BRIEF FOR GEOTECHNICAL INVESTIGATIONS & ENVIRONMENTAL ASSESSMENT

Mount Pleasant – Phoenix Place
3868
21 July 2016

1.0 INTRODUCTION

This document outlines the requirements for the geotechnical investigations and environmental assessment associated with the Mount Pleasant Project, Plot C2.

The Contractor shall mean the consultant geotechnical / geo-environmental specialist, fieldwork operatives and specialist testing laboratories.

Laboratory testing shall be carried out by appropriate laboratories, which shall operate an appropriate quality assurance scheme and accredited for the scheduled test.

The contractor shall use appropriately qualified staff for each aspect of the investigation.

The investigation shall be carried out where appropriate in accordance with BS EN 1997-2:2007 and where necessary BS5930:1999 "Code of practice for site investigations". The investigations shall also be carried out following the principles of BS10175:2001 "Investigation of potentially contaminated sites – Code of practice" and other current, relevant and nationally accepted codes / guidelines.

2.0 PROPOSED DEVELOPMENT

The Phoenix place site is currently used by Royal Mail as a car park for the Royal Mail staff.

The site is located in the Clerkenwell area of Finsbury, Central London. It is approximately 800m south of Kings Cross St. Pancras station and 600mm north of Farringdon station. The ordinance survey National Grid reference is TQ 310 823.

The project is part of a larger redevelopment masterplan which proposes to build residential buildings on the site. The buildings are arranged in Blocks (A to D) with heights of up to 12 storeys plus roof. A two level deep basement is covering about two thirds the footprint of the site.

The site has the following key contraints:

- Proximity of Fleet sewer along Phoenix Place with a branch across the site;
- Foundations and retaining wall of existing buildings

3.0 SCOPE OF INVESTIGATIONS

The geotechnical investigations needs to be undertaken to establish soil profiles and provide the necessary design parameters, to the inform choice of foundation solutions for the scheme and finalise the design of the selected foundation system. The project is currently at planning stage and options for the for the foundation system are still being considered.

At this stage the elements listed below are being considered for the scheme and design parameters should be provided for these elements as set out below:

- Raft, pile or pad or hybrid (e.g. piled raft) foundations, provide recommendations on site specific suitability.
  - Site specific pile design capacity calculations should be provided with full derivation and consideration of group effects.
  - For spread foundations the design parameters should include as a minimum
    - allowable bearing pressure
    - design values for the modulus of subgrade reaction
    - for the ground movement analysis both short and long term values for the equivalent Young's modulus (E) and Poisson's ratio for the strata encountered.
    - For a piled raft an initial assessment of predicted load-settlement behaviour and load sharing ratio shall be provided.
- Ground bearing or suspended ground floor and basement slabs.
- Temporary retaining walls.
- Slope stability during temporary and permanent conditions.
- Earthwork specification, including the suitability of the excavated materials for re-use and the treatment required.
- Protection against ground water and chemical / gaseous contamination.
- Permanent retaining walls.
- Underpinning of adjacent properties.
- Service and access roads plus car parking areas.
- Underslab/ground storm and foul drainage. Assessment of the suitability of sub-soils for soakaway construction.
- Road and pavement build-ups.

The investigations should cover the following as a minimum:-

- A detailed desk study covering existing and past use of the site and ground conditions, this should also cover anticipated contamination problems.

- All statutory undertakers and other relevant authorities to be contacted and record drawings obtained for all underground features and services.

- Boreholes (10 number are required 8 to a depth of 40m and 2 to a depth of 50m).

- Soil sampling and testing.

- Establishing and monitoring ground water during the period of the investigations and material testing, plus a further 12 months.

- ~~____ no. trial pits to establish the depth and profile of existing foundations within and around the perimeter of the site.~~

- ~~____ no. infiltration tests carried out in accordance with BRE Digest 365 – "Soakaway Design".~~

- ~~____ no. California Bearing Ratio tests carried out in accordance with BS1377-4: 1990 – "Soils for civil engineering purposes. Compaction related tests".~~

On completion of the field works and material testing a factual and interpretative report (3 copies) must be prepared covering all stages of the investigations. The results of the geotechnical investigation carried out by Geotechnics (Factual report) shall be considered in the interpretive report where appropriate.

The report must include as a minimum the following:-

i) The results of the desk study including the following:-

- Geological maps
- Historical maps
- Topographical maps
- Previous ground investigations
- Literature search of technical papers
- Underground features and services, past mining incidences
- Likely contaminants
- Public Register enquiries to the Environmental Agency
- Infiltration rates for soakaway design
- California Bearing Ratio values for road and pavement design

ii) Daily drillers records containing the following data:-

Site name, borehole number, drilling depth - start/finish, date sampling depths and type, details of casing depth - required for each undisturbed sample and insitu test. Details of all obstruction - size and time spent chiselling, brief description of strata encountered. Details of size of hole with depth details of instrument installation. Borehole trial pit layout. Locations of any site tests related to datum and any other pertinent information.

~~iii) Logs of trial pits to include colour photographs.~~

iv) Interpretative information:-

This section of the report must include:-

- Comments and recommendations on the appropriate form of construction for all the permanent and temporary elements listed above.

- Any overall comments and recommendations relating to the development.

- Comments and recommendations with respect to total and differential settlements in the new structure (estimated building loads will be provided after the tender)

- Suitability of excavated materials as back fill below and behind new structures of external works. A specification for the treatment and compaction of the material to render it suitable must be included.

- Recommendations on the appropriate measures to be taken with respect to ground contaminants during site operations and in the design of the permanent works.

- Recommendations on the suitability of sub-soils for infiltration and the design infiltration rate to be used.

- ~~Recommendations on the design California Bearing Ratio value to be used.~~

6.0 INFORMATION REQUIRED AT TENDER STAGE

The contractor shall provide the following information with his tender:-

1. A detailed scope of fieldwork, sampling and testing proposed.

2. A method statement covering the fieldwork to include equipment, access routes, working hours and protection measures.

3. A detailed pricing schedule for completing the investigation.

4. A programme indicating from the receipt of the instruction to proceed to the provision of the final report.

5. A budget price for the whole of the work.

The scope of the field work and material testing will need to be varied in accordance with the actual site conditions and information revealed. Final costs of these investigations may thus vary but should not exceed the above budget without prior written approval from AKT II Limited.

The contractor shall allow in his tender for 5 man days of a senior geotechnical engineer to assist AKT II Limited in the finalisation of the substructure design. The rates for this shall be identified independently in the tender, the monies shall be expended only with the prior approval of AKT II Limited.

7.0 ACCESS AND APPROVALS

The contractor shall visit the site to establish access arrangements, working hours and protection measures during the tender period. He shall take due note of all restrictions and headrooms on pricing the works and the preparation of the method statement. It should be noted that some of the boreholes will need to be undertaken within the existing basement and this headroom will be restricted.

The contractor shall make all necessary arrangements for providing all plant, equipment and services required to complete the investigations. He shall also be responsible for obtaining all necessary approvals and provisions to complete the work from the statutory authorities or other relevant bodies.

The contractor shall take all necessary measures to protect the building and its contents, including that from vibrations and dust, during the site operations in accordance with the Clients requirements.

The contractor shall be responsible for establishing locations of all services within and below the building and taking all necessary safety and protection measures. The field works will be carried out in accordance with all the relevant Health & Safety regulations including the CDM regulations.

On completion of the field works the exploratory holes should be reinstated to their original condition and the site left in a clean and safe manner, any damage caused during the course of the works must be repaired to the original condition and to the satisfaction of the Client.

The contractor shall notify AKT II Limited 48 hours prior to undertaking any fieldwork, to allow them the opportunity to visit the site during these operations.

8.0 DESIGN OF THE INVESTIGATIONS

The contractor is responsible for the design of the geotechnical investigations to ensure they are adequate to provide all the information required within this document. Any alternative proposals should be clearly defined in the tender submission.

Borehole positions should be agreed with AKT II Limited prior to work commencing on site.

9.0 CONTRACT

AKT II Limited are arranging this work to be undertaken on behalf of their Client, Royal Mail Group with whom the contract will be placed to undertake the geotechnical investigations.

All invoices should be addressed to the Client, but submitted via AKT II Limited for certification and approval.

10.0 CONFIDENTIALITY

The contents of this document and the results of the investigation are to remain confidential and not released to any other party without the written permission of the Client.

11.0 PROGRAMME

The works are to be undertaken in the shortest timescale, a detailed programme indicating periods for mobilisation, field works, material testing and report writing shall be submitted with the tender. It should be noted that the site is an operational mail sorting centre and access, working and programme need to be agreed with their operations team.

The extent of the field works and material testing is to be reviewed on completion of the desk study and agreed with AKT II Limited prior to proceeding with the investigations.

12.0 INSURANCES

The contractor shall carry all necessary insurances related to the work undertaken, these shall include as a minimum the following levels of cover (each and every claim):-

Professional Indemnity	-	£2 million
Public Liability	-	£5 million
Employers Liability	-	£5 million

Details of insurances shall be provided if requested by the Client.

