions* *Urgent investigation (if not undertaken already) and remediation are likely to be required.*
High	Harm is likely to arise to a designated receptor from an identified hazard. Realisation of the risk is likely to present a substantial liability. *Required Actions* *Urgent investigation (if not undertaken already) is required and remedial works may be necessary in the short term and are likely over the longer term.*
Moderate	It is possible that harm could arise to a designated receptor from an identified hazard. However, if it is either relatively unlikely that any such harm would be severe, or if any harm were to occur it is likely that the harm would be relatively mild. *Investigation (if not already undertaken) is normally required to clarify the risk and to determine the potential liability. Some remedial works may be required in the longer term.*
Low	It is possible that harm could arise to a designated receptor from an identified hazard, but it is likely that this harm, if realised, would at worst normally be mild.
Very Low	There is a low possibility that harm could arise to a receptor. In the event of such harm being realised it is not likely to be severe.