Geo-Environmental Assessment Report

Upper Brook Street, Manchester

Presented to: HDR Inc.

Issued: February 2024

Delta-Simons Project No: 101718.591891

Protecting people and planet

Report Details

Client	HDR Inc.
Report Title	Geo-Environmental Assessment
Site Address	Elizabeth Yarwood Court, Kincardine Road, Manchester, M13 9SY
Report No.	101718.591891
Delta-Simons Contact	Simon Steele [redacted]

Quality Assurance

Issue No.	Status	Issue Date	Comments	Author	Technical Review	Authorised
02	Final	15/02/2024	Preliminary pile calculations now included.	[redacted] PP Tom Bywater Senior	[redacted] PP Melanie Booth Principal Matthew Hemus Principal	[redacted] Simon Steele Unit Director Corinne Burrows Associate Director

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Executive Summary

Brief	Delta-Simons Limited ('Delta-Simons') was instructed by HDR Inc. (the 'Client') to undertake a Geo-Environmental Assessment for a plot of land located at Elizabeth Yarwood Court which is bounded by both Upper Brook Street and Kincardine Road, Manchester, M13 9SY (hereafter referred to as the 'Site'). The Site has received outline planning permission for the construction of a new six to nine storey block to provide combined laboratory and office space along with ground floor publicly accessible spaces. The purpose of this assessment is to identify the potential for land contamination issues to be present at the Site in the context of the proposed development, to support the planning application and to provide a geotechnical assessment.
Site Setting	The Site was previously occupied by residential properties from the earliest map reviewed (dated 1848) until 1948. The building belonging to Elizabeth Yarwood Court is first shown on the 1969 mapping, which remains to the present day. A canopy is present on the southwestern boundary, reported to be associated with a neighbouring car sales business, dating from the 1980s. Published geology indicates that the superficial deposits beneath the Site comprise Devensian Till, underlain by sandstone of the Chester Formation. Glaciofluvial sheet deposits of sand and gravel are recorded in proximity to the Site. British Geological Survey (BGS) borehole records in the vicinity of the Site indicate that potentially significant thickness of Made Ground may be present at the Site (associated with the former residential demolition), underlain by superficial sands and gravels, and sandstone bedrock (Chester Formation).
Ground Conditions	The current ground investigation recorded potentially significant thicknesses of Made Ground, which is in turn underlain by superficial deposits comprising sands and gravel of the Devensian Till Formation, and bedrock (sandstone) of the Chester Formation. Monitoring of standpipes indicates that groundwater is within the Chester Formation.
Land Contamination Assessment	<u>Soil Analysis</u> In comparison to commercial end use generic assessment criteria (GAC), marginal exceedances of Polycyclic Aromatic Hydrocarbons were noted in one location in the north of the Site. In the context of the proposed end use, the development will utilise hardstanding across the Site, breaking the potential pollutant linkages. Groundworkers and sub-surface maintenance workers should be made aware of the possibility of encountering contaminated soils through toolbox talks and in particular the potential presence of asbestos and an appropriate protocol to mitigate exposure of the workforce and general public should be in place. At this point, it is considered reasonable to discount the on-Site soils from presenting a significant risk of harm to the health of future Site users. <u>Groundwater Analysis</u> Elevated contaminants were not identified in the groundwater situated within the Chester Formation. In the context of the Site setting, it is considered reasonable to discount groundwater at the Site from presenting a significant risk of harm to controlled waters. <u>Ground Gas</u> Ground gas monitoring indicates the Site can be classified as CS1, where no gas protection are considered necessary for the proposed development.

	Vapours No potential sources of volatile contaminants have been identified. Aggressive Ground The results of the Made Ground soils indicate particularly high Total Sulphur and Water Soluble Sulphate in one location (RO2), and buried concrete is recommended to be designed to concrete design class AS-4 and ACEC-3. This is due to a high volume of concrete present in the Made Ground soils at RO2. The remainder of the Made Ground soils are not considered to have the potential to attack buried concrete with respect to elevated sulphates. Consideration should be given to the removal of concrete and / or larger fragments in the Made Ground soils prior to development. Aggressive ground chemistry was not identified in the natural soils located beneath the Site (Devensian Till and Chester Formation). Should a deeper piled foundation solution be adopted, then buried concrete is recommended to be designed to concrete design class AS-1 and ACEC-1.
Geotechnical Assessment	A piled foundation solution using traditional bored or continuous flight auger (CFA) piles transferring loads to competent geology is the preferable solution for the proposed development given the anticipated design loads. Piles will utilise both skin friction and end bearing capacity. The precise method of pile installation and applicability of proprietary systems, diameters and depths required would need to be informed based on the results of this investigation, by discussions with a piling contractor with suitable experience, whose design should be warranted. The upper horizons of the Chester Formation were characterised by heavily weathered sandstone recovered as gravelly medium grained sand and should be treated as a granular soil as a conservative measure during a piling assessment. It is considered that pile groups should be advanced to c. 15 m bgl, within the more competent Chester Formation. At these depths, with 0.3 m diameter piles, loads up to 935 kN may be achieved. However, consideration should be given to areas of deeper Made Ground and effects of negative skin friction which will affect pile capacity. A specialist piling contractor should be consulted to confirm design pile capacities. It is recommended that during demolition of the building, all relict basements, foundations, and other obstructions are removed to avoid in-ground obstructions during piling. It is understood that the movement of Made Ground soils is likely necessary to achieve the proposed FFL of 38.6 m AOD. Should the re-use of materials on-Site be required and where the material is chemically and geotechnically suitable for its proposed end location, material re-use should be undertaken under a Materials Management Plan. Consideration should be given to the likelihood of encountering larger boulders and or cobbles of brick/concrete in the Made Ground.
Recommendations	Based on the findings of this Report, the following recommendations are made: • Foundations Works Risk Assessment during demolition of the on-Site buildings and / or a supplementary investigation incorporating trial pits to assess the current foundations of Elizabeth Yarwood Court and potential other obstructions across the Site; • Given the absence of significant contamination present at the Site, preparation of a Remediation Strategy is not considered necessary. However, an appropriate 'hotspot' protocol and / or watching brief should be implemented for future groundworkers to act upon should such

	contamination, particularly asbestos (which is known to be present at the Site), be identified during the construction process; • Undertake a United Utilities Risk Assessment to confirm the required water supply pipe material; and, • Plate CBR's are also recommended following any minor cut and fill operations and the emplacement of imported granular fill, thus, verifying CBR performance has been achieved prior to placement of sub-base. It should also be ensured that appropriate UXO support is in place during the development phase of works, to comprise: • Explosive Ordnance Site Safety Instructions: to be on site for the duration of the development phase of works; • Explosive Ordnance Safety and Awareness Briefings: for all development phase personnel undertaking intrusive ground works; • EOD Engineer Supervision: for all boreholes and all development phase mechanical excavations within the Moderate Risk zone; and, • Intrusive Magnetometer Probe Survey: at each pile location within the Moderate Risk zone, to a depth of 10.0 m bgl.
This is intended as a summary only. Further detail and the limitations of the assessment are provided within the main body of the Report.	

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1.0 Introduction

1.1 Appointment

Delta-Simons Limited ("Delta-Simons") was instructed by HDR Inc. (the "Client") to prepare a Geo-Environmental Assessment Report for a plot of land, currently comprising Elizabeth Yarwood Court, which is bounded by both Upper Brook Street and Kincardine Road, Manchester, M13 9SY (the "Site").

1.2 Context & Purpose

The aim of the study was to complete a geo-environmental assessment of the proposed development area. The investigation has obtained information regarding ground conditions, from which risks to end-users, the environment and structures have been assessed, with mitigation measures suggested where necessary. The investigation has also gathered geotechnical information to inform comment on the preliminary design of foundations and infrastructure. The Report provides recommendations for further work (where appropriate) based on the findings of the investigation.

1.3 Scope of Works

The layout of this Report has been designed with consideration of guidance on Land Contamination: Risk Management pages of the GOV.UK web pages, the relevant requirements of the National Planning Policy Framework (NPPF) (as revised 2023) (paragraphs 174 & 183-184)[1] and the Planning Practice Guidance (Land Affected by Contamination)[2].

The project was undertaken to an agreed brief as set out in Delta-Simons' proposal (reference 101718.591891, dated 29th August 2023). Intrusive investigation locations were placed in locations requested by the Client.

The detailed scope of works is outlined in Section 3.

Specific sections of this Report may generally follow guidance set out in Eurocode 7 for a Ground Investigation Report (GIR), as defined in BS EN 1997-1:2004 and BS EN 1997-2:2007. Eurocode 7 includes specific guidance on the number and spacing of investigation positions, methods of investigation and sample quality to be achieved which may not have been met by this investigation. The Report also includes information which may support a Geotechnical Design Report (GDR) as defined in BS EN 1997-1:2004; however, unless otherwise explicitly stated, the investigation has not been undertaken in accordance with Eurocode 7 and the preliminary geotechnical interpretation, assessments and recommendations presented within this Report may not meet the full requirements of a GDR.

1.4 Proposed Development

The proposed development is understood to comprise the demolition of the existing two storey building and canopy structure formerly used by a car dealership and the construction of a new six to nine storey block, to provide combined laboratory and office space along with a ground floor publicly accessible café, meeting room suites, and a secure cycle store and cycle changing room. The building massing is split into a low level six storey block (inc. plant) to Kincardine Road, rising to nine storeys (inc. plant) at Upper Brook Street, with an atrium to the centre of the floorplates that houses informal breakout spaces and forum stairs at ground floor level.

Full details of the development and associated plans have not been included within this Report and reference should be made to the planning application.

The proposed redevelopment is subject to a planning application reference 137399/FO/2023 (alternative reference: PP-12094149) from Manchester City Council. The proposed development is understood to have been split into Plot C and Plot B; the Site assessed within this Report refers to Plot B only. The application details the proposed development as follows:

[1] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1182995/NPPF_Sept_23.pdf
[2] https://www.gov.uk/guidance/land-affected-by-contamination

"Erection of a 6 to 9 storey building for Sci-Tech use (Use Class E (g)(ii)) and 265sqm of a cafe/bar (Use Class E (b)), and a 9 to 23 storey building for Purpose Built Student Accommodation (PBSA) (Use Sui Generis), comprising 737 bedrooms and 293sqm of community use (Use Class F2 (b)) and 80sqm of commercial floorspace (Use Class E), alongside new public realm, access, parking, and associated works following demolition of existing buildings".

The proposed development located at the subject Site (Plot B) relates to the erection of a six to nine storey Sci-Tech use and café / bar, along with the use of commercial floorspace.

In addition, the following conditions related to land contamination have been presented:

11) a) Notwithstanding the Phase I Ground Investigation Desk Study Upper Brook Street Masterplan, A2 Site Investigation Limited. Reference: 53-57 Upper Brook Street 28723. Date: 25.5.2023. received by the City Council, as Local Planning Authority, on the 3 August 2023, a plot of development shall not commence until the following information has been submitted for approval in writing by the City Council, as Local Planning Authority, to identify and evaluate all potential sources and impacts of any ground contamination, groundwater contamination and/or ground gas relevant to the site:

- Submission of Site Investigation Proposals

- Submission of a Site Investigation and Risk Assessment Report

- Submission of a Remediation Strategy

b) When the development commences, the development shall be carried out in accordance with the previously agreed Remediation Strategy.

Reason - To ensure that the presence of or the potential for any contaminated land and/or groundwater is detected and appropriate remedial action is taken in the interests of public safety, pursuant to policies DM1 and EN18 of the Core Strategy.

12) If, during the development, contamination or conditions not previously identified as part of the agreed documents within condition 11 are found to be present at the site (or in the monitored vicinity) then no further operations shall be carried out until a strategy which details how this unsuspected circumstance shall be dealt with has been submitted for approval in writing by the City Council, as Local Planning Authority. The approved strategy shall then be implemented and then verified as required by condition 20.

Reason - To ensure that the works to be undertaken do not contribute to, or adversely affect, unacceptable levels of water pollution from previously unidentified contamination sources pursuant to policies EN17 and EN18 of the Manchester Core Strategy (2012).

13) Prior to a plot of development hereby approved being brought into first use, and following completion of the remediation strategy approved as part of condition (11), a Completion/Verification Report shall be submitted for approval in writing by the City Council as Local Planning Authority. This shall demonstrate that the completion of works has been carried out in accordance with the approved remediation strategy and has been effective. The report shall include results of sampling and monitoring carried out in accordance with the approved verification plan to demonstrate that the site remediation criteria have been met.