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SITE INVESTIGATION REPORT REQUIREMENTS

Project Title	Mount Pleasant	Project No.	3868
Revision	00 – 19/07/2016	Reference	

	CALTHORPE STREET	PHOENIX PLACE
Design parameters		

The following design parameters are required for the ground movement analysis and raft/pad foundations design. The contractor shall specify the site investigation to derive the design parameters noted in below table.

Undrained shear strength (c_u)
Undrained Young's modulus (E_u)
Drained Young's modulus (E')
Undrained Poisson's ratio (v_u)
Drained Poisson's ratio (v')
Modulus of compressibility (m_v)
Modulus of reload compressibility (m_s)
Coefficient of consolidation (C_v)

A		
Modulus of subgrade reaction It is intended to utilise half-space analysis for the structural design of a piled foundation, raft and pad foundations, modulus values are required under the brief for design check purposes. Provide recommended values for short- and long-term conditions, with reference to how these values have been derived.	YES	YES
Short term (undrained) stiffness parameters The brief requires both Young's modulus and Poission's ratio values to be recommended for the purpose of raft design and prediction of immediate	YES	YES

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	CALTHORPE STREET	PHOENIX PLACE
settlement & heave. The recommended values should account for variation with depth and should consider the impact of weathering. Distinction should be made between unload and reload scenarios as relevant.		
Long term (drained) stiffness parameters The brief requires Young's modulus and Poission's ratio values to be provided for the purpose of raft design including prediction of consolidation settlement & heave. The recommended values should account for variation with depth and should consider the impact of weathering. Distinction should be made between unload and reload scenarios as relevant. Groundwater profiles should be provided as required. Please provide recommended values for design with details of how these values have been derived.	YES	YES

	CALTHORPE STREET	PHOENIX PLACE
B *Settlement predictions*		
Initial settlement Provide estimates of initial settlements of raft and pad foundations considering the soil parameters for raft and pad foundations. Loading and unloading scenarios will be provide at a later stage.	YES, pad foundations only	YES
Consolidation settlement Provide estimates of initial settlements of raft and pad foundations considering the soil parameters for raft and pad foundations.	YES, pad foundations only	YES
Time dependency An assessment of the rate of consolidation settlement will be required to form part of the final design. It is proposed to use the calculation method outlined by Tomlinson pp. 78-81 Please provide comment on applicability of the method proposed given your interpretation of the ground profile together with recommended coefficient of consolidation (C_v) values	YES, pad foundations only	YES

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	CALTHORPE STREET	PHOENIX PLACE
C *Heave predictions*		
Heave contouring Please provide short and long-term heave predictions for the site. Loading and unloading scenarios will be provided at a later stage.	No	YES
Time dependency An assessment of the rate of long term heave will be required to form part of the final design.	No	YES

	CALTHORPE STREET	PHOENIX PLACE
D **Piled foundations**		
Undrained shear strength for design Allow for adequate samples and insitu testing to derive the c_u design line.	YES	YES
Peak adhesion factor (α_p) & bearing capacity factor (N_c) Provide recommended peak adhesion factor and bearing capacity factors for pile design in clay and Lambeth group soils encountered. No information provided in draft report.	YES	YES
Heave & settlement effects Given the susceptibility of the ground to heave as a result of excavation please provide comment and recommendations related to heave and settlement effects, in relation to embedded piled.	YES	YES
Pile design for loads provided Provide design capacities for pile each diameters noted in piles schedule, give range of pile capacity using end bearing and shaft friction	YES	YES

COMMENT	CALTHORPE STREET	PHOENIX PLACE
E **Retaining wall design**		
Coefficients of earth pressure In order to complete the design of the proposed retaining walls values for the following parameters are required: *a. Coefficient of active earth pressure at rest (K_0)* *b. Coefficient of active earth pressure (K_a)* *c. Coefficient of passive earth pressure (K_p)* *d. Coefficient of active earth pressure for deflections (K_{SLS}) (eg the Simpson & Driscoll recommendations in relation to EC7)* Please provide relevant references/derivation.	YES	YES

Appendix D Unexploded Ordnance Report

APPENDIX 13.2: DESK-BASED EXPLOSIVE THREAT ASSESSMENT

BACTEC | Globally Trusted Locally Dependable

Explosive Ordnance Threat Assessment in respect of Mount Pleasant Sorting Office, London

For
Waterman

4144TA

13th February 2012

BACTEC

Explosive Ordnance Threat Assessment

in respect of

Mount Pleasant Sorting Office, London

for

Waterman

4144TA 13th December 2012

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This Report has been produced in compliance with the Construction Industry Research and Information Association guidelines for the preparation of Detailed Risk Assessments in the management of UXO risks in the construction industry.

Glossary of Terms

AAA	Anti-Aircraft Artillery
ARP	Air-raid Precautions
BDO	Bomb Disposal Officer
EOD	Explosive Ordnance Disposal (current term for "bomb" disposal)
HE	High Explosive
HG	Home Guard
IB	Incendiary Bomb
kg	Kilogram
LCC	London County Council
LM	Land Mine
LSA	Land Service Ammunition (includes grenades, mortars, etc.)
Luftwaffe	German Air Force
m bgl	Metres Below Ground Level
MoD	Ministry of Defence
OB	Oil Bomb
PM	Parachute Mine
RAF	Royal Air Force
SI	Site Investigation
SAA	Small Arms Ammunition (small calibre cartridges used in rifles & machine guns)
UXB	Unexploded Bomb
UXO	Unexploded Ordnance
V-1	"Doodlebug" the first cruise type missile, used against London from June 1944. Also known as 'Flying Bomb'.
V-2	The first ballistic missile, used against London from September 1944
WWI	First World War (1914 -1918)
WWII	Second World War (1939 – 1945)

Executive Summary

The Sites: The study area, centred on the approximate National Grid Reference: 530983, 182347, is formed of two individual sites separated by Phoenix Place. The sites are located approximately 350m north of Chancery Lane Underground Station, within the Clerkenwell area of The City of London. The larger northern site is bound to the north-west by Calthorpe Street and to the north-east by Farringdon Road. The southern site is bound to the south-west by Gough Street and to the south-east by Mount Pleasant.

The northern site occupies to levels and makes up the vehicle park and loading bays to the rear of the main sorting office building. The southern site is mostly occupied by the Sorting Office staff car park and also incorporates two commercial units, one of which (Freeling House) forms part of the Royal Mail Archive.

Proposed Works: No details regarding the type and extent of intrusive works were available during the production of this report.

Risk Assessment Methodology: In accordance with CIRIA guidelines this assessment has carried out research, analysed the evidence and considered the risks that the site has been contaminated with unexploded ordnance; that such items remained on site; that they could be encountered during the proposed works and the consequences that could result. Appropriate risk mitigation measures have been proposed.

Explosive Ordnance Risk Assessment: BACTEC concludes that there are areas of **Low** and **Medium** risk from unexploded ordnance at the site of the proposed development. This is based on the following factors:

- The study area is located just north of The City of London, the most heavily bombed area in Britain, as confirmed by official bombing statistics and mapping. ARP bomb census maps and anecdotal accounts indicate that two HE bombs fell immediately adjacent to the southern site (as well as two 1kg incendiary bomb showers) during 1940/41, one large incendiary bomb fell within the northern site during 1943, and a 500kg HE bomb fell at the southern corner of the southern site during 1944.

- The 1943 incident resulted in a fire which gutted the vast majority of the Postal Section building that occupied the entire northern site. The building was then abandoned for a time and therefore the possibility cannot be discounted that a subsequent UXB could have fallen within these ruins during the Steinbock air raids of 1944 and became obscured within the rubble and debris. This is also a possibility for the smaller, but still significantly damaged, buildings within the southern site.

- Although several other buildings sustained damage within the southern site, this minor blast damage (broken windows, dislodged roof tiles etc) is not considered sufficient enough to have obscured a subsequent UXB strike.

- As a dense, built-up urban area, frequency of access is likely to have been high across the two sites. All the businesses (prior to any serious damage) would have remained in operation, suggesting that a UXB strike is unlikely to have gone unnoticed. Furthermore, the sites did not contain any significant areas of vegetation in which a UXB entry hole could have become obscured by dense foliage.

- It should be noted however that, although considered unlikely, it is conceivable that a UXB strike could have gone unnoticed within the unoccupied southern corner of the southern site, considering the WWII-era ground cover is ambiguous and may not have been hard-surfaced.

- It is considered unlikely that there has been any significant post-war intrusive work on site, therefore the risk of encountering deep buried HE UXBs will not have been mitigated to any serious degree.

- No evidence has been located to suggest that the site formerly had any British military occupation or usage.

Bomb Penetration Assessment: It has been assessed that a 500kg bomb would have had a maximum bomb penetration depth of up to **8m** below WWII ground level. Penetration depth could potentially have been greater if the UXB was larger (though only 4% of German bombs used in WWII over Britain were of that size). Note that UXBs may be found at any depth between just below the WWII ground level and the maximum penetration depth. This assessment has been made using generic geological information.

Risk Mitigation Measures: The following risk mitigation measures are recommended to support the intrusive works:

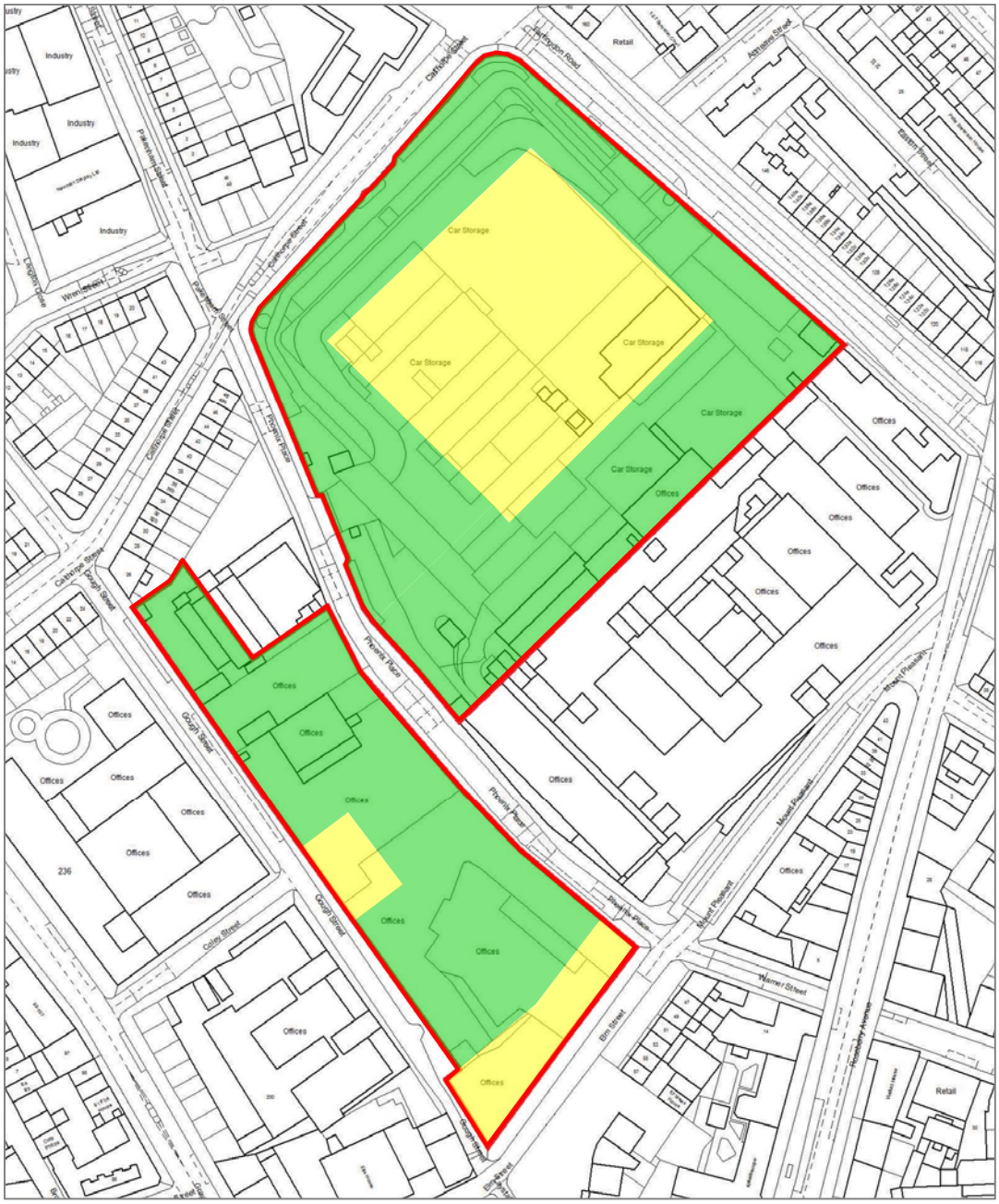
All Risk Zones

- Explosive Ordnance Safety and Awareness Briefings to all personnel conducting intrusive works
- The provision of Unexploded Ordnance Site Safety Instructions

Medium Risk Zones only

- Explosive Ordnance Disposal (EOD) Engineer presence on site to support shallow intrusive works
- Intrusive Magnetometer Survey of all borehole and pile locations down to a maximum bomb penetration depth

Risk Map



Low Risk Zones

Medium Risk Zones

Contents

Annexes

Explosive Ordnance Threat Assessment

In Respect of

Mount Pleasant Sorting Office, London

1. Introduction

1.1. Background

Waterman has commissioned BACTEC International Limited to conduct an Explosive Ordnance Threat Assessment for the proposed redevelopment works at the Mount Pleasant Sorting Office sites, London.

Unexploded Ordnance presents a significant threat to construction projects in parts of the UK as a result of enemy actions during the two 20th Century World Wars and historic British and Allied military activity.

The most intensive period of bombing over London was the nine months between October 1940 and May 1941 which became known as "The Blitz". During this period the Luftwaffe attempted to overwhelm Britain's air defences, destroy key industries and infrastructure and break the country's morale ahead of invasion. After mid-1941 the bombing strategy changed to include a number of other British cities and towns but, although the intensity of attacks over the capital lessened, it still remained a focus of bombing raids throughout WWII. A total of 18,000 tons of bombs were dropped on London between 1940 and 1945.

One of the legacies of this conflict is buried unexploded air-dropped bombs or anti-aircraft projectiles resulting from the failure of a proportion of the weapons to function as designed. It is commonly accepted that the failure rate of these munitions was approximately 10% and, depending on their shape, weight, velocity and ground conditions, many penetrated the ground and came to rest at depth. Intensive efforts were made during and after the war to locate and render safe all UXO but, unsurprisingly, not all were found and dealt with. This is evidenced by the regular, on-going discoveries of unexploded ordnance during construction-related intrusive ground works.

The UK was also bombed during WWI, though to a much lesser extent, and it is thought that a similar proportion of these weapons also malfunctioned. There have been occasional finds of unexploded WWI bombs in recent years but the risk of encountering them today is generally very low.

As a result of a generally increased risk awareness amongst professionals involved in ground engineering works and proactive health and safety measures, the threat to life and limb from unexploded ordnance has been minimised. However even the simple discovery of a suspected device during on-going works can cause considerable disruption to production and cause unwanted delays and expense.

Such risks can be more fully addressed by a better understanding of the site-specific threat and the implementation of appropriate risk mitigation measures.

2. Construction Industry Duties and Responsibilities

2.1. The UK Regulatory Environment

There is no specific legislation covering the management and control of the UXO risk in the UK construction industry but issues regarding health and safety are addressed under a number of regulatory instruments, as outlined below.

In practice the regulations impose a responsibility on the construction industry to ensure that they discharge their obligations to protect those engaged in ground-intrusive operations (such as archaeology, site investigation, drilling, piling or excavations) from any reasonably foreseeable UXO risk.

2.2. The Health and Safety at Work Act, 1974

The Act places a duty of care on an employer to put in place safe systems of work to address, as far as is reasonably practicable, all risks (to employees and the general public) that are reasonably foreseeable.

2.3. Construction (Design and Management) Regulations 2007

This legislation defines the responsibilities of all parties (primarily the client, the CDM Co-ordinator, the Designer and the Principal Contractor) involved with works.

Although UXO issues are not specifically addressed the regulations effectively place obligations on all these parties to:

- Ensure that any potential UXO risk is properly assessed
- Put in place appropriate risk mitigation measures if necessary
- Keep all parties affected by the risk fully informed
- Prepare a suitably robust emergency response plan

2.4. Other Legislation

Other relevant legislation includes the "Management of Health and Safety at Work Regulations 1999" and "The Corporate Manslaughter and Corporate Homicide Act 2007".

3. The Role of the Authorities and Commercial Contractors

3.1. The Authorities

The Police have the responsibilities for co-ordinating the emergency services in the case of an ordnance-related incident on a construction site. They will make an initial assessment (i.e. is there a risk that the find is ordnance or not?) and if they judge necessary impose a safety cordon and/or evacuation and call the military authorities (JSEODOC - Joint Services Explosive Ordnance Disposal Operations Centre) to arrange for investigation and/or disposal. In the absence of an EOD specialist on site many Police Officers will use the precautionary principle, impose cordon(s)/evacuation and await advice from the JSEODOC.

The priority given to the request by JSEODOC will depend on their judgement of the nature of the threat (ordnance, location, people and assets at risk) and the availability of resources. They will respond immediately or as resources are freed up. Depending on the on-site risk assessment the item of ordnance may be removed or demolished (by controlled explosion) in situ. In the latter case additional cordons and/or evacuations may be necessary.

Note that the military authorities will only carry out further investigations or clearances in very high profile or high risk situations. If there are regular ordnance finds on a site the JSEODOC

may not treat each occurrence as an emergency and will encourage the construction company to put in place alternative procedures (i.e the appointment of a commercial contractor) to manage the situation and relieve pressure from the JSEOD disposal teams.

3.2. Commercial Contractors

In addition to pre-construction site surveys and follow-on clearance work, a commercial contractor is able to provide a reactive service on construction sites. The presence of a qualified EOD Engineer with ordnance recognition skills will avoid unnecessary call-outs to the authorities and the Contractor will be able to arrange for the removal and disposal of low risk ordnance. If high risk ordnance is discovered actions will be co-ordinated with the authorities with the objective of causing the minimum possible disruption to site operations whilst putting immediate, safe and appropriate measures in place.