Reason - To ensure that the site has been appropriately remediated prior to the commencement of works associated with the redevelopment of the site, pursuant to policies EN17, EN18 and DM1 of the Manchester Core Strategy (2012).

This Report may be used in support of the discharge of these planning conditions.

1.5 Limitations

The assessment is limited to the issues agreed within the proposal for the works. General notes on limitations associated with this assessment are provided in Appendix A.

1.6 Data Gaps and Uncertainty

In addition, the following specific data gaps and uncertainty apply to this assessment:

- The presence of buildings on-Site prevented unrestricted access to all investigation locations with the support vehicle and equipment. Although this altered the approach to drilling at some locations, it is not considered to have affected the data collected;
- The investigation scoped and geotechnical assessments provided are specific to the current proposed development anticipated, and may not be relevant for other development schemes should these be considered in the future;
- It is understood that the investigation was designed to provide preliminary information only and further information may be required in due course to discharge Site specific planning conditions / detailed design;
- Due to the nature of water flush drilling techniques, some groundwater strikes were unable to be recorded at the time of the investigation. Likewise, the granular nature of the Devensian Till at shallower depths required more water to be added during rotary drilling, and similarly some groundwater strikes were unable to be recorded;
- Due to the nature of the weak and weathered sandstone strata in the upper horizons, the rock unit deteriorated during drilling and subsequent subsampling. Thus, Point Loads Tests (PLTs) were largely substituted for Uniaxial Compressive Strength (UCS) tests although this is not considered to adversely affect any assessments; and,
- At the time of writing, no proposed loadings have been provided by the Client and / or engineer.

2.0 Site Details

2.1 Site Setting

A summary of the current Site status, environmental setting and key historical features is presented below.

Co-ordinates	Centred approximately at National Grid Reference 384864, 396846.	**Elevation**	Approximately 38.0 – 40.0 m AOD
		Area	Approximately 0.60 Ha
Site Address and Location	The Site is located approximately 500 m south-east of Manchester City Centre's Ring Road (A57M) and can be accessed from the east off Kincardine Road, M13 9SY. The Site is bounded by Upper Brook Street in the west, Cottenham Street in the south and a small industrial unit / car parking in the north. A Site location map is provided as Figure 1. Google Maps Link Google, Imagery©2023 Bluesky, InforterraLtd&COWI A/S, CNES / Airbus, Getmapping plc, Landsat / Copernicus, Maxar Technologies, Map data ©2023.		
Current Site Description	The Site is currently occupied by Elizabeth Yarwood Court, (independent living accommodation), which can be accessed from the northeast off Kincardine Road. The area also comprises soft landscaped areas and car parking. An elongated canopy occupies the south-western edge of the Site, formerly a car showroom, which can be accessed from Upper Brook Street. The area is underlain by a mixture of concrete and macadam hardstanding.		
Physical Setting	Published geology indicates that the superficial deposits beneath the Site comprise Devensian Till, underlain by sandstone of the Chester Formation. BGS logs available for the area indicate that Made Ground deposits, anticipated topertain to the previous phases of demolition at the Site, are also likely to be present, previously identified to a maximum depth of 1.8 m bgl. Glaciofluvial sheet deposits of sand and gravel are recorded in proximity to the Site. The Devensian Till is listed as a Secondary (undifferentiated) Aquifer and the Chester Formation (bedrock) is listed as a Principal Aquifer. The closest surface water feature is understood to be the River Medlock, located approximately 600 m north of the Site. The Site also resides within a Coal Mining Reporting Area but not within a Development High Risk Area.		
Key Historical Features	From the earliest reviewed mapping, the Site was occupied by residential properties (dated 1848) until 1948, after which a unspecified "Works" is shown in the north-east of the Site. By 1960 the Site is shown as vacant, with the building of Elizabeth Yarwood Court shown by the 1969 mapping, which remains to the present day. A canopy is present along the southwestern boundary, reported to be associated with a neighbouring car sales business, dating from the 1980s. Given the Site proximity to Manchester City Centre, Zetica online Unexploded Ordnance (UXO) risk maps indicate that the Site is located within an area considered to be at a moderate risk from UXO. Consequently, a detailed UXO Risk Assessment Report has been undertaken and is included as Appendix H.		

Preliminary Conceptual Site Model	Sources • Potentially significant thicknesses of Made Ground; • Potential on-Site historical sources including former unknown 'Works' and former showroom (with potential for associated fuel / oil storage); and, • Potential residual contaminants (e.g. asbestos) and 'hot-spot' areas from historical use of the Site as former residential areas. Pathways • Direct contact, ingestion or inhalation of soil bound contaminants / dust during or following redevelopment; • Inhalation of potential organic vapours associated with contamination; • Migration of ground gas / vapours into on-Site buildings causing asphyxiation or risk of explosion; • Leaching of contamination into groundwater followed by migration of groundwater to the wider groundwater environment or discharge to surface waters; and, • Direct contact between aggressive ground conditions and new infrastructure. Receptors • Construction workers; • Third parties during construction (adjacent Site users and adjacent residents); • Future Site users and maintenance workers; • The underlying superficial (Secondary Undifferentiated) and bedrock aquifers (Principal); and, • The Built Environment (new buildings and infrastructure / utilities). Widespread contamination has been considered unlikely and the Delta-Simons preliminary risk assessment has identified a **low to moderate** risk of soil / groundwater contamination and hazardous ground gas at the Site.

3.0 Ground Investigation

3.1 Intrusive Investigation

Delta-Simons carried out intrusive investigation work from 27th November to 5th December 2023 to assess the potential contaminative linkages and to provide geotechnical information.

3.2 Ground Investigation and Rationale

3.2.1 Intrusive Works

The ground investigation comprised the following items:

- Service avoidance exercise to ensure proposed exploratory locations are clear of services, followed by spot-surveying of exploratory boreholes to provide x,y co-ordinates and elevation (z);
- Supervision of all works by a Delta-Simons Geo-Environmental engineer. All intrusive locations were logged in general accordance with BS 5930:2015+A1:2020 Code of Practice for Ground Investigations;
- Supervision of intrusive works by a suitably qualified EOD (Explosive Ordnance Disposal) engineer to provide a UXO watching brief and down-hole intrusive magnetometer UXO survey;
- Drilling of three rotary borehole locations (RO1 to RO3), utilising a mix of open holing and coring methods to a maximum depth of 20.50 metres below ground level (m bgl);
- Drilling of seven dynamic sampler boreholes (DS1 to DS7) to a maximum depth of 4.00 m bgl;
- Installation of all borehole locations (10) with a 50 mm combined groundwater and ground gas monitoring standpipe, to a maximum depth of 10 m bgl in rotary borehole locations and to a maximum depth of 3.5 m bgl in dynamic sampler borehole locations; and,
- Ground gas and groundwater monitoring on three occasions over a month period.

An intrusive exploratory borehole and excavation location plan is presented as Figure 2.

Specific limitations affecting the proposed scope of works are summarised in Section 1.7.

Delta-Simons' exploratory borehole logs are presented as Appendix B together with the Standard Penetration Testing (SPT) Calibration Certificates, in accordance with BS EN ISO 22476-3:2005+A1:2011 (incorporating corrigendum No. 1 2007), Geotechnical investigation and testing - Field testing - Part 3: Standard Penetration Test for SPT trip hammers.

3.2.2 Rationale

Location	Rationale	Key Contaminants of Concern
RO1 to RO3	To obtain soil and rock samples located beneath the Site. The boreholes aided assessment of superficial deposit thicknesses, depth to bedrock, and, strength and nature of underlying Chester Sandstone Formation to inform preliminary foundation design. All three locations were installed as combined groundwater and ground gas monitoring wells.	Total petroleum hydrocarbons (TPH), Polycyclic aromatic hydrocarbons (PAHs), heavy metals, and asbestos.
DS1 to DS7	To obtain Side-wide shallow soil samples to facilitate environmental and in-situ geotechnical testing (SPTs as required). All seven locations were installed as combined groundwater and ground gas monitoring wells.	

3.3 Geotechnical Sampling and In-Situ Testing

3.3.1 Sampling

Sampling comprised disturbed jar / tub and bulk samples as detailed on the borehole logs. Details of undisturbed core sampling, sub-sampling, and preparation is detailed on the rotary borehole logs as included as Appendix B.

3.3.2 In-Situ Tests

SPTs were undertaken in all dynamic sampler boreholes at 1.00 m intervals from the base of the hand pit (1.20 m bgl) until refusal (4.00 m bgl). SPTs were undertaken (where feasible) in all rotary boreholes at selected intervals. The results of these tests are presented on the borehole logs included as Appendix B. A plot of Corrected SPT 'N_{60}' values versus Depth are included as Figures 3a and 3b.

3.4 Geotechnical Laboratory Testing

A selection of soil and rock samples were submitted to the UKAS accredited laboratory for a range of geotechnical testing, the results of which are included in Appendix C. The rationale for the laboratory tests undertaken is provided in the table below.

Laboratory Test	Test Standard	Number of Samples Tested	Rationale
Classification			
Water Content	BS1377-2:3	9	For general classification and to assess the potential for cohesive soils to shrink and swell due to changes in the water content of a soil associated with the presence, removal or addition of trees and shrubs.
Liquid and Plastic Limits	BS1377-2:4 – 5	3	
Rock Testing			
Point Load Test	ISRM 2007	23	Used to provide a strength index to classify rocks for pile design purposes.
Uniaxial Compressive Strength		1	To characterise material properties of a rock core sample for pile design purposes.
Geo-Chemical – Soil Samples			
pH	BRE Special Digest 1 or other	30	To assess the soil and groundwater conditions of the Site in accordance with BRE Special Digest 1 Concrete in aggressive ground and specify an appropriate concrete class to resist chemical attack.
Water-Soluble Sulphate (2:1 water/soil extract)		30	
Acid Soluble Sulphate		20	
Total Sulphur		20	
Geo-Chemical – Water Samples			
pH	BRE Special Digest 1 or other	3	To assess the soil and groundwater conditions of the Site in accordance with BRE Special Digest 1 Concrete in aggressive ground and specify an appropriate concrete class to resist chemical attack.
Soluble Sulphate		3	

3.5 Environmental Sampling and Laboratory Analysis

Soils collected for laboratory analysis were placed in a variety of containers appropriate to the anticipated testing suite. Records of the samples taken as part of the Site investigation works, including their depths and location, are included within the exploratory hole records in Appendix B.

Three groundwater samples were collected from each of the installed rotary boreholes on 14th December 2023. The groundwater samples were collected using a dedicated disposable bailer. Samples were stored in accordance with Delta-Simons' quality procedures to maintain sample integrity and preservation and to minimise the chance of cross contamination. Samples analysed for environmental purposes were placed in cool boxes on Site and transported to the laboratory for analysis on completion of the Site investigation works/groundwater sampling visit.

The rationale for chemical analysis is presented in the table below and the results of the chemical laboratory testing are included in Appendix D and E.

Analytes	**No. of Samples Tested**		**Rationale**
	Soil	**Ground-water**	
Asbestos	12	-	Common potential contaminant - analysed in all samples of Made Ground.
As, Cd, Cu, Cr, Hg, Pb, Ni, Zn, speciated Polycyclic Aromatic Hydrocarbons (PAH)	10	3	Potential contaminants of concern, common to many sites. To allow comparison of potentially elevated contaminants against their relevant assessment criteria.
Total Petroleum Hydrocarbons	10	3	
Criteria Working Group Method (TPHCWG), Benzene, Toluene, Ethylbenzene and Xylene (BTEX)	10	3	
pH, sulphate	30	3	
Total Organic Carbon (TOC)	10	-	To allow comparison of potentially elevated contaminants against their relevant assessment criteria.
Volatile and Semi-Volatile Organic Compounds (VOC and SVOC)	3	-	Targeting specific identified areas of concern in preliminary CSM in the north of the Site at the location of the historical unidentified 'Works'.
Cyanide (Total, complex and free)	3	-	As specified by the Client, and to allow comparison of potentially elevated contaminants against their relevant assessment criteria.
Phenols – Speciated by GCMS	3	-	

3.6 Monitoring Programme

Three rounds of groundwater level and ground gas monitoring were undertaken on all ten newly installed wells between 8th and 19th December 2023.

Measurements of the depth to groundwater within the monitoring wells were taken using an interface probe.

To characterise the ground gas regime at the Site, an infrared gas meter was used to measure gas flow, concentrations of carbon dioxide (CO_2), methane (CH_4) and oxygen (O_2) in percentage by volume. Initial and steady state concentrations were recorded. The atmospheric pressure before and during monitoring, together with the weather conditions, was recorded.