4. This Report

4.1. Aims and Objectives

The aim of this report is to examine the possibility of encountering any explosive ordnance during the proposed works at the Mount Pleasant Sorting Office sites. Risk mitigation measures will be recommended, if deemed necessary, to eliminate or reduce the threat from explosive ordnance during the envisaged works. The report follows the CIRIA Guidelines.

4.2. Risk Assessment Methodology

The following issues will be addressed in the report:

- The risk that the site was contaminated with unexploded ordnance.
- The risk that unexploded ordnance remains on site.
- The risk that ordnance may be encountered during the proposed works.
- The risk that ordnance may be initiated.
- The consequences of initiating or encountering ordnance.

Risk mitigation measures, appropriate to the assessed level of risk and site conditions, will be recommended if required.

4.3. Approach

In preparing this Explosive Ordnance Threat Assessment Report, BACTEC has considered general and, as far as possible, site specific factors including:

- Evidence of German bombing and delivery of UXBs.
- Site history, occupancy and conditions during WWII.
- The legacy of Allied military activity.
- Details of any known EOD clearance activity.
- The extent of any post war redevelopment.
- Scope of the current proposed works.

4.4. Sources of Information

BACTEC has carried out detailed historical research for this Explosive Ordnance Threat Assessment including accessing military records and archived material held in the public domain and in the MoD.

Material from the following sources has been consulted:

- The National Archives, Kew.
- Landmark Maps.

- English Heritage National Monuments Record.
- Relevant information supplied by Waterman.
- Available material from 33 Engineer Regiment (EOD) Archive.
- BACTEC's extensive archives built up over many years of research and hands-on Explosive Ordnance Disposal activities in the UK.
- Open sources such as published books, local historical records and the internet.

4.5. Reliability of Historical Records

4.5.1. General Considerations

This report is based upon research of historical evidence. Whilst every effort has been made to locate all relevant material BACTEC cannot be held responsible for any changes to the assessed level of risk or risk mitigation measures based on documentation or other information that may come to light at a later date.

The accuracy and comprehensiveness of wartime records is frequently difficult or impossible to verify. As a result conclusions as to the exact location, quantity and nature of the ordnance threat can never be definitive but must be based on the accumulation and careful analysis of all accessible evidence. BACTEC cannot be held responsible for inaccuracies or gaps in the available historical information.

4.5.2. Bombing Records

During WWII considerable efforts were expended in recording enemy air raids. Air Raid Precautions (ARP) wardens were responsible for making records of bomb strikes either through direct observation or by post-raid surveys. However their immediate priority was to deal with casualties and limit damage, so it is to be expected that records are often incomplete and sometimes contradictory. Record keeping in the early days of bombing was not comprehensive and details of bombing in the early part of the war were sometimes destroyed in subsequent attacks. Some reports may cover a single attack, others a period of months or the entire war.

Records of raids that took place on sparsely or uninhabited areas were often based upon third party or hearsay information and are not always reliable; records of attacks on military or strategic targets were often maintained separately from the general records and have not always survived.

5. The Site

5.1. Site Location

The study area is formed of two individual sites separated by Phoenix Place. The sites are located approximately 350m north of Chancery Lane Underground Station, within the Clerkenwell area of The City of London. The larger northern site is bound to the north-west by Calthorpe Street and to the north-east by Farringdon Road. The southern site is bound to the south-west by Gough Street and to the south-east by Mount Pleasant.

The study area is centred on the approximate National Grid Reference: 530983, 182347.

Site location maps are presented in Annex A.

5.2. Site Description

The northern site occupies to levels and makes up the vehicle park and loading bays to the rear of the main sorting office building. The southern site is mostly occupied by the Sorting Office staff car park and also incorporates two commercial units, one of which (Freeling House) forms part of the Royal Mail Archive.

Recent aerial photograph showing the boundary of the site area are presented in Annex B.

6. Scope of the Proposed Works

No details regarding the type and extent of intrusive works were available during the production of this report.

A site plan is presented in Annex C.

7. Ground Conditions

7.1. General

Published BGS data for a borehole located at the south-western corner of the northern site records the following geological sequence: approximately 5m of made ground, 2m of superficial gravel, London Clay Formation bedrock to depth.

8. Site History

8.1. General

Pre and post WWII historical maps[1] were obtained for the site from Landmark Maps. These are presented in Annexes D-1 and D-2. Goad Insurance Plans (for the southern site only) were obtained from Envirocheck and are presented in Annexes D-4 and D-5.

8.2. Pre-WWII OS Maps

The 1916 (1:2,500 scale) map shows the northern site to be occupied by a large building labelled *Post Office*, surrounded by what is likely to be hard-standing. This site forms part of a larger *Post Office* site that extends south-east to *Mount Pleasant* (road). The southern site however is occupied by a mixture of commercial/light industrial units, one of which is labelled *Phoenix Foundry*, and some terraced houses fronting Gough Street and *Mount Pleasant*.

The immediate pre-war 1938 (1:10,560 scale) map is of small scale and shows considerably less detail. The *Post Office* building still occupies the northern site however a smaller structure that encroached on its southern corner has been removed. No significant changes are recorded within the southern site however, five small courtyard areas (unidentifiable on the 1916 map) are highlighted.

8.3. Post-WWII OS Map

The 1953-54 (1:1,250) map shows no significant changes to the northern site, however the southern site exhibits two areas of clearance and a building labelled *Ruin.* Note that these features are usually indicative of serious bomb damage on early post-war OS maps. Some of the footprints of other buildings are also different however, it is likely that this is due to immediately pre-WWII redevelopment (unidentifiable on the 1938 map) or the difference in mapping scales between this and the 1916 map.

8.4. Pre-WWII GOAD Insurance Plan

The 1927 plans show the southern site in detail. There are several small courtyards within the site boundary and the south corner area is already shown to be cleared, unlike on the 1938 OS Map.

8.5. Post-WWII GOAD Insurance Plan

The 1951 plans confirm that the three neighbouring buildings (shown to be cleared on the 1953-54 OS Map) were cleared due to bomb damage (green). It also shows that the other section of apparent clearance (exclusively fronting Gough Street) actually survived the war intact. No other significant changes are apparent within the site boundary.

[1] *Latest pre-war and earliest post-war.*

9. The Threat from Aerial Bombing

9.1. General Bombing History of London

9.1.1. First World War

During WWI London was targeted and bombed by Zeppelin Airships and by 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.

WWI bombs were generally smaller than those used in WWII and were dropped from a lower altitude, resulting 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. When combined with the relative infrequency of attacks and an overall low bombing density the threat from WWI UXBs is considered low and will not be further addressed in this report.

9.1.2. Second World War

At the start of WWII, the Luftwaffe planned to destroy key military installations, including RAF airfields and Royal Navy bases, during a series of daylight bombing raids. After the Battle of Britain these tactics were modified to include both economic and industrial sites. Targets included dock facilities, railway infrastructure, power stations, weapon manufacturing plants and gas works. As a result of aircraft losses, daylight raids were reduced in favour of attacking targets under the cover of darkness.

As the war progressed the strategy changed to one of attempting to destroy the morale of the civilian population by the "carpet bombing" of London. The Blitz on London began on 7th September 1940 with concentrated attacks coming to an end in May 1941 as the Luftwaffe was diverted east to prepare for 'Operation Barbarossa'; the invasion of the Soviet Union. During 1942 and 1943 there were a number of minor raids carried out by small formations of fighter bombers and then between January and May 1944 the Luftwaffe returned to London in mass, for Operation Steinbock. These raids were executed by inexperienced Luftwaffe crews and were less frequent when compared to the original Blitz of 1940/41. Poor navigation and improved defences resulted in unsustainable Luftwaffe losses and many raids were unsuccessful.

Between 1940 and 1945 there were a total of 71 'major' air raids on London. In this period it is estimated that a total of 190,000 bombs, equivalent to 18,000 tons, were dropped resulting in the deaths of 29,000 people.

From mid-1944 the "V-weapon" (for Vengeance) campaign, using unmanned cruise missiles and rockets, represented Hitler's final attempt to reverse Germany's imminent defeat. The V1 (Flying Bomb or Doodlebug) and the V2 (Long Range Rocket) were launched from bases in Germany and occupied Europe. Totals of 2,419 V1s and 517 V2s were recorded in the London Civil Defence region. Although these weapons caused considerable destruction their relatively low numbers allowed accurate records of strikes to be maintained and these records have mostly survived. There is a negligible risk from unexploded V-weapons on land today since even if an unexploded 1000kg warhead had survived impact the remains of the munition's body would have left incontrovertible evidence of the strike, and it would have been dealt with at the time.

9.2. Aerial Delivered Ordnance in the Second World War

9.2.1. Generic Types of WWII German Air-delivered Ordnance

The nature and characteristics of the ordnance used by the Luftwaffe allows an informed assessment of the hazards posed by any unexploded items that may remain today. Detailed illustrations of German air delivered ordnance are presented at Annex E.

- HE Bombs: In terms of weight of ordnance dropped, HE bombs were the most frequent weapon deployed. Most bombs were 50kg, 250kg or 500kg (overall weight, about half of which was the high explosive) though large bombs of up to 2,000kg were also used. HE bombs had the weight, velocity and shape to easily penetrate the ground intact if they failed to explode. Post-raid surveys would not always have spotted the entry hole or other

indications that a bomb penetrated the ground and failed to explode and contemporary ARP documents describe the danger of assuming that damage, actually caused by a large UXB, was due to an exploded 50kg bomb. Unexploded HE bombs therefore present the greatest risk to present–day intrusive works.

- Blast Bombs/Parachute Mines: Blast bombs generally had a slow rate of descent and were extremely unlikely to have penetrated the ground. Non-retarded mines would have shattered on most ground types, if they had failed to explode. There have been extreme cases when these items have been found unexploded, but this was where the ground was either very soft or where standing water had reduced the impact. BACTEC does not consider there to be a significant threat from this type of munition on land.
- Large incendiary bombs: This type of bomb ranged in size from 36kg to 255kg and had a number of inflammable fill materials (including oil and white phosphorus), and a small explosive charge. They were designed to explode and burn close to the surface but their shape and weight meant that they did have penetration capability. If they penetrated the ground complete combustion did not always occur and in such cases they remain a risk to intrusive works.
- 1kg Incendiary Bombs (IB): These bombs, which were jettisoned from air-dropped containers, were unlikely to penetrate the ground and in urban areas would usually have been located in post-raid surveys. However, if bombs did not initiate and fell in water or dense vegetation, or became mixed with rubble in bomb damaged areas they could have been overlooked. Some variants had explosive heads and these present a risk of detonation during intrusive works.
- Anti-personnel (AP) Bomblets: AP bombs 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.
- Specialist Bombs (smoke, flare, etc): These types do not contain high explosive and therefore a detonation consequence is unlikely. They were not designed to penetrate the ground.

9.2.2. German Air-delivered Ordnance Failure Rate

Based on empirical evidence, it is generally accepted that 10% of the German HE bombs dropped during WWII failed to explode as designed. This estimate is probably based on the statistics of wartime recovered UXBs and therefore will not have taken account of the unknown numbers of UXBs that were not recorded at the time, and is probably an underestimate.

The reasons for failures include:

- Fuze or gaine malfunction due to manufacturing fault, sabotage (by forced labour) or faulty installation.
- Clockwork mechanism failure in delayed action bombs.
- Failure of the bomber aircraft to arm the bombs (charge the electrical condensers which supplied the energy to initiate the detonation sequence) due to human error or equipment defect.
- Jettison of the bomb before it was armed or from a very low altitude. Most likely if the bomber was under attack or crashing.

War Office Statistics document that a daily average of 84 bombs which failed to function were dropped on civilian targets in Great Britain between 21st September 1940 and 5th July 1941. 1 in 12 of these (probably mostly fitted with time delay fuzes) exploded some time after they fell - the remainder were unintentional failures.

From 1940 to 1945 bomb disposal teams dealt with a total of 50,000 explosive items of 50kg and over (i.e. German bombs), 7,000 AAA shells and 300,000 beach mines. These operations resulted in the deaths of 394 officers and men. However, unexploded ordnance is still regularly encountered across the UK (see recent press articles, Annex F-1).

9.2.3. UXB Ground Penetration

9.2.3.1. General Considerations

The actual penetration depth of aerial delivered bombs into the ground will have been determined by the mass and shape of the bomb, the velocity and angle of the bomb on impact (dependent on the height of release) and the nature of the ground and ground cover; the softer the ground, the greater the potential penetration. Peat, alluvium and soft clays are easier to penetrate than gravel and sand. Bombs are brought to rest or are commonly deflected by bedrock or large boulders.

9.2.3.2. The "j" Curve Effect

An air-dropped bomb falling from normal bombing altitude (say 5,000m) into homogeneous ground will continue its line of flight but turn in an upwards curve towards the surface as it comes to rest. This offset from vertical is generally thought to be about one third of the penetration depth, but can be up to 15m depending on ground conditions or the bomb's angle of impact.

9.2.3.3. Second World War Bomb 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 1328 bombs as reported by Bomb Disposal, mostly in the London area. They then came to conclusions as to the likely average and maximum depths of penetration of different sized bombs in different geological strata.

The median penetration of 430 x 50kg German bombs in London Clay was 4.6m and the maximum penetration observed for the SC50 bomb was 9m.

They concluded that the largest common German bomb, 500kg, had a likely penetration depth of 6m in sand or gravel but 8.7m in clay. The maximum observed depth for a 500kg bomb was 10.2m and for a 1,000kg bomb 12.7m. Theoretical calculations suggested that significantly greater penetration depths were probable.

9.2.4. Initiation of Unexploded Bombs

Unexploded bombs do not spontaneously explode. All high explosive requires significant energy to create the conditions for detonation to occur. In the case of unexploded German bombs discovered within the construction site environment, there are a number of potential initiation mechanisms:

- Direct impact onto the main body of the bomb: 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) to initiate a buried iron bomb. Such violent action can cause the bomb to detonate.
- Re-starting the clock timer in the fuze: Only a small proportion of German WWII bombs employed clockwork fuzes. It is probable that significant corrosion has taken place within the fuze mechanism over the last 60 years that would prevent clockwork mechanisms from functioning, nevertheless it was reported that the fuze in a UXB dealt with by 33 EOD Regiment in Surrey in 2002 did re-commence.
- Induction of a static charge, causing a current in an electric fuze: The majority of German WWII bombs employed electric fuzes. It is probable that significant corrosion has taken place within the fuze mechanism over the last 60 years such that the fuze circuit could not be activated.
- Friction impact initiating the (shock-sensitive) fuze explosive: This is the most likely scenario resulting in the bomb detonating.

Annex F-2 details UXB incidents where intrusive works have caused UXBs to detonate, resulting in death or injury and damage to plant.

9.3. Bombing History of Finsbury

9.3.1. Second World War Overview

At the outbreak of WWII the Luftwaffe's objective was to paralyse the commercial life of the capital by bombing the docks, warehouses, wharves, railway lines, factories and power stations. The regions of the City and East End were the most heavily targeted areas in London. The City of London was designated as a primary bombing target by the Luftwaffe and was assigned its own specific target designation – Zielraum 'O' (target area 'O'). This encompassed the financial centre of London and was situated immediately south of the site.

The site was historically located at the southern boundary of the WWII-era borough of Finsbury, immediately adjacent to the Holborn borough boundary. Holborn sustained the highest bombing density of all the 95 London boroughs during the war. Like today this part of the capital was not home to much industry or military targets but instead was occupied by governmental departments, embassies, educational institutes, historic landmarks, society headquarters etc. Therefore the district was considered vitally important to the country and its destruction would cause a severe lowering of civilian moral. Consequently the Luftwaffe made this a major target area. Furthermore, a 1939 Luftwaffe reconnaissance photograph (presented in Annex G) highlights a Water Works (approximately 310m north-east of the site) as a target.

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 the London Port Authority and railways, maintained separate records. Records would be in the form of typed or hand written incident notes, maps and statistics. These records of bombing incidents for Finsbury are presented in the following sections.

9.4. Second World War Bombing Statistics

The following table summarises the quantity of German bombs (excluding 1kg incendiaries and anti-personnel bombs) falling on the Metropolitan Borough of Finsbury between 1940 and 1945:

Record of German Ordnance Dropped on the Metropolitan Borough of Finsbury	
Area Acreage	587
High Explosive Bombs (all types)	208
Parachute Mines	4
Oil Bombs	17
Phosphorus Bombs	4
Pilotless Aircraft (V1)	5
Fire Pot	0
Long Range Rocket (V2)	1
Total	239
Items Per 1,000 Acres	407.2

Source: Home Office Statistics

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 incendiaries are not particularly significant in the threat they pose, they nevertheless are items of ordnance that were designed to cause damage and inflict injury and should not be overlooked in assessing the general risk to personnel and equipment. The anti-personnel bombs were used in much smaller quantities and are rarely found today but are potentially more dangerous.

This table does not include UXO found during or after WWII.

9.5. WWII Bombing Density

The bombing density map, presented at Annex H, depicts the concentration of bombs that fell on Greater London throughout WWII. The highest densities were recorded around Central and East London along the River Thames.

The London Borough of Greenwich was an area of high bombing density with between 400 and 499 bombs per 1,000 acres.

9.6. Site Specific WWII Bombing Records

9.6.1. London ARP Bomb Census Maps

A review was conducted of The London ARP Bomb Census Maps. Those showing bomb strikes on and in the immediate vicinity of the site are presented in Annex I and described below. Note that all distances given are approximations from the nearest site boundary.