All monitoring results obtained to date are contained within Appendix F.

4.0 Ground Summary

4.1 Introduction

The sections below summarise the ground and groundwater conditions encountered during the Site investigation.

4.2 Ground Summary

A summary of the observed ground conditions at the Site is provided below. A qualitative detailed summary of the ground model at the Site is discussed further in Section 5.0.

Strata	Typical Strata Description	Depth Range of Strata Top (m)	Depth Range of Strata Base (m)	Thickness Range (m)	Comments
Topsoil	Grass over very soft gravelly CLAY with fine roots. Gravel predominantly comprised brick fragments, concrete and natural lithologies.	*0.00*	*0.09 - 0.19*	*0.09 - 0.19*	*Recorded in all areas of soft landscaping, predominantly located at the rear of Elizabeth Yarwood Court, in the center of the Site.*
Made Ground (hard standing)	Paving slab.	*0.00*	*0.08*	*0.08*	*Encountered in RO3 only.*
	Black macadam.	*0.00*	*0.04 – 0.08*	*0.04 – 0.08*	*Encountered in the car park of Elizabeth Yarwood Court (DS7) and beneath the canopy in the south-west of the Site (DS1 and DS2).*
Made Ground (all other deposits)	Multicolored sandy GRAVEL of concrete, red brick fragments and sandstone, with occasional plastic, glass and cloth. Strata had a medium to high cobble content of concrete and red bricks.	*0.00*	*1.30 – 4.50*	*1.30 – 4.50*	*Recorded in all locations at varying thicknesses.* *Bulk asbestos fragments were noted in the hand pit of RO2.*
Devensian Till	Commonly recovered as either soft to firm brownish grey CLAY and / or SAND and GRAVEL comprising natural lithologies.	*1.30 – 4.50*	*3.00 – 5.00*	*0.50- 2.30*	*Recorded in all locations between the base of the Made Ground and top of the Chester Formation.*
Weathered Chester Formation	Predominantly recovered as brownish red clayey SAND.	*3.00 – 5.00*	*9.70 – 10.50*	*5.00 - 6.90*	*Encountered at the base of all dynamic sampling locations and within all rotary boreholes.*
Chester Formation	Predominantly moderately weak (but varying in strength) thinly bedded reddish brown medium grained SANDSTONE.	*9.70 – 10.50*	*Not proven. Recorded to maximum depth of 20.50 m bgl.*		*Encountered in the rotary boreholes RO1 to RO3.*

Strata	Typical Strata Description	Depth Range of Strata Top (m)	Depth Range of Strata Base (m)	Thickness Range (m)	Comments
	Fracture sets are largely horizontal and / or subhorizontal and closely spaced.				

4.3 Groundwater

4.3.1 Strikes During Investigations

Due to the nature of water flush drilling techniques, groundwater strikes were unable to be recorded in the rotary boreholes at the time of the investigation.

No groundwater strikes were encountered during advancement of the dynamic sampling.

4.3.2 Levels During Monitoring Programme

Groundwater levels were monitored on a total of three occasions between 8th and 19th December 2023. Monitoring data and LNAPL measurements are provided in Appendix F and summarised in the table below.

Exploratory Hole	Water level during monitoring Max to Min Range		LNAPL Y/N	Stratum
	m bgl	m AOD.		
RO1	8.44 – 8.63	31.08 – 31.27	N	Weathered Chester Formation
RO2	8.32 – 8.88	30.33 – 30.89	N	Weathered Chester Formation
RO3	8.49 – 9.02	29.80 – 30.33	N	Weathered Chester Formation
DS1	-	-	N	-
DS2	-	-	N	-
DS3	3.55 – 3.59	35.32 – 35.36	N	Weathered Chester Formation
DS4	-	-	N	-
DS5	-	-	N	-
DS6	-	-	N	-
DS7	-	-	N	-

Residual groundwater / rainwater was likely encountered in DS3 on two occasion and is not indicative of the groundwater table as encountered in the rotary boreholes. Groundwater levels during monitoring in RO1 to RO3 varied between 8.32 and 9.02 m bgl (29.80 to 30.89 m AOD) within the Chester Formation.

4.4 Visual and Olfactory Evidence of Contamination

Suspected bulk asbestos samples were identified in the hand pit of rotary borehole location RO2. Suspected samples were appropriately bagged and sent to the laboratory for asbestos identification.

Borehole ID	Depth (m bgl)	Reference	Test Standard	Asbestos Identification
RO2	0.20 – 1.00	B1	ISO 17025	Chrysotile – Asbestos Cement
RO2	0.20 – 1.00	B2	ISO 17025	Chrysotile, Amosite – Asbestos Cement

No other visual or olfactory evidence of potential gross contamination was observed during the investigation. Light Non-Aqueous Phase Liquid (LNAPL) was not detected during the monitoring programme.

4.5 Material Properties

The table below summarises the factual material properties based upon the results of in-situ and laboratory test data and where appropriate provides derived geotechnical parameters.

Parameter	Unit	Value or Range (adopted characteristic design parameters)	Justification
Made Ground			
Uncorrected SPT 'N'	Blows	2 – 50	In Situ testing.
Corrected SPT 'N60'	-	2 – 57	SPT N values corrected for energy ratio (Er %) after BS EN ISO 22476-3:2005. Er % stated on borehole logs.
Devensian Till			
w (Water Content)	%	5.9 – 17	Laboratory classification testing.
IP (Plasticity Index)	-	14 – 19	
PL (Plastic Limit)	%	13 – 18	
LL (Liquid Limit)	%	31 – 32	
I'P (Modified Plasticity Index)	%	9 – 17	Modified PI derived from I'P = (IP x % Passing 425 µm) / 100.
Volume Change Potential	-	Low	Derived from NHBC Chapter 4.2.4 considered to represent industry best practice.
Uncorrected SPT 'N'	Blows	12 – 50	In Situ testing.
Corrected SPT 'N60'	-	13 – 57	SPT N values corrected for energy ratio (Er %) after BS EN ISO 22476-3:2005. Er % stated on borehole logs.
Chester Formation (+ Weathered)			
w (Water Content)	%	9.9 – 15.7	Laboratory classification testing.
Uncorrected SPT 'N'	Blows	50	In Situ testing.
Corrected SPT 'N60'	-	55 – 57	SPT N values corrected for energy ratio (Er %) after BS EN ISO 22476-3:2005. Er % stated on borehole logs.

Parameter	Unit	Value or Range (adopted characteristic design parameters)	Justification
Laboratory Derived Unconfined Compressive Strength (UCS)	Mpa	4.56	Laboratory strength testing.
Point Load Index – $I_{s(50)}$		0.10 – 0.47	
$I_{s(50)}$ Derived Unconfined Compressive Strength (UCS)		1.80 – 8.46	Where: [UCS = (IS(50) x K)], the conversion factor (K) is assumed to equal 18 (for sandstones) based on Das, 1995.
Total Core Recovery (TCR)	%	76 – 100	On-Site calculation from bedrock core arisings.
Solid Core Recovery (SCR)		42 – 100	
Rock Quality Designation (RQD)		12 – 80	

A plot of Corrected SPT 'N_{60}' values versus Depth are included as Figures 3a and 3b.

4.6 Geochemical Testing

Geochemical analysis was undertaken on 30 soil samples of Made Ground, Devensian Till and the Chester Formation, tested for selective contaminants (BRE Special Digest 1:2005 (3rd Edition)), Concrete in Aggressive Ground, the results of which are summarised in the table below.

Tests	No. of Tests	Minimum	Maximum
Made Ground			
Soil – pH	15	7.4	11.7
Soil – Total Sulphur	5	0.021 %	0.975 %
Soil – Acid Soluble Sulphate	5	0.023 %	1.98 %
Soil – Water Soluble Sulphate	15	11.3 mg/L	1660 mg/L
Devensian Till			
Soil – pH	5	7.4	8.4
Soil – Total Sulphur	5	<0.005 %	0.013 %
Soil – Acid Soluble Sulphate	5	0.01 %	0.026 %
Soil – Water Soluble Sulphate	5	11.9 mg/L	31.2 mg/L
Chester Formation			
Soil – pH	10	7.6	8.9
Soil – Total Sulphur	10	<0.005 %	<0.005 %
Soil – Acid Soluble Sulphate	10	<0.005 %	0.012 %
Soil – Water Soluble Sulphate	10	4.2 mg/L	16.8 mg/L
Water – pH	3	7.0	7.3
Water – Sulphate	3	54.3 mg/L	278 mg/L

5.0 Geotechnical Assessment

5.1 Introduction

5.1.1 Summary of Development Proposals

A proposed development plan is provided as Drawing 1 – General Arrangement – Sci-tech Building Ground Floor Plan (Drawing No.: UBS-SRA-ST-00-DR-A-02-500) dated 6th June 2023 and outlines the building footprint at ground floor level.

The proposed redevelopment is subject to a planning application reference 137399/FO/2023 (alternative reference: PP-12094149) from Manchester City Council and comprises the demolition of the existing two storey building and canopy structure used for car dealership and the construction of a new six to nine storey block to provide combined laboratory and office space along with a ground floor publicly accessible café, meeting room suites, and a secure cycle store with cycle changing room. The building massing is split into a low level six storey block (inc. plant) to Kincardine Road, rising to nine storeys (inc. plant) at Upper Brook Street.

In reference to Drawing 2 (Site Elevation Proposed – Cottenham Street: South East), the proposed level of the ground floor is anticipated to be at 38.6 m AOD. At the time of writing, structural and floor loadings were unknown. Consequently, the information provided below should be treated as preliminary and will be subject to review once a scheme and levels have been finalised, and further detailed assessment may be required.

5.1.2 Ground Model Review

The current ground investigation recorded a mixture of hardstanding along with peripheries of the Site, with topsoil located in the soft landscaped areas at the rear of the property in the centre of the Site. Potentially significant thicknesses of Made Ground were encountered across the Site, recorded to a maximum depth of 4.50 m bgl. The Made Ground soils predominantly comprised gravel material where anthropogenic materials included red brick, concrete, plastic, glass and rare asbestos fragments (in RO2). A significant quantity of larger sized particles (boulders and cobbles) of red bricks and concrete was also encountered in the hand pits during the investigation. Potential obstructions were also encountered to 4.50 m bgl in RO2.

A limited thickness of Devensian Till was encountered beneath the base of the Made Ground in all locations with a maximum recorded thickness of 2.30 m. The Devensian Till was recovered as either clay or sand and gravel and showed a general increase in strength with respect to depth (Figure 3b).

The Chester Formation was encountered in all locations across the Site. The dynamic sampling locations (DS1 to DS7) encountered the upper most weathered zones at the base of each hole. The SPTs conducted at 4.00 m bgl all refused on the weathered bedrock although the material recovered was of a granular nature. The weathered zones of the Chester Formation were encountered to maximum depth of 10.50 m bgl. SPTs conducted in this material all refused (where N60 = >50) indicated a very dense sand. Beyond this, competent bedrock of the Chester Formation was encountered at a shallowest depth of 9.70 m bgl and recovered to a maximum depth of 20.50 m bgl. The strength profile of the competent Chester Formation generally ranged from very weak (at its shallowest), to moderately strong. The results of the rock testing (Figure 4b), indicate a general increase in uniaxial compressive strength with respect to depth.

5.1.3 Preliminary Geotechnical Hazards

The geohazards listed below have been identified to follow guidance presented in the HE document CD622 'Managing Geotechnical Risk' (2020) which aims to identify and manage the geotechnical risks associated with a scheme throughout its lifespan, from planning to construction to maintenance.

The following geohazards are considered to be substantial ground related risks associated with the proposed development. A substantial risk is defined by Delta-Simons in Appendix G.

- Deep Made Ground – The ground investigation has recorded potentially significant thicknesses of Made Ground, identified to a maximum depth of 4.50 m bgl (in RO2) considered to be associated with

the former demolition of residential housing during the 1900s. The Made Ground deposits were identified to comprise a range of particles sizes from clay to boulders of red bricks and concrete. Made Ground is typically variable in nature and strength with a potentially low bearing capacity and unacceptable levels of total/differential settlement may occur.

- Aggressive ground conditions – Although the natural geology underlying the Site is not considered likely to comprise of pyritic geochemistry, the Made Ground at the Site has recorded significant quantities of concrete deposits within the soils which may indicate elevated levels of Total Sulphur and Total Water Soluble Sulphates. Sulphates can attack and degrade concrete / the built environment if not mitigated against.
- Relict foundations – With the proposed demolition of the current buildings (Elizabeth Yarwood Court) and historical demolition of residential buildings across a significant portion of the Site, there is the potential for relict foundations to remain which may pose an obstruction during construction phase ground works.