Consolidated Maps

Date Range	Number of Incidents	Weapon	Closest Incident to the Site
Night bombing up to 07/10/1940	17	HE bombs	60m east and west
Night bombing 07/10/1940 - 21/07/1941	numerous	HE bombs	One on the northern site, three immediately adjacent to the southern site

Weekly Maps – *Weekly bomb plot maps covering the period October 1940 to April 1944 were also consulted.*

Date Range	Number of Incidents	Weapon	Closest Incident to the Site
11/11/1940 - 18/11/1940	1	HE UXB	45m south-east
23/12/1940 - 30/12/1940	1	IB shower	On southern site
30/12/1940 - 06/01/1941	3	IB showers	On part of the southern site
14/04/1941 - 24/04/1941	11	HE bombs and HE UXBs	HE 30m north-east of southern site
05/05/1941 - 12/05/1941	6	HE bombs	On road in between the two sites
14/06/1943 - 20/06/1943	1	Unknown bomb strike	On northern site
20/03/1944 - 26/03/1944	2	500kg HE bombs	On corner of southern site

9.6.2. London V1 Bomb Census Map

Following the beginning of the V1 campaign in mid-1944 a series of maps showing where these weapons fell was produced for the London Civil Defence region and these were updated as the war progressed. An extract of the map, showing the site and immediate surrounding area, is presented in Annex J.

The map extract displays one V1 strike in the local surrounding area. This weapon fell approximately 215m south-west of the site.

9.6.3. LCC Bomb Damage Map

The LCC Bomb Damage map for the area of the site was obtained and is presented in Annex K. The maps were compiled by the Architects Department soon after the bombing of London commenced and were updated throughout the war to document levels of damage that structures sustained.

The northern site is mostly undamaged, however there is a semi-circular section of purple and orange (damage beyond repair/general blast damage) in the central part of the Post Office building, corresponding generally with the 1943 bomb strike. The southern site includes nine small buildings that were damaged beyond repair (purple) and seriously damage (red). Several other units have received minor/general blast damage and a row of buildings at the southern corner is shown to have been cleared. Note however that this is known to have occurred prior to WWII.

9.6.4. The British Postal Museum & Archive

Information obtained from the British Postal Museum & Archive confirms bomb damage to the Mount Pleasant Sorting Office that occupied the northern site throughout WWII.

On 16th September 1940 Mount Pleasant was hit for the first time by incendiary bombs. The Parcel Office received further direct raids from incendiaries and high explosive bombs in October and November 1940, and again in January and April 1941. Note however the London ARP Bomb Census Maps indicate that these incidents occurred just outside the site boundary.

Surrounding areas, including Eyre Street Hill, Farringdon Road, the Daily Sketch garage at the corner of Mount Pleasant and Gough Street (within the southern site boundary), and Bideford Mansions in Mount Pleasant, were bombed, causing damage to the sorting office.

Several houses in what is now the staff car park suffered serious damage, including those owned by the Post Office at 34-40 Gough Street (shown to have sustained general blast damage on the LCC Damage Map).

On 18th June 1943 the Parcel Section was hit by a single incendiary bomb. Exploding into the block towards the north east corner, the bomb resulted in a fire which soon had the whole building ablaze. The fire was fought for four hours but almost the entire building was gutted. Images of the damage caused (presented in Annex L) show that this incident gutted almost the entire northern site building, contradicting the lack of damage recorded on the LCC Damage Map.

The fire resulted in the Parcel Office becoming a 'shapeless mass of twisted girders and smouldering ruins' and the whole operation had to be moved to the Royal Agricultural Hall in Islington.

9.6.5. Second World War Era Aerial Photography

RAF aerial photography of the site and surrounding area was obtained from the National Monuments Record Office, Swindon. An image dated 1944 is presented in Annex M.

The appearance of the northern site is the same as in the 1953-54 OS map, however the building appears to have sustained some damage, some of which has been subsequently repaired (as highlighted). The remainder of the northern site building appears intact and no damage is apparent to the surrounding hard-standing.

Within the southern site most of the buildings appear to have survived the war intact. The buildings shown to have sustained serious bomb damage on the LCC Damage Map are still standing however there structural integrity is not identifiable on this image. Also those shown to be damaged beyond repair resemble ruins. The vacant area at the southernmost corner is again shown to be unoccupied.

9.6.6. 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 were 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, nor 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.

BACTEC holds no records of officially registered abandoned bombs at or near the site of the proposed works.

9.6.7. Site Specific Bomb Penetration Considerations

When considering an assessment of the bomb penetration at the Mount Pleasant Sorting Office sites the following parameters would be used:

- Geology – approximately 5m of made ground, 2m of superficial gravel, London Clay Formation bedrock to depth.
- Impact Angle and Velocity – 80-90^{O} from horizontal and 267 metres per second.
- Bomb Mass and Configuration – The 500kg SC (General Purpose) HE bomb, without retarder units or armour piercing nose. This was the largest of the common bombs used against Britain.

Taking into account the above-mentioned factors it has been assessed that a 500kg bomb would have had a maximum bomb penetration depth of up to **8m** below WWII ground level. Penetration depth could potentially have been greater if the UXB was larger (though only 4% of German bombs used in WWII over Britain were of that size). Note that UXBs may be found at any depth between just below the WWII ground level and the maximum penetration depth. This assessment has been made using generic geological information.

9.7. Likelihood of Post-raid UXO Detection

Utilising the available historical bombing records as reviewed in sections 9.1 to 9.6, it is possible to make an assessment of the likelihood that evidence of unexploded ordnance would have been noted on a site during the war and the incident dealt with or recorded at the time. Factors such as bombing density, frequency of access, ground cover, damage and failure rate have been taken into consideration.

9.7.1. Density of Bombing

Bombing density is an important consideration for assessing the possibility that UXBs remain in an area. A very high density of bombs can for example result in increased levels of damage sustained to structures, greater likelihood of errors in record keeping and a higher risk that UXBs fell over the area.

Bombing statistics and mapping indicate that the sites were situated in an area of high bombing density during WWII. ARP bomb census maps and anecdotal accounts indicate that two HE bombs fell immediately adjacent to the southern site (as well as two 1kg incendiary bomb showers) during 1940/41, one large incendiary bomb fell within the northern site during 1943, and a 500kg HE bomb fell at the southern corner of the southern site during 1944.

9.7.2. Damage

If structures on a site have been subject to significant bomb or fire damage, rubble and debris are likely to have been present; similarly a HE bomb strike on open ground is likely to have resulted in a degree of soil disturbance. Under such conditions there is a greater risk of the entry holes of unexploded bombs dropped during subsequent raids being obscured and going unnoticed.

The recorded bombing resulted in various degrees of damage across the sites. The LCC damage map indicates that nine small buildings in the southern site were damaged beyond

repair (purple) and seriously damaged (red), with some additional minor blast damage, however the vast majority of the structures survived the war intact. The building that occupied the northern site however, was almost entirely gutted by a fire during 1943. These areas of damage would have resulted in rubble and debris on site and therefore the possibility cannot be entirely discounted that a subsequent unobserved UXB fell within these areas leaving no lasting evidence of its incidence.

9.7.3. Frequency of Access

Unexploded ordnance at sites where human access was infrequent would have a higher chance of being overlooked than at those sites which were subject to greater occupancy. The importance of a site or facility to the war effort is also an important consideration as such sites are likely to have been both frequently accessed and are also likely to have been subject to post-raid checks for evidence of UXO.

As a dense, built-up urban area, frequency of access is likely to have been high across the two sites. The parcel section building (northern site) would have remained in use up until its partial destruction in 1943 when it was known to have been abandoned.

The same can be said of the businesses that occupied the southern site. They are also likely to have remained in operation throughout the Luftwaffe bombing campaign. Furthermore, post-raid checks for damage and evidence of UXO are likely to have taken place.

9.7.4. Ground Cover

The degree and type of groundcover present during WWII would have a significant effect on the visual evidence at ground level which may have indicated the presence of buried UXO.

With the exception of the ruins on site, the entire study area was occupied by buildings and hard-standing during WWII and therefore a UXB strike on site will have resulted in significant, observable damage that would have been noted and dealt with at the time.

9.7.5. Bomb Failure Rate

There is no evidence to suggest that the bomb failure rate in the vicinity of the site would have been different from the "approximately 10%" figure normally used.

10. The Threat from Allied Military Ordnance

10.1. General

BACTEC has found no evidence to suggest that the area of the site had any other former military use which could have led to ordnance contamination.

The following potential military uses have been considered:

- Anti-Aircraft Defences
- Home Guard
- Training or firing ranges or the storage of ammunition
- Military bases
- Defensive Positions
- Manufacture of explosives or ordnance

The most likely source of Allied ordnance is from anti-aircraft fire, as discussed in the following section.

10.2. Defending London from Aerial Attack

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

Passive defences included measures to hinder the identification of targets (such as a lighting blackout at night and the camouflaging of strategic installations); to mislead bomber pilots into attacking decoy sites located away from the city and to force attacking aircraft to higher altitudes with the use of barrage balloons.

Active air defence relied on a coordinated combination of fighter aircraft to act as interceptors, anti-aircraft gun batteries and later the use of rockets and missiles, in order to actively engage and oppose attacking aircraft.

10.2.1. Anti-Aircraft Artillery and Projectiles

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

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

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

The HAA projectiles were high explosive shells, usually fitted with a time delay or barometric pressure fuze to make them explode at a pre-determined height. Before the war all the clockwork fuses used by the Royal Artillery had come from Switzerland. When that source of supply was cut off, Britain had been forced to make its own. After four years of war, the country still lacked the engineering skills to produce a reliable fuse. This resulted in aspace considerable number of AA projectiles either exploding prematurely, killing the gunners or failing to explode at all; falling to the ground as UXBs. In January 1944 more people in London were killed by HAA shells than by German bombs. Details of the most commonly deployed WWII AAA projectiles are shown below:

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

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

Numerous unexploded AAA shells were recovered during and following WWII and are still occasionally encountered on sites today. Illustrations of Anti-Aircraft artillery, projectiles and rockets are presented at Annex N.

11. Ordnance Clearance and Post-WWII Ground Works

11.1. General

The extent to which any ordnance clearance activities have taken place on site or extensive ground works have occurred is relevant since on the one hand they may indicate previous

ordnance contamination but also may have reduced the risk that ordnance remains undiscovered.

11.2. EOD Clearance

BACTEC holds a number of official records of explosive ordnance disposal operations during and following WWII, obtained from the Explosive Ordnance Disposal (EOD) Archive Information Office at 33 Engineer Regiment (EOD). However no records could be found to indicate that any EOD tasks have taken place on or within very close proximity to the study site.

11.3. Post War Redevelopment

A review of post-WWII OS mapping between 1954 and 1996 suggests that majority of the WWII-era buildings have been demolished and sites have remained undeveloped.

12. The Overall Explosive Ordnance Threat Assessment

12.1. General Considerations

Taking into account the quality of the historical evidence, the assessment of the overall threat to the proposed works from unexploded ordnance must evaluate the following risks:

- That the site was contaminated with unexploded ordnance
- That unexploded ordnance remains on site
- That such items could be encountered during the proposed works
- That ordnance may be activated by the works operations
- The consequences of encountering or initiating ordnance

12.2. The Risk that the Site was Contaminated with Unexploded Ordnance

For the reasons discussed in section 9.7 BACTEC believes that there is a risk that unexploded high explosive bombs and/or anti-aircraft projectiles or incendiary bombs may have fallen unnoticed and unrecorded within the site boundary.

- The study area is located just north of The City of London, the most heavily bombed area in Britain, as confirmed by official bombing statistics and mapping. ARP bomb census maps and anecdotal accounts indicate that two HE bombs fell immediately adjacent to the southern site (as well as two 1kg incendiary bomb showers) during 1940/41, one large incendiary bomb fell within the northern site during 1943, and a 500kg HE bomb fell at the southern corner of the southern site during 1944.

- The 1943 incident resulted in a fire which gutted the vast majority of the Postal Section building that occupied the entire northern site. The building was then abandoned for a time and therefore the possibility cannot be discounted that a subsequent UXB could have fallen within these ruins during the Steinbock air raids of 1944 and became obscured within the rubble and debris. This is also a possibility for the smaller, but still significantly damaged, buildings within the southern site.

- Although several other buildings sustained damage within the southern site, this minor blast damage (broken windows, dislodged roof tiles etc) is not considered sufficient enough to have obscured a subsequent UXB strike.

- As a dense, built-up urban area, frequency of access is likely to have been high across the two sites. All the businesses (prior to any serious damage) would have remained in operation, suggesting that a UXB strike is unlikely to have gone unnoticed. Furthermore, the sites did not contain any significant areas of vegetation in which a UXB entry hole could have become obscured by dense foliage.

- It should be noted however that, although considered unlikely, it is conceivable that a UXB strike could have gone unnoticed within the unoccupied southern corner of the southern site, considering the WWII-era ground cover is ambiguous and may not have been hard-surfaced.

No evidence has been located to suggest that the site formerly had any military occupation or usage that could have led to contamination with items of allied ordnance.

12.3. The Risk that Unexploded Ordnance Remains on Site

It is considered unlikely that there has been any significant post-war intrusive work on site, therefore the risk of encountering deep buried HE UXBs will not have been mitigated to any serious degree.

12.4. The Risk that Ordnance may be Encountered during the Works

The most likely scenarios under which 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.

Since an air-dropped bomb may come to rest at any depth between just below ground level and its maximum penetration depth there is also a chance that such an item could be encountered during shallow excavations (for services or site investigations) into the original WWII ground level. A risk of encountering UXO will only present itself if intrusive work is carried out into virgin geology (or WWII-era made ground), outside the volume of post-war foundations.

12.5. The Risk that Ordnance may be Initiated

The risk that UXO could be initiated if encountered will depend on its condition, how it is found and the energy with which it is struck. The most violent activity on most construction sites is percussive piling. As a result items that are shallow buried present a slightly lower risk than those that are deep buried, since the force of impact is usually lower and they are more likely to be observed – when immediate mitigating actions can be taken.

12.6. The Consequences of Encountering or Initiating Ordnance

Clearly the consequences of an inadvertent detonation of UXO during construction operations would be catastrophic with a serious risk to life, damage to plant and a total site shutdown during follow-up investigations.

Since the risk of initiating ordnance is significantly reduced if appropriate mitigation measures are undertaken, the most important consequence of the discovery of ordnance will be economic. This would be particularly so in the case of high profile locations and could involve the evacuation of the public. The unexpected discovery of ordnance may require the closing of the site for any time between a few hours and a week with a potentially significant cost in lost time. Note also that the suspected find of ordnance, if handled solely through the authorities, may also involve loss of production since the first action of the Police in most cases will be to isolate the locale whilst awaiting military assistance, even if this turns out to have been unnecessary.

12.7. BACTEC's Assessment

Taking into consideration the findings of this study, BACTEC considers the risk across the Mount Pleasant Sorting Office sites to be heterogeneous and can therefore be divided into **Low** and **Medium** Risk Zones. These zones are illustrated on the Risk Map presented in Annex O.

Low Risk Zone – Occupied by buildings that sustained an insignificant degree of bomb damage during WWII and survived the war intact.

	Level of Risk			
Type of Ordnance	**Negligible**	**Low**	**Medium**	**High**
German HE UXBs		*		
British AAA	*			
German incendiaries and anti-personnel bombs	*			
Other Allied Ordnance	*			

Medium Risk Zone – Occupied by buildings that were either destroyed by bombing or significantly damaged during WWII. This area includes a buffer zone to account for the J – Curve Effect.

	Level of Risk			
Type of Ordnance	**Negligible**	**Low**	**Medium**	**High**
German HE UXBs			*	
British AAA		*		
German incendiaries and anti-personnel bombs		*		
Other Allied Ordnance	*			

13. Proposed Risk Mitigation Methodology

13.1. General

BACTEC believes the following risk mitigation measures should be deployed to support any intrusive works at the Mount Pleasant Sorting Office sites.

13.2. Recommended Risk Mitigation Measures

Both Risk Zones

- ***Explosive Ordnance Safety and Awareness Briefings to all personnel conducting intrusive works:*** A specialised briefing is always advisable when there is a possibility of explosive ordnance contamination. It is an essential component of the Health & Safety Plan for the site and conforms to requirements of CDM Regulations 2007. All personnel working on the site should be instructed on the identification of UXB, actions to be taken to alert site management and to keep people and equipment away from the hazard. Posters and information of a general nature on the UXB threat should be held in the site office for reference and as a reminder.

- ***The provision of Unexploded Ordnance Site Safety Instructions:*** These written instructions contain information detailing actions to be taken in the event that unexploded ordnance is discovered. They are to be retained on site and will both assist in making a preliminary assessment of a suspect object and provide guidance on the immediate steps to be taken in the event that ordnance is believed to have been found.

Medium Risk Zones only

- ***Explosive Ordnance Disposal (EOD) Engineer presence on site to support shallow intrusive works:*** When on site the role of the EOD Engineer would include; monitoring works using visual recognition and instrumentation and immediate response to reports of suspicious objects or suspected items of ordnance that have been recovered by the ground workers on site; providing Explosive Ordnance Safety and Awareness briefings to any staff that have not received them earlier and advise staff of the need to modify working practices to take account of the ordnance threat, and finally to aid Incident Management which would involve liaison with the local authorities and Police should ordnance be identified and present an explosive hazard.

- ***Intrusive Magnetometer Survey of all borehole and pile locations down to a maximum bomb penetration depth:*** BACTEC can deploy a range of intrusive magnetometry techniques to clear ahead of all the pile locations. The appropriate technique is governed by a number of factors, but most importantly the site's ground conditions. The appropriate survey methodology would be confirmed once the enabling works have been completed. A site meeting would be required between BACTEC and the client to determine the methodology suitable for this site. Target investigation or avoidance will be recommended as appropriate.