5.2 UXO

Zetica online Unexploded Ordnance (UXO) risk maps indicate that the Site is located within an area considered to be at a moderate risk from UXO. Subsequently, a Detailed UXO Risk Assessment was undertaken for the Site by Impartial Assessments, and is included in Appendix H,

The assessment concluded that the Site can be zoned, with low risk and a moderate risk zones identified. Pertinent points are summarised below, though the report should be read in full for additional detail:

- Impartial Assessments consider that two unrecorded HE bombs struck the south-east corner of the Site, causing the destruction / damage beyond repair of terraced houses;
- Subsequent bombing raids may have resulted in UXB landing on and being undetected / unrecorded on Site, with a local probable HE bomb-stick aligning with the Site during a 1940 raid;
- Impartial Assessments consider that there is a Moderate risk from iron HE bombs to humans, plant and structures. The pathways considered to pose a Moderate risk include excavation of boreholes, mechanical excavations and piling.

The following recommendations are made by Impartial Assessments regarding mitigation measures:

- Explosive Ordnance Site Safety Instructions: to be on site for the duration of the development phase of works;
- Explosive Ordnance Safety and Awareness Briefings: for all development phase personnel undertaking intrusive ground works;
- EOD Engineer Supervision: for all boreholes and all development phase mechanical excavations within the Moderate Risk zone;
- Intrusive Magnetometer Probe Survey: at each pile location within the Moderate Risk zone, to a depth of 10.0 m bgl.

5.3 Earthworks

At the time of writing, detailed final levels were unclear, but it is understood that the proposed final floor level (FFL) of the ground floor is anticipated to be at 38.6 m AOD, as per Drawing 2. Given the relatively flat topography at the Site, a significant cut and fill operation is not anticipated. Shallow earthworks on the Site will likely predominantly encounter Made Ground deposits.

From an Earthwork strategy point of view, it is considered that the existing Made Ground soils on Site should remain in situ and untouched as far as possible. However, the approximate highest point of the Site is located at RO1 (39.71 m AOD) and so a surplus of Made Ground material is likely. Should the re-use of

materials on-Site be required and where the material is chemically and geotechnically suitable for its proposed end location, material re-use would need to be undertaken under a Materials Management Plan.

Wherever possible, any materials required for earthworks to raise levels should comprise clean, graded materials (e.g. crushed concrete/brick) following the demolition of the existing development or be suitable imported material Alternatively, should existing Made Ground soils (containing asbestos) be utilised as fill, then strict controls and continual monitoring (e.g. via a watching brief) will need to be in place in order to ensure there are no releases of asbestos fibres to the environment which could detrimentally impact human health.

Materials used as fill will need to be placed to a suitable engineering specification with the degree of compaction required dependent on end usage and serviceability criteria. For example, a lesser degree of compaction may be suitable for paved areas than for building platforms supporting foundations. Uplift in areas where vibro-replacement is to be used should comprise granular fill placed loosely, or with nominal compaction.

Unprotected stockpiled materials often deteriorate due to water infiltration, and they may become unsuitable for incorporation in the works.

Further earthworks testing may be required prior to completion of a suitably detailed earthworks specification for the works.

5.4 Foundations

Given the depth and variability of the Made Ground and Devensian Till beneath the Site and anticipated large design loads, it is not anticipated that shallow foundations or ground improvement techniques will be suitable for the purpose of supporting proposed foundation loads.

5.4.1 Piling

A piled foundation solution using traditional bored or continuous flight auger (CFA) piles transferring loads to underlying competent Chester Formation is preferable for the proposed or anticipated design loads, utilising both skin friction and end bearing capacity.

The precise method of pile installation and applicability of proprietary systems, diameters and depths required would need to be informed based on the results of this investigation, by discussions with a piling contractor with suitable experience, whose design should be warranted. Reference should be made to the Delta-Simons exploratory logs as included in Appendix B.

The upper horizons of the Chester Formation were characterised by heavily weathered sandstone recovered as gravelly medium grained sand and should be treated as a granular soil as a conservative measure. Results of all SPTs conducted in the weathered sandstone horizon indicate very dense sand (SPT N60 > 50, Figures 4a and 4b). It may be prudent to advance pile groups to c. 15 m bgl, 5 m into the more competent Chester Formation. Consideration should be given to the effects of negative skin friction in the Made Ground.

Preliminary pile capacities (kN) for a range of pile diameters between 300mm and 600mm are presented in the table below based on CFA or bored cast in place piles constructed on Site.

Pile Diameter	Pile Toe Level (m bgl)			
	8	10	12	15
300	370kN	525kN	640kN	935kN
450	760kN	1065kN	1275kN	1845kN
600	1285kN	1790kN	2125kN	3050kN

The preliminary pile capacities provided are based on the parameters outlined in section 5.1.3 and the following:

- No contribution from ground level to 2.50m bgl due to Made Ground – it is noted that Made Ground is less than this in places, however this is generally representative. In areas of deep Made Ground, for example at R02, these calculations will not be appropriate and consideration of negative skin friction should be given;
- The superficial deposits were not accounted for as their thickness is <1 m in multiple locations; and
- Groundwater Level taken at 4.00 m bgl as a conservative measure to account for perched water.

Partial safety factors have been applied to the calculated pile capacities above in accordance with Design Approach 1: Combination 2, as detailed within Tables A.6, A.7 and A.8 of Annex A in BS EN 1997-1 and should preliminary pile tests be carried out, a reduced model factor can be adopted.

Loads are based on single piles only and do not take into account the action of groups of piles. This should be considered at the detailed design stage. The pile capacity estimates presented above are preliminary and are based on a conservative soil profile derived from exploratory holes undertaken on-site.

Where soils are desiccated, piled foundations could be subject to tension if moisture contents return to equilibrium conditions. Piles should therefore be sleeved through the zone of desiccation or designed to accommodate the resultant tensile forces. A compressible medium is required beneath pile caps as described in Chapter 4.2 of the NHBC Standards.

Consideration was given to the presence of groundwater within DS3 despite the fact this was not deemed to be part of a wider groundwater body as a conservative measure. Groundwater may cause instability with an open bored hole, therefore, a CFA method of drilling may be deemed more appropriate.

Early consultation with an appropriate piling contractor is recommended to confirm pile working capacities and to ensure the contractor can achieve the required depths and capacities. Specialist piling contractors may potentially show greater load capacities than those shown above based on specific knowledge of their piling equipment, supported by testing evidence that may be acceptable to the Local Authority.

An appropriate piling platform should be designed and constructed in accordance with BRE Digest 470 (Working Platforms for Tracked Plant).

5.5 Roads and Pavements

At this point, it is recommended that a conservative CBR value of 2 % should be adopted for the shallow soils for preliminary pavement design in the proposed external areas (e.g. service yard). It is recommended that plate CBR tests are undertaken at formation level after demolition prior to finalising pavement design.

5.6 Excavations & Obstructions

It is expected that conventional mechanical excavators will readily remove the existing hardstanding encountered at the Site. Given the previous phases of demolition at the Site, it is likely that shallow obstructions are present in the Made Ground soils. Larger sized cobbles and / or boulders were encountered in the hand pits across the Site during the investigation. In particular, suspected red bricks and concrete obstructions were noted to a depth of 4.50 m bgl in RO2.

Implementing a Foundations Works Risk Assessment during the demolition phase and / or a supplementary investigation incorporating trial pits to assess the current foundations of Elizabeth Yarwood Court and potential other obstructions across the Site would aid better understanding of the shallow Made Ground soils.

All shallow foundation or services excavations at the Site should be considered unstable, therefore, temporary support of all excavations should be considered when excavating on Site.

5.7 Groundwater

Groundwater was recorded to be situated within the Chester Formation, in proximity to the weathered / non-weathered interface at approximately 9.00 m bgl. As such, significant groundwater would not be anticipated during the excavations required as part of the proposed development. Should any perched groundwater be encountered, then local dewatering via sump pumps should be suitable, however, treatment prior to disposal to sewer may be required.

5.8 Chemical Attack on Buried Concrete

The laboratory results from the Made Ground soils indicate particularly high Total Sulphur and Water Soluble Sulphate in one location (RO2). This is considered to be due to a high volume of concrete present in the Made Ground soils at RO2. The remainder of the Made Ground soils are not considered to have the potential to attack buried concrete with respect to elevated sulphates. Consideration should be given to the removal of concrete and / or larger fragments in the Made Ground soils prior to development. As a conservative measures, if the Made Ground soils are to be left in-situ, buried concrete is recommended to be designed to concrete design class DS-4 and ACEC-3.

Aggressive ground chemistry was not identified in the natural soils located beneath the Site (Devensian Till and Chester Formation). Should a deeper piled foundation solution be adopted, in accordance with the recommendations of BRE Special Digest 1, 'Concrete in Aggressive Ground' 2005, the conditions of the natural soils and rock beneath the Site would therefore be classified as Design Sulphate Class DS-1 and ACEC Class AC-1 for soils and groundwater, when considering the most appropriate type of concrete to be used at the Site in order to resist chemical attack from elevated sulphate present in the soils (assuming mobile groundwater in non-pyritic soils).

6.0 Generic Quantitative Risk Assessment

6.1 Introduction

The presence of hazardous substances in or on a Site is generally only of concern if an actual or potential unacceptable risk exists. Legislation and guidance on the assessment of contaminated sites, consistent with UK best practice, acknowledges the need for a tiered risk-based approach. This section represents a Generic Quantitative Risk Assessment (GQRA) being a comparison of Site contaminant levels against Generic Assessment Criteria.

6.2 Human Health GQRA

The assessment of risks in relation to human health has been undertaken using Generic Assessment Criteria (GAC) as detailed within the appropriate tables. Risks from soil, groundwater and Non-Aqueous Phase Liquids (NAPL) have been considered. The GAC are predominantly based on long term (chronic) risk to health. However, in the limited circumstances where short-term (acute) risks are more pronounced, these GAC have been utilised to ensure a thorough and conservative initial assessment is undertaken.

Based on the proposed commercial use of the Site, the soil and groundwater chemical data has been compared against a commercial end use GAC for 1% soil organic matter (SOM) content.

6.2.1 Risks from Soil Sources

The laboratory results for contaminants exceeding concentrations compared to their respective GAC are presented in the table below.

Contaminant	Max Conc. (mg/kg)	GAC (mg/kg)	GAC Source	No. Exceed GAC / No. of samples	Location of Exceedances (depth) = Concentration (mg/kg)
Asbestos	Detected		DS	3/10	DS5 (0.20 – 0.40 m bgl) = Amosite Loose Fibres DS6 (0.20 – 0.40 m bgl) = Amosite Loose Fibres RO3 (0.30 – 0.70 m bgl) = Amosite Loose Fibrous Debris
Polycyclic Aromatic Hydrocarbons					
Benzo[b]fluoranthene	49	44	LQM	1/10	DS6 (0.20 – 0.40 m bgl)
Benzo[a]pyrene	46	35	LQM	1/10	
Dibenz(a,h)anthracene	8.7	3.5	LQM	1/10	
Notes: LQM = Land Quality Management/CIEH S4Uls for Human Health Risk Assessment, 2014.					

6.2.2 Soil Analysis Summary

Localised marginal (with respect to the applied GAC) soil contamination with respect to Polycyclic Aromatic Hydrocarbons has been identified in one location (DS6) in the north of the Site in the vicinity of the former works. The majority of the remaining tested contaminants across the Site did not exceed their laboratory limit of detections.

Asbestos was identified in three locations (DS5, DS6 and RO3) within the shallow Made Ground soils.

Significant areas in the centre of the Site are currently covered with hardstanding and / or occupied by buildings (Elizabth Yarwood Court) which will be removed as part of the demolition and Site clearance works. As such, these areas were inaccessible for investigation during the ground investigation. Therefore, it would be prudent to implement a hotspot protocol and watching brief during the Site clearance works

should suspected areas of unexpected contamination, notably the potential presence of asbestos fragments be encountered.

6.2.3 Risks from Groundwater Sources

Based on the proposed use of the Site for commercial use, the groundwater chemical data has been compared against a commercial end use GAC to assess risks from groundwater sources to indoor air and subsequent vapour inhalation indoors.

None of the site-specific contaminants of concern were recorded at concentrations in excess of their detection limits/respective GAC.

6.2.4 Risks from Non-Aqueous Phase Liquids (NAPL)

Soil and groundwater exposure models used in generating Generic Assessment Criteria do not account for the potential for NAPL to represent a source of risk to human health, principally due to the production of vapours. Whilst it is possible to calculate theoretical soil saturation limits, in reality, due to co-solubility effects, these are not an appropriate indicator of the presence of NAPL. In order to assess the presence of NAPL, for petroleum hydrocarbons, an assessment criterion of 5,000 mg/kg for Total Petroleum Hydrocarbons has been applied based on professional experience.

The following has been identified in relation to NAPL at the Site:

- No observations of NAPL were made within the soils observed during drilling;
- No concentrations of Total Petroleum Hydrocarbons in excess of 5,000 mg/kg were recorded;
- No NAPL was measured during groundwater monitoring works.

On this basis, there is no evidence of NAPL being present on the Site.

6.3 Controlled Waters/Water Environment GQRA

The approach adopted to assessing risks to Controlled Waters/Water Environment is based principally on considering the concentrations of contaminants identified within the groundwater samples obtained in comparison to relevant GAC.

Given the 'prevent and limit' approach of the Water Framework Directive (2000/60/EC) and the identified receptors, a range of Water Quality Standards (WQS) have been applied as Generic Assessment Criteria (GAC), these include Water Framework Directive standards and thresholds (WFD), the Freshwater Environmental Quality Standards (EQS), the UK Drinking Water Quality Standards (DWQS), WHO Guidelines for Drinking Water Quality or SEPA resource protection values which have been used as initial conservative GAC to assess whether groundwater contamination requires further assessment or discussion in terms of the risks to controlled waters. Where specific water quality standards are not available, Delta-Simons has adopted surrogate values based on professional judgement (DS GAC).

6.3.1 Groundwater Results

The Site is not located within a Source Protection Zone and there are no licensed groundwater abstractions within 1 km of the Site. The results of groundwater analysis have been compared to the GACs for the protection of drinking water. Sulphates (as SO4) was the only determinand that exceeded the applied GAC, of which the results are summarised in the table below.

Contaminant	Max Conc. (µg/l)	GAC (µg/l)	GAC Source	No. Exceed GAC / No. of samples	Location of Exceedances
Sulphate					
Sulphate as SO4	278,000	250,000	DWQS 2016	1/3	RO2
Notes: DWQS 2016 – The Water Supply (Water Quality) Regulations 2016 [UK Drinking Water Standards]					

6.3.2 Groundwater Results Summary

The majority of determinands tested for were below the relevant screening criteria, protective of drinking water.

Concentrations of sulphate as SO4 were found to exceed the screening criteria protective of groundwater receptors in one sampled location. However, it is considered that the drinking water standard is overly conservative for the Site considering it is not within an SPZ or within 1km of a potable abstraction.

6.4 Built Environment

6.4.1 Potable Water Supply Pipes

The investigation requirements for the selection of potable water pipe material are set out in UKWIR Report 10/WM/03/21. Guidance for the Selection of Water Supply Pipes to be used in Brownfield Sites (UKWIR, 2010). This Report has very specific and onerous investigation requirements and as such the detailed investigation of each utility route was not within the scope of this investigation. The relevant water supply company needs be contacted at an early stage to confirm its requirements for assessment, which may not necessarily be the same as those recommended by UKWIR.

6.5 Waste Management

In recent years a number of mechanisms have aimed to change the way in which waste materials have traditionally been managed (*i.e.* a move away from less sustainable options such as landfill disposal). These include:

- Legislation and guidance (e.g. the Waste Framework Directive [2008, as amended]; the Waste [England and Wales] Regulations, 2011; the Definition of Waste: Development Industry Code of Practice, Version 2 [DoWCoP; CL:AIRE, 2011]).
- Fiscal drivers (e.g. the landfill tax escalator).
- Corporate responsibility campaigns (e.g. WRAP: Halving waste to landfill & Quality Protocol projects; Ellen Macarthur Foundation).

There is now a greater focus on waste re-use, treatment and recovery as organisations try and move their waste materials up the Waste Hierarchy and move to more circular models of material supply and re-use.

In accordance with current industry best practice, guidance and legislation Delta-Simons would always recommend options including managing materials on site through the DoWCoP, waste treatment and waste recovery be considered ahead of landfill disposal. Landfill disposal should be seen as an option of last resort given that in terms of cost, environment and social outcomes it is less sustainable. However, the availability of alternatives to landfill disposal depends on the timescales of the project, proactive involvement of qualified advisors and the nature and status of the materials being considered.

6.6 Waste Classification

In general, the predominant waste material encountered during the construction phase of development schemes will likely be construction and demolition waste, predominantly waste soils and crushed demolition arisings. These may be found *in situ* in the ground or stockpiled on sites and they may be contaminated which may have implications for their classification and subsequent management.

This investigation was not undertaken to advise on the classification or potential management routes for such waste materials. Classification and management of these types of wastes either on to site, off site or within the development are likely to require further investigation and assessment. The extent of such work will depend on the particular management option that is being considered and could, for example, involve the use of waste acceptance criteria analyses.

7.0 Bulk Ground Gas Risk Assessment

7.1 Ground Gas Conceptual Site Model

7.1.1 Sources

The following potential sources of ground gas have been identified:

- Potentially significant thicknesses of Made Ground, recorded to a maximum depth of 4.50 m bgl, where total organic carbon (TOC) ranged from 0.6 to 2.7 % in the ten tested Made Ground samples.

7.1.2 Pathways

- Vertical and lateral migration of ground gas through permeable strata;
- Potential for gases to enter current and future buildings through voids in the floor including service entry points and cracks and accumulate in confined spaces; and,
- Future maintenance/construction workers may come into contact with hazardous ground gases via entry into below ground confined spaces such as excavations or service entries/inspection points.

7.1.3 Receptors

The principal receptors under consideration are future Site users and construction workers.

7.2 Duration & Extent of Monitoring

Tables 5.5a and 5.5b within CIRIA C665 detail current recommended monitoring duration and frequency for sites in the UK. Based on the identification of potential sources, the gas generation potential is considered to be very low, whilst the sensitivity of the proposed development is low (commercial). On this basis, CIRIA C665 recommends between three and four visits over a minimum period of one month.

Gas monitoring has been carried out upon the Site on three occasions for an assessment of the ground gas regime.

Barometric pressures during the gas monitoring period ranged from 999 mBar to 1019 mBar, of which one visit was completed during a period of falling pressure.

7.3 Ground Gas Risk Assessment

7.3.1 Background

Based on the proposed commercial end use, the following documents have been consulted when assessing the gas regime at the Site:

- CIRIA C665 (2007), Assessing risks posed by hazardous ground gases to buildings.
- British Standards Institute (BSI, 2019): Code of practice for the design of protective measures for methane and carbon dioxide ground gases for new buildings, BS:8485:2015+A1:2019.

The presence of a source of hazardous gas within the ground does not necessarily indicate a risk will be present. Consideration of recorded gas flows together with source concentrations can allow an initial assessment to be made of the potential both for generation and subsequent migration of gas. A Characteristic Situation (CS) is derived from an assessment of the ground gas data and forms the basis of determining mitigation measures.

7.3.2 Gas Screening Value (GSV)

The Gas Screening Value (gas concentration as a fraction x maximum recorded flow) is used to provide an initial assessment of risks to future Site users. The GSVs calculated for the monitoring wells are presented in the following table.

Location	Maximum Steady Methane (%v/v)	Maximum Steady Carbon Dioxide (%v/v)	Maximum Steady Flow Rate (l/hr)	GSV/Classification				Flooded?
				Methane		Carbon Dioxide		
				GSV	Classification	GSV	Classification	
RO1	<0.1	4.1	<0.1	0.0001	1	0.0041	1	N
RO2	<0.1	3.0	<0.1	0.0001	1	0.0030	1	N
RO3	<0.1	2.5	<0.1	0.0001	1	0.0025	1	N
DS1	<0.1	4.1	<0.1	0.0001	1	0.0041	1	N
DS2	<0.1	0.9	<0.1	0.0001	1	0.0009	1	N
DS3	0.1	4.0	<0.1	0.0001	1	0.0040	1	N
DS4	<0.1	4.3	<0.1	0.0001	1	0.0043	1	N
DS5	<0.1	0.2	<0.1	0.0001	1	0.0002	1	N
DS6	<0.1	0.4	<0.1	0.0001	1	0.0004	1	N
DS7	<0.1	<0.1	<0.1	0.0001	1	0.0001	1	N

The data indicates that the Site can be classified as CS1 (very low hazard potential) in accordance with BS 8485:2015 Table 2. The GSV for the site-wide worst-case flow rate and ground gas concentration (either CO_2 or CO_4) has also been assessed which also indicates that the Site may be classified as CS1.

Based on the results of the preliminary assessment, further ground gas monitoring is not considered to be required.

7.4 Ground Gas Risk Mitigation

The ground gas regime at the Site has been classified as CS1 in accordance with the CIRIA guidance and it is recommended that a CS1 situation is assumed for design purposes.

As such no ground gas measures are considered to be required in the new development.

7.5 Radon

A detailed radon assessment falls outside of the scope of this Report. Data based on UK Health Security Agency guidance, available throughukradon.org.uk, indicates that the Site is located within an area where radon protection measures are not required. However it cannot be precluded that further assessment might be required by the Local Authority.

7.6 Organic Vapours

No sources of volatile vapours have been identified as part of the ground investigation.

8.0 Revised Conceptual Site Model

A CSM is presented in the table below, and has been formulated taking into account all of the available data from the Delta-Simons intrusive investigation, suitable for a site with a proposed commercial end use.

Revised Conceptual Site Model				
Source	**Pathways**	**Receptors**	**Pollutant Linkage?**	**Discussion and Mitigation**
Made Ground deposits	Direct contact, ingestion and/or inhalation of soil/dust	Human health – future Site users	No	Marginal exceedances with respect to the applied commercial GAC for three determinands of Polycyclic Aromatic Hydrocarbons were noted in one location in the north of the Site at the location of the former historical works. The remainder of the analysed contaminant concentrations were not reported to exceed the adopted screening criteria. In addition, the current proposed development will utilise hardstanding across the Site, breaking pollutant linkages. As such, it is considered reasonable to discount the on-Site soils from presenting a significant risk of harm to the health of future Site users.
		Human health – construction workers	No	Short term risk would be mitigated by use of Personal Protective Equipment (PPE) and provision of suitable hygiene/welfare practices and facilities. Groundworkers and sub-surface maintenance workers should be made aware of the possibility of encountering contaminated soils through toolbox talks and in particular the potential presence of asbestos.
	Migration of contaminants into groundwater	Secondary Undifferentiated (Devensian Till) and Principal (Sherwood Sandstone) Aquifers	No	The Site is considered low sensitivity for controlled water receptors and a plausible contaminant pathway is considered unlikely. In the context of the Site setting, it is considered reasonable to discount groundwater at the Site from presenting a significant risk of harm to controlled waters.
	Migration of contaminants into surface waters	The River Medlock (600 m north of the Site)		No elevated concentrations of contaminants were identified in groundwater. It is considered that the groundwater encountered in the Chester Formation reflects general groundwater concentrations in the local area. In addition, groundwater in the area is considered unlikely to represent a significant groundwater resource. As such, a significant risk is not thought to be posed to surface water receptors.

Revised Conceptual Site Model				
Source	**Pathways**	**Receptors**	**Pollutant Linkage?**	**Discussion and Mitigation**
Organic contamination in soils and groundwater	Direct infiltration in water supply pipes	Drinking water supply pipes	Yes	Hydrocarbons, especially aromatics, are known to permeate plastic pipes. Assessment of the risk to water pipes for any new supply will have to be undertaken as a requirement of the statutory undertakers, who should be provided with a copy of this assessment and provide recommendations for upgrading of potable water supply pipes. It is recommended that the Local Water Authority is contacted prior to development to confirm if further assessment is required in relation to water supply pipes, and confirm the required pipeline material.

9.0 Conclusions & Recommendations

9.1 Ground Model Summary

The current ground investigation recorded a mixture of hardstanding soft landscaped across the Site. Potentially significant thicknesses of Made Ground was also encountered Site wide, recorded to a maximum depth of 4.50 m bgl. The Made Ground soils predominantly comprised gravel material where anthropogenic materials included red brick, concrete, plastic, glass and rare asbestos fragments (in RO2). A significant quantity of larger sized particles (boulders and cobbles) of red bricks and concrete was also encountered in the hand pits during the investigation.

Devensian Till was encountered beneath the base of the Made Ground and was recovered as either clay or sand and gravel.