BACTEC International Limited 13th December 2012

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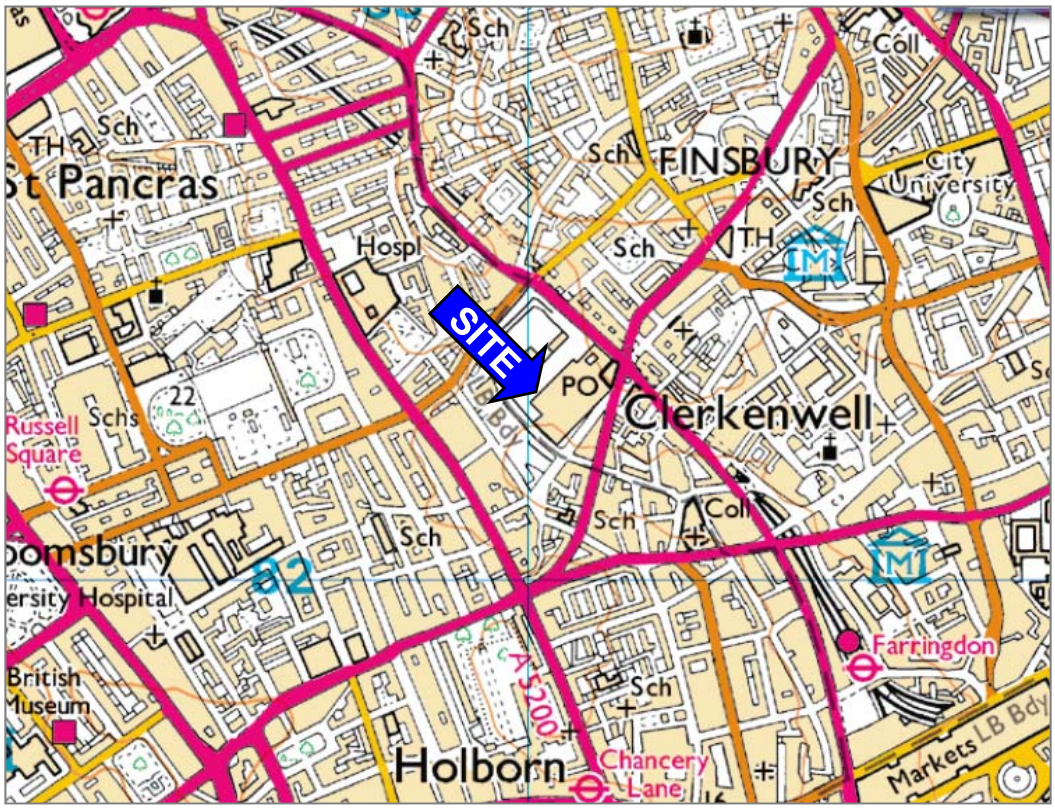
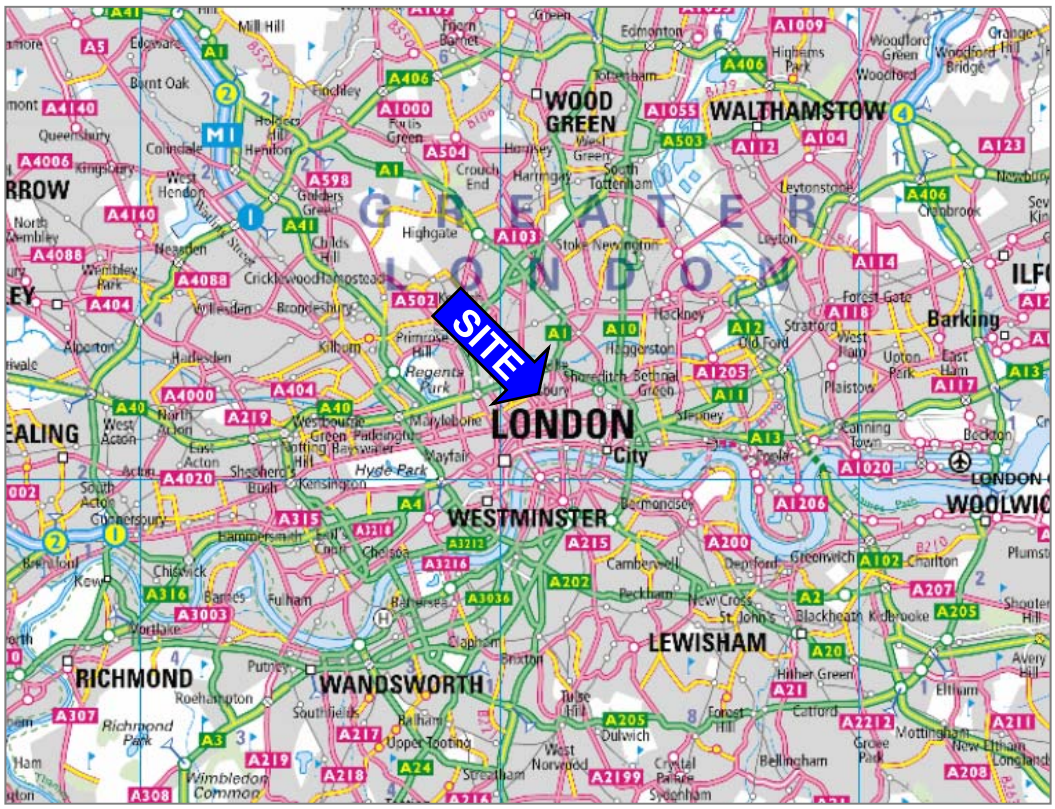
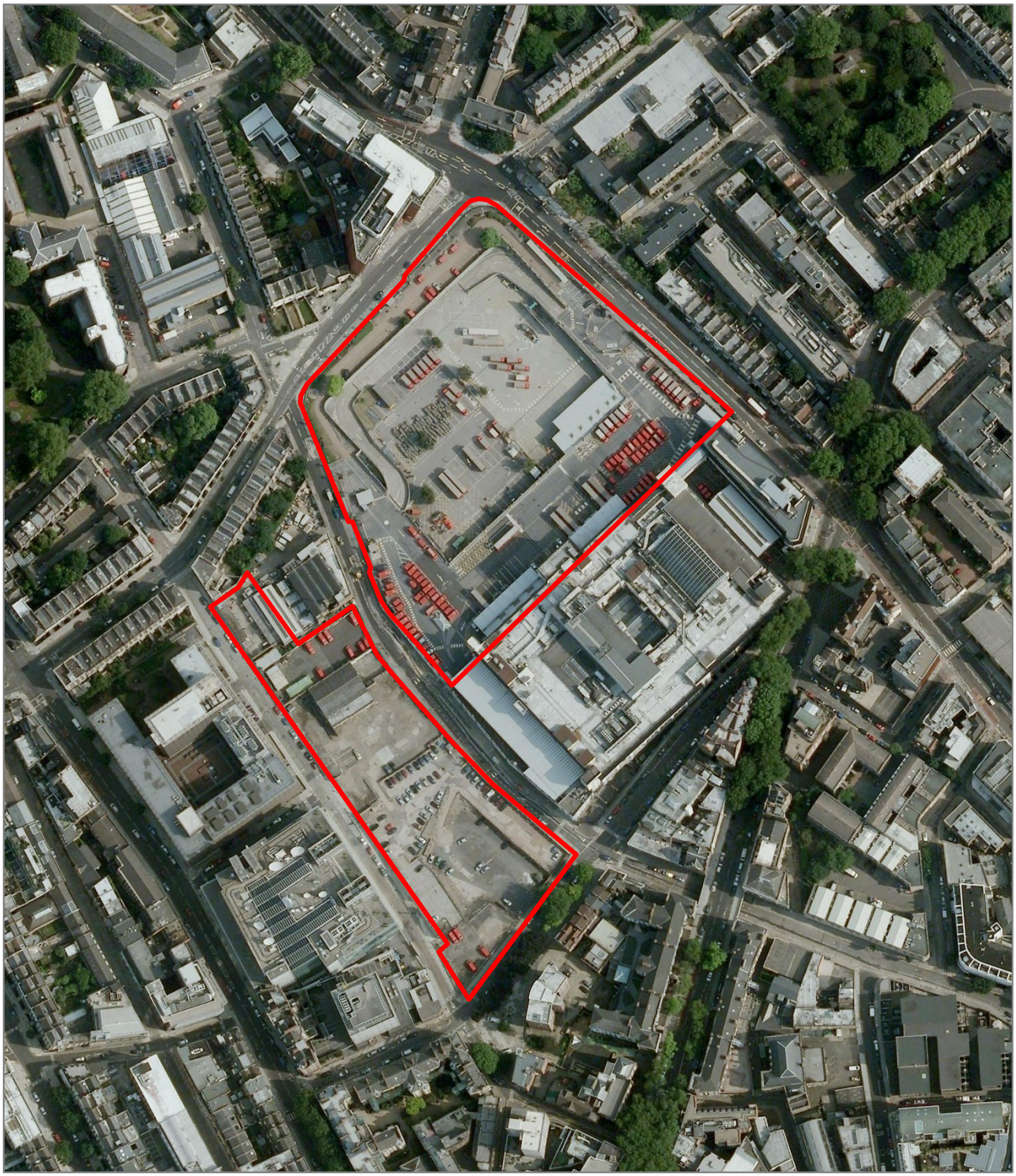
North





Report Reference:	Client:	
4144TA	Waterman	BACTEC
	Project: Mount Pleasant Sorting Office, London	

North



Approximate site boundary

Report Reference:	Client:	
4144TA	Waterman	BAC TEC
	Project: Mount Pleasant Sorting Office, London	

Source: Google Earth ™ Mapping Services

Approximate site boundary

Report Reference: 4144TA	Client: Waterman	BAC TEC
	Project: Mount Pleasant Sorting Office, London	

Source: Waterman