The Chester Formation was encountered in all locations across the Site and can be generally separated into a weathered and non-weathered zone. The weathered zone of the Chester Formation was encountered to maximum depth of 10.50 m bgl. Beyond this, competent bedrock was encountered at a shallowest depth of 9.70 m bgl and recovered to a maximum depth of 20.50 m bgl. The strength profile of the competent Chester Formation generally ranged from very weak (at its shallowest), to moderately strong at the base of the borehole.

9.2 Geotechnical Summary

A piled foundation solution using traditional bored or continuous flight auger (CFA) piles transferring loads to competent geology is the preferable solution for the proposed development given the anticipated design loads. Piles will utilise both skin friction and end bearing capacity. The precise method of pile installation and applicability of proprietary systems, diameters and depths required would need to be informed based on the results of this investigation, by discussions with a piling contractor with suitable experience, whose design should be warranted.

The upper horizons of the Chester Formation were characterised by heavily weathered sandstone recovered as gravelly medium grained sand and should be treated as a granular soil as a conservative measure during a piling assessment. It may be prudent to advance pile groups to c. 15 m bgl, approximately 5 m into the more competent Chester Formation. Preliminary working loads have been provided for at these depths. With 0.3 m diameter piles, loads up to 935 kN may be achieved across most of the Site. However, it is noted that in areas of deep Made Ground (e.g. around RO2 where Made Ground is significantly thicker) an alternate design may be required due to the effects of negative skin friction in the Made Ground.

It is recommended that during demolition of the building, all relict basements, foundations, and other obstructions are removed to avoid in-ground obstructions during piling.

It is understood that the movement of Made Ground soils is likely necessary to achieve the proposed FFL of 38.6 m AOD. Should the re-use of materials on-Site be required and where the material is chemically and geotechnically suitable for its proposed end location, material re-use should be undertaken under a Materials Management Plan.

Consideration should be given to the likelihood of encountering larger boulders and or cobbles of brick/concrete in the Made Ground.

9.3 Contamination Summary

The investigation has been carried out in order to provide information on the quality of the soil and groundwater beneath the Site in the context of land contamination and provide information on the ground gas regime beneath the Site for a commercial end use. The assessment is being completed prior to the proposed redevelopment of the Site.

Data gaps and uncertainties remain as outlined within Section 1.7.

9.3.1 Human Health

Localised marginal soil contamination with respect to Polycyclic Aromatic Hydrocarbons has been identified in one location in the north of the Site in the vicinity of the former works, however, it is considered that the proposed placement of hardstanding within this area during development will suitably break the pathway to future Site users. The majority of the remaining tested contaminants across the Site did not exceed their laboratory limit of detections and as such it is considered reasonable to discount the on-Site soils from presenting a widespread risk of harm to the health of future Site users.

Soil bound asbestos was identified in three locations (DS5, DS6 and RO3) within the shallow Made Ground spoil, as well as bulk samples retrieved for laboratory analysis in the hand pit of RO2.

Unrecorded asbestos containing materials (ACM) is likely to be present in across the remainder of the Site, pertaining to the previous phases of demolition during the 1900s. ACMs may also be present within the buildings currently on-Site. Groundworkers and sub-surface maintenance workers should be made aware of the possibility of encountering contaminated soils through toolbox talks and in particular the potential presence of asbestos and an appropriate protocol to mitigate exposure of the workforce and general public should be in place. The Contractor will need to prepare a risk assessment which identifies a safe system of work to handle the asbestos containing soils which is likely to include asbestos awareness training, a protocol for unexpected finds (should gross asbestos material be identified) as well as safe working procedures such as damping down of excavations and stockpiles in line with general dust generation mitigation. The risk assessment will need to identify the appropriate levels of PPE and/or Respiration Protective Equipment (RPE) required. This recommendation should be captured in Site health and safety documentation and in maintenance plans.

9.3.2 Controlled Waters

No widespread contamination of groundwater was encountered during this investigation.

9.3.3 Ground Gas

The ground gas monitoring programme indicates the Site can be classified as CS1, where no ground gas protection measures are considered necessary for the proposed development.

9.3.4 Volatile Vapours

No potential sources of volatile contaminants have been identified.

9.3.5 Built Environment

The ground investigation was not designed to assess ground conditions in full accordance with the UKWIR guidance for water supply pipes. It is recommended that the Local Water Authority is contacted to confirm the most suitable water supply pipe material for the proposed development.

With respect to potentially aggressive ground chemistry, the results of the Made Ground soils indicate particularly high Total Sulphur and Water Soluble Sulphate in one location (RO2), and buried concrete is recommended to be designed to concrete design class AS-4 and ACEC-3. This is due to a high volume of concrete present in the Made Ground soils at RO2. The remainder of the Made Ground soils across the Site are not considered to have the potential to attack buried concrete with respect to elevated sulphates. Consideration should be given to the removal of concrete and / or larger fragments in the Made Ground soils prior to development.

Aggressive ground chemistry was not identified in the natural soils located beneath the Site (Devensian Till and Chester Formation). Should a deeper piled foundation solution be adopted, then buried concrete is recommended to be designed to concrete design class AS-1 and ACEC-1.

9.4 Recommendations

Based on the findings of this Report, the following recommendations for supplementary investigation / assessment are made:

- Foundations Works Risk Assessment during demolition of the on-Site buildings and / or trial pits to assess the current foundations of Elizabeth Yarwood Court and potential other obstructions across the Site; and
- Undertake a United Utilities Risk Assessment to confirm the water supply pipe material requirements for the new development.

The above recommendations may be achieved during a supplementary ground investigation at the Site. In addition:

- Given the absence of significant contamination present at the Site, preparation of a Remediation Strategy is not considered necessary. However, given the presence of asbestos in the Made Ground soils, an appropriate 'hotspot' protocol and / or watching brief should be implemented for future groundworkers to act upon should such contamination be identified during the construction process; and,
- Plate CBRs are also recommended following any minor cut and fill operations and the emplacement of imported granular fill, thus, verifying CBR performance has been achieved prior to placement of sub-base.

The following recommendations for the development of the Site are made:

- Waste classification has not been undertaken as part of the scope of works; should it be proposed to dispose of materials from the Site then specific additional investigations may be needed to classify the materials in accordance with current regulatory requirements;
- An asbestos survey should be undertaken prior to demolition by a specialist contractor and removed in accordance with legislation to prevent further contamination of the ground;
- Groundworkers and sub-surface maintenance workers should be made aware of the possibility of encountering contaminated soils through toolbox talks and in particular the potential presence of asbestos and an appropriate protocol and risk assessments to mitigate exposure of the workforce and general public should be in place. Good standards of personal hygiene should be observed, and appropriate levels of PPE / RPE utilised where necessary;
- Unidentified localised areas of contamination may exist at the Site and an appropriate 'hotspot' protocol and / or watching brief should be in place for groundworkers to act upon should such contamination be identified during the construction process;
- Appropriate UXO support in line with Impartial Assessment's recommendations;
- Suitable dust suppression techniques and prevention of nuisance/environmental impacts will need to be implemented by the groundworkers during construction works; and,
- The re-use of materials on-Site may be possible if required and where the material is chemically and geotechnically suitable for its proposed end location. Material re-use would need to be undertaken under a Materials Management Plan.

Drawings

Drawing 1 – General Arrangement – Sci-tech Building Ground Floor Plan (Drawing No.: UBS-SRA-ST-00-DR-A-02-500) dated 6th June 2023



A1

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KEY

- Reception/Amenity
- Cafe
- Office/Lab
- Cycle Store
- FM Spaces
- BOH/Bin Store/Core
- Circulation

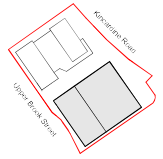
Legend

- Planning Application Boundary

REV.	DATE	AMENDMENT
P01	06.06.2023	Issued for Planning

0 2 4 6 8 10 m

KEYPLAN



Client

McLAREN PROPERTY KADANS Science Partner

SHEPPARD ROBSON
77 Parkway Camden Town London NW1 7PU
T: +44 (0)20 7504 1700 E: enquiries@sheppardrobson.com

PROJECT
Phase One, Upper Brook Street Masterplan

SCALE@A1	DATE	ORIGINATOR	CHECKED	AUTHORISED
1 : 200	06.06.2023	PC	JW	ES

General Arrangement - Sci-Tech Building Ground Floor Plan

Stage 2

STATUS	PURPOSE FOR ISSUE	SR NO.
S2	Planning	7025

DRAWING NO. — REV.
UBS - SRA - ST - 00 - DR - A - 02-500 — P01

Drawing 2 – Site Elevation Proposed – Cottenham Street: South East (Drawing No.: UBS-SRA-ZZ-EE-DR-A-02-308) dated 6th June 2023

A1

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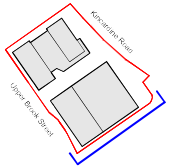
KEY

1. Double Glazed Curtain Wall and Back Painted Glass Insulated Spandrel Panel
2. Anodized Aluminium Cladding with Precast Concrete Plinth
3. Anodized Aluminium Panels Outward Profile. Textured Spandrel Panel. Double Glazing
4. Anodized Aluminium Panels Inward Profile. Textured Spandrel Panel. Double Glazing
5. Anodized Aluminium Panels Outward Profile. Textured Spandrel Panel. Double Glazing: Fritted/ Back-painted/ Split
6. Anodised Aluminium Rainscreen Cladding
7. Atrium Overrun: Double Glazed Curtain Wall
8. Perforated Aluminium Metal Screen
9. Anodized Aluminium Panels open, inset Perforated Metal Screen
10. Precast Cladding to Columns
11. Anodized Aluminium Louvres
12. Red Coloured Brick – Stretcher Bond
13. Red Coloured Brick – Soldier Course
14. Buff Coloured Brick – Stretcher Bond
15. Buff Coloured Brick – Soldier Course
16. Anodized Aluminium Window System: Bronze Coloured Anodized Aluminium Window Frame. Glass Upper Panel and Back Painted Glass Insulated Lower Panel
17. Anodized Aluminium Window System: Bronze Coloured Anodized Aluminium Window Frame and Glass Panel
18. Bronze Coloured Anodized Aluminium Decorative Perforated Panel
19. Bronze Aluminium Louvres [at high level]
20. Curtain Wall: Bronze Coloured Anodized Aluminium Frame and Glass Panel
21. Curtain Wall: Bronze Coloured Anodized Aluminium Frame and Bronze Coloured Back Painted Glass Insulated Panel
22. Bronze Coloured Aluminium Insulated Panel [behind railing]
23. Metal Rail Balustrade
24. Aluminium Louvred Door
25. Bronze Aluminium Cladding [at high level]

REV.	DATE	AMENDMENT
P01	06/06/2023	Issued For 'Planning'

0 2.5 5 7.5 10 12.5 m

KEYPLAN



CLIENT

McLAREN PROPERTY
KADANS Science Partner

SHEPPARD ROBSON
77 Parkway Camden Town London NW1 7PU
T: +44 (0)20 7504 1700 E: enquiries@sheppardrobson.com

PROJECT
Upper Brook Street Masterplan - McLaren/Kadans

SCALE@A1	DATE	ORIGINATOR	CHECKED	AUTHORISED
1 : 250	06/06/2023	SN	MV	RG

Site Elevation Proposed - Cottenham Street: South East

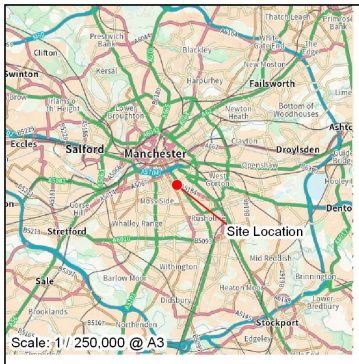
Stage 2

STATUS	PURPOSE FOR ISSUE	SR NO.
S2	Planning	6601_7025

DRAWING NO. REV.
UBS -SRA-ZZ-EE-DR-A-02-308 P01

Figures

Figure 1 – Site Location Map



Site Boundary

0 200 400 600 800 1,000 1,200 1,400 m

DO NOT SCALE. NOT FOR CONSTRUCTION

N

Figure: Site Location Map		
Job: Upper Brook Street		
Client: HDR Inc.		
Figure No.: 1	Revision: 1	Date: 11 December 2023
Drawn by: TB	Checked by: MB	Scale: 1:10,000
Job No.: 101718.591891		

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Figure 2 – Exploratory Hole Location Plan



Legend

Site Boundary

Exploratory Hole Locations

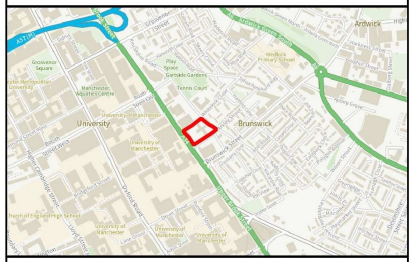
DS - Dynamic Sampling

R - Rotary

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N

Figure: Exploratory Hole Location Plan		
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Client: HDR Inc.		
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Drawn by: TB	Checked by: MB	Scale: 1:400
Job No.: 101718.591891		



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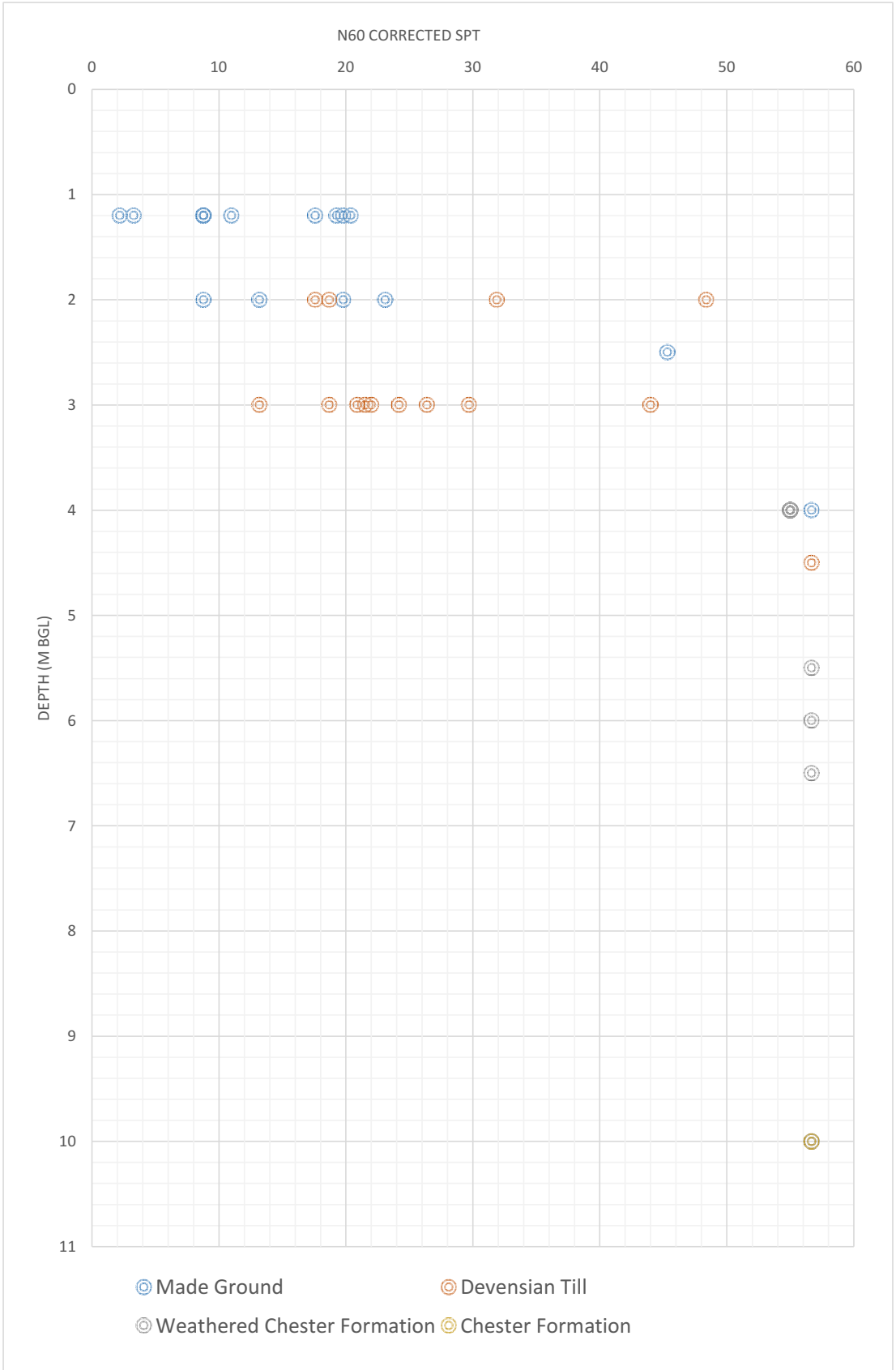
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Figure 3a – Correct SPT vs Depth Plot (m bgl)



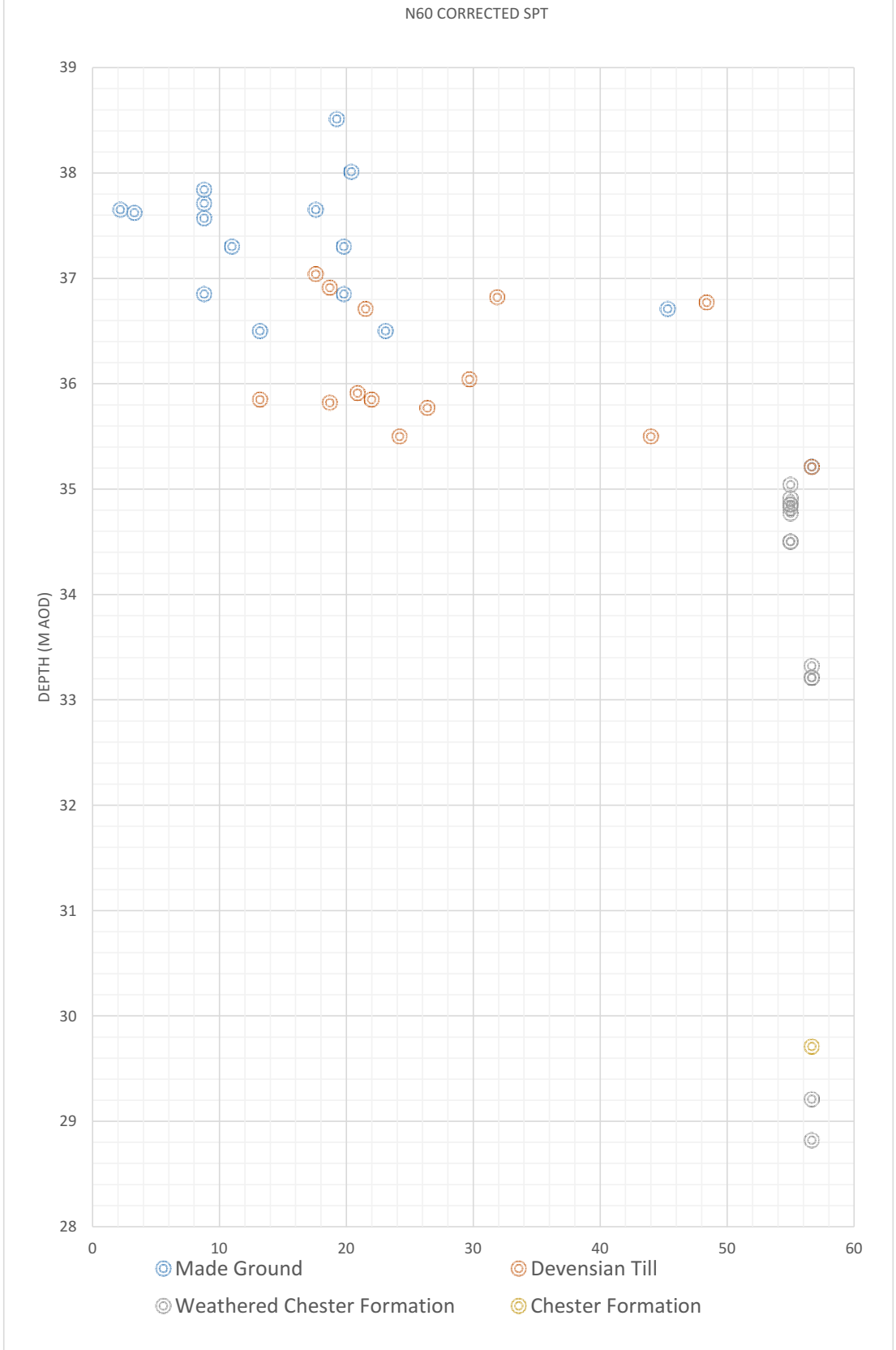
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TITLE:

N60 Corrected SPT Plot
Upper Brook Street
(m bgl)

DWN:	PROJECT NO.:
TB	591891
DATE:	Figure:
Jan-24	3a

Figure 3b – Correct SPT vs Depth Plot (m AOD)



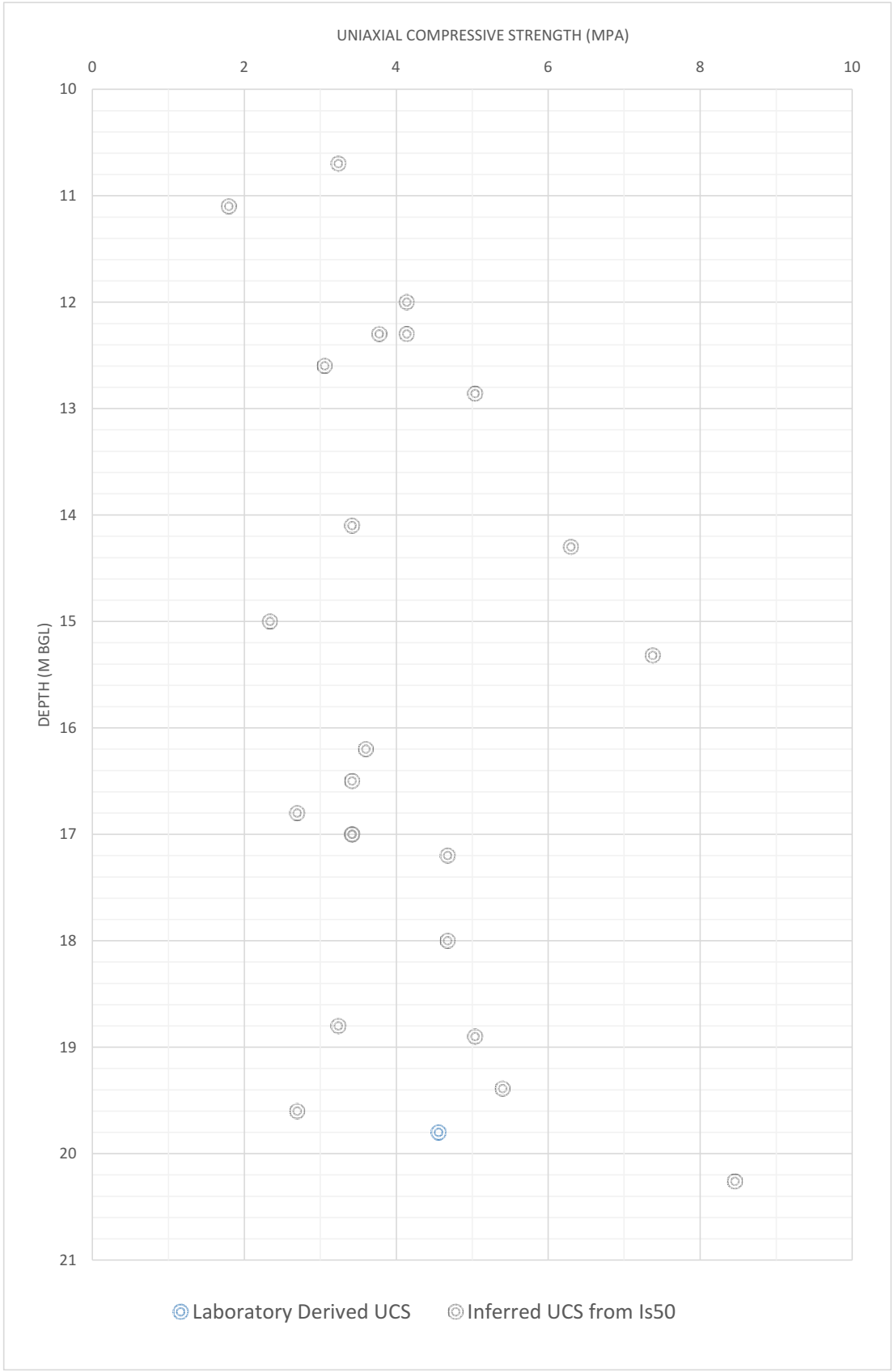
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TITLE:

N60 Corrected SPT Plot
Upper Brook Street
(m AOD)

DWN:	PROJECT NO.:
TB	591891
DATE:	Figure:
Jan-24	3b

Figure 4a – Uniaxial Compressive Strength vs Depth Plot (m bgl)



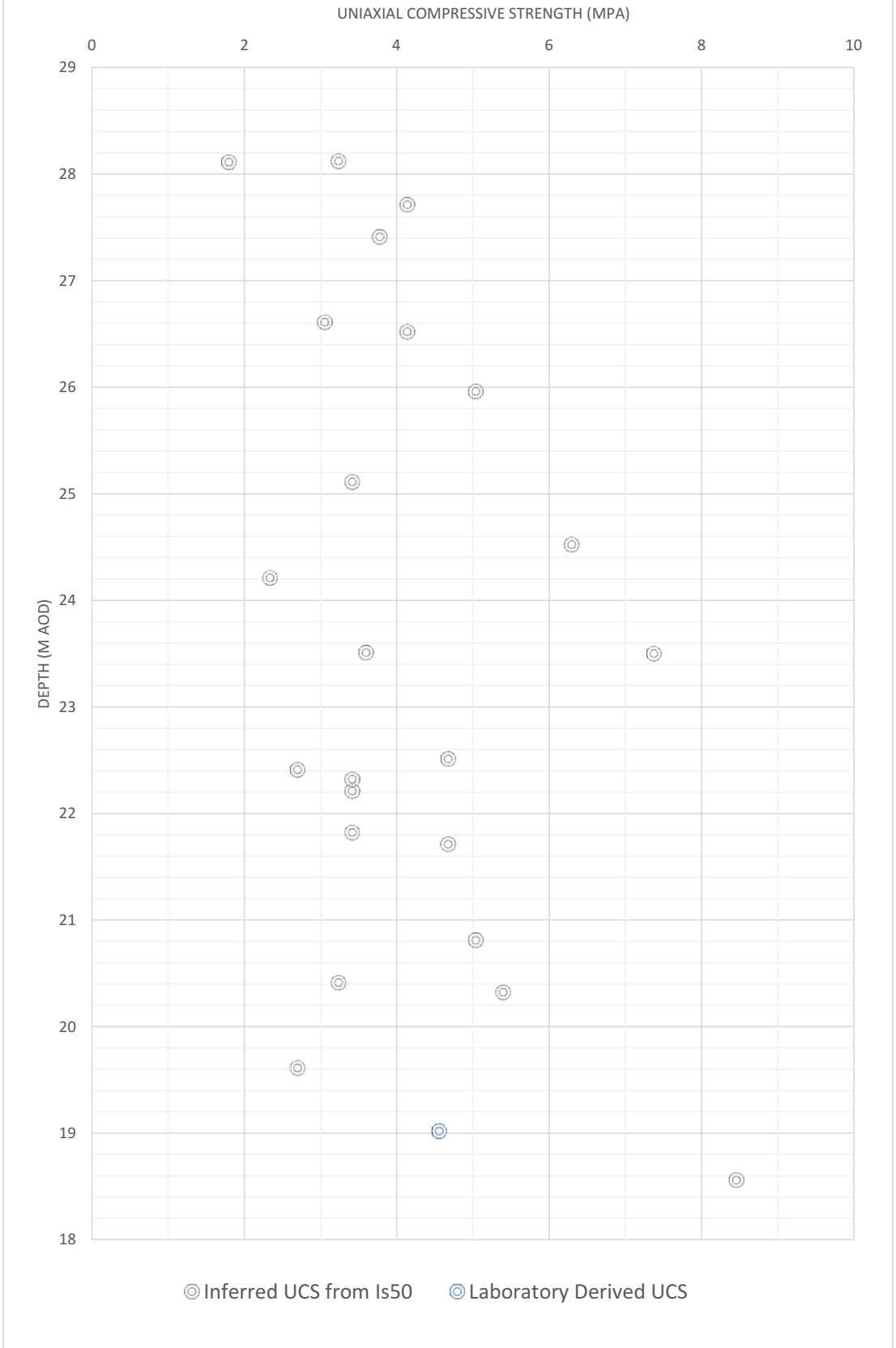
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TITLE:

Uniaxial Compressive Strength vs Depth Plot
Upper Brook Street
(m bgl)

DWN:	PROJECT NO.:
TB	591891
DATE:	Figure:
Jan-24	4a

Figure 4b – Uniaxial Compressive Strength vs Depth Plot (m AOD)



DeltaSimons

TITLE:

Uniaxial Compressive Strength vs Depth Plot
Upper Brook Street
(m AOD)

DWN:	PROJECT NO.:
TB	591891
DATE:	Figure:
Jan-24	4b

Appendices

Appendix A – Limitations

Limitations

This Report was prepared by Delta-Simons Ltd (Delta-Simons) for the sole and exclusive use of the Client and for the specific purpose for which Delta-Simons was instructed. Nothing contained in this Report shall be construed to give any rights or benefits to anyone other than the Client and Delta-Simons, and all duties and responsibilities undertaken are for the sole and exclusive benefit of the Client and not for the benefit of any other party. Delta-Simons does not intend, without its written consent through a formal letter of reliance or warranty, for this Report to be disseminated to any party other than the named Client or to be used or relied upon by any party other than the named Client. Use of the Report by any other party is unauthorised and such use is at the sole risk of the user. Any party using or relying upon this Report, other than the Client, agrees by virtue of its use to indemnify and hold harmless Delta-Simons from and against all claims, losses and damages (of whatsoever nature and howsoever or whensoever arising), arising out of or resulting from the performance of the work by Delta-Simons. Unless explicitly agreed otherwise, in writing, this Report has been prepared under Delta-Simons' Standard Terms and Conditions as included within our proposal to the Client.

The recommendations contained within this Report represent Delta-Simons professional opinions, based upon the information detailed within the Report, exercising the reasonable skill and care to be expected of a professional consultant holding itself out as having the competence, experience and resources necessary for the purpose of carrying out similar work in scope and character to the services performed. The Report needs to be considered in the light of the proposal and associated limitations of scope. The Report needs to be read and considered in full and isolated sections cannot be used without full reference to other elements of the Report and any previous works referenced within the Report.

Where Delta-Simons has obtained, reviewed and evaluated information in preparing this Report from the Client and others and Delta-Simons conclusions, opinions and recommendations has been reasonably determined using this information, Delta-Simons does not warrant the accuracy of the third-party information provided to it and cannot be responsible for any opinions which Delta-Simons has expressed, or conclusions which it has reached in reliance upon information which is subsequently proven to be inaccurate.

Site surveys document the conditions encountered at the time of survey only and conditions may change due to natural processes or human intervention. As such, surveys represent an assessment at a specific point in time and Delta-Simons cannot be responsible for adverse conditions which arise or become apparent after the time of the survey or for conditions which sit outside the scope for which the survey or Report was commissioned.

Where intrusive investigations have been completed, information, comments and opinions given in this Report are based on the ground conditions encountered during the site work period and on the results of laboratory and field tests performed during the investigation. Ground conditions are inherently variable such that no investigation can be exhaustive to the extent that all adverse conditions are revealed. Conditions may therefore be present beneath the site that were not apparent in the data reviewed or obtained as part of this assessment. It should be noted that groundwater levels vary due to seasonal and other effects and may at times differ to those measured during the investigation. Delta-Simons does not warrant or guarantee that the Site is free of hazardous or potentially hazardous materials or conditions. Where risk assessment is undertaken, this is based upon the standards, guidance and common practice at the time of the assessment and Delta-Simons cannot be responsible for conditions which become apparent following changes in guidance or practice or advancements in scientific knowledge which change the position in relation to assessment of risk.

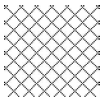
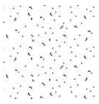
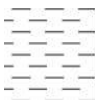
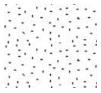
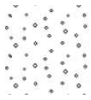
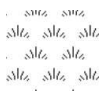
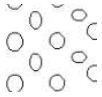
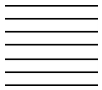
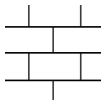
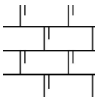
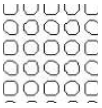
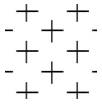
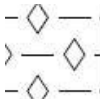
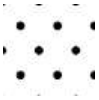
No aspect of this Report constitutes a design. Where this information is used in design, the designer should verify the information has been used appropriately.

Where budgets are prepared and presented within the Report, these are for information only to indicate the likely magnitude of a cost and do not represent an invitation to treat for the works. All budgets and programmes presented should be reviewed and verified by appropriately qualified and experienced independent Project Managers and Cost Consultants.

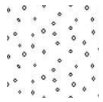
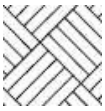
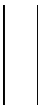
Appendix B – Borehole Logs and SPT Calibrations Certificate

KEY TO BOREHOLE AND TRIAL PIT LOGS

MATERIAL LEGENDS

	Topsoil		Made Ground		Bituminous Material
	Concrete		Clay		Silt
	Sand		Gravel		Peat
	Cobbles		Boulders		Mudstone
	Siltstone		Sandstone		Limestone
	Chalk		Coal		Breccia
	Conglomerate		Igneous		Metamorphic
	Pyroclastic (volcanic ash)		Gypsum		Shale
	Ironstone		Bedrock (Unidentified)		Void

INSTALLATION/BACKFILL LEGENDS

	Sand		Gravel		Bentonite/Grout
	Arisings		Concrete		Plain Pipe
	Slotted Pipe				

Legend symbols in general accordance with BS 5930:2015+A1:2020 and standard industry practice.

SAMPLE TYPES

ACM	Asbestos Containing Material Sample
B	Bulk Disturbed Sample
BLK	Block Sample
C	Core Sample
CBR	Undisturbed Sample for California Bearing Ratio Test – 154mm diameter
D	Disturbed Sample - Tub
ES	Soil Sample for Environmental Testing
EW	Water Sample for Environmental Testing
G	Gas Sample
U	Undisturbed Driven Tube Sample – 70/102mm diameter, 450mm long
W	Water Sample

TEST TYPES

CPT	Cone Penetrometer Test (kN/m^2)
FID	Flame Ionisation Detector Test (ppm)
HV	In-Situ Hand Shear Vane Test (kN/m^2)
PID	Photoionisation Detector Test (ppm)
SPT (S)	Standard Penetration Test – Split Spoon Sampler
SPT (C)	Standard Penetration Test – Solid 60 Degree Cone

CORE DETAILS

If	Fracture Spacing (mm) – Minimum, Average, Maximum
NI	Non-Intact where >25 fracture spacings per metre
TCR	Total Core Recovery (%)
SCR	Solid Core Recovery (%)
RQD	Rock Quality Designation (%)
AF	Air Flush Return (%)
WF	Water Flush Return (%)
NIDD	Non-Intact - Drilling Disturbed
AZCL	Assessed Zone of Core Loss

WATER COLUMN DETAILS

	Water Strike
	Water Level

DeltaSimons
Head Office
3 Henley Way, Doddington Road
Lincoln, LN6 3QR
Tel: +44 (0) 1522 882555
Email: info@deltasimons.com

Project No: 101718.591891 | Hole ID: DS1 | Page: 1 of 1

Project: Upper Brook Street

Dynamic Sampler Log

Date: 01/12/2023 | Client: HDR Inc.

Description of Strata	Legend	Strata Depth (m bgl)	Strata Thickness (m)	Reduced Level (mAOD)	Casing Diameter (mm)	Water	Sample Details: Depth (m)	Sample Details: Type	Sample Details: Ref	Test Details: Depth (m)	Test Details: Results	Backfill
MADE GROUND: Black macadam.		0.08		38.42								
MADE GROUND: Brownish grey very sandy fine to coarse angular to subangular GRAVEL of roadstone, concrete and sandstone. Sand is fine to coarse.		0.52	(0.44)	37.98								
MADE GROUND: Multicoloured sandy very clayey angular to rounded fine to coarse GRAVEL of red brick, concrete and sandstone with rare glass, tile and ceramic and with medium angular cobble content of red brick. Sand is fine to coarse. *Black textile membrane at 0.52 m bgl.*							0.60 - 1.00	ES	1	0.60	PID=0.0ppmv	
										1.20	SPT(C) N=10 (3,4/4,2,2,2)	
			(2.43)				2.00 - 2.50	ES	2	2.00	SPT(C) N=12 (3,4/4,4,2,2)	
										2.00	PID=0.0ppmv	
		2.95		35.55								
Brown and greyish brown SAND and GRAVEL. Sand is fine to coarse. Gravel is angular to rounded fine to coarse of sandstone, siltstone, mudstone and quartz. (DEVENSIAN TILL)			(0.60)							3.00	SPT(C) N=40 (6,8/8,10,12,10)	
		3.55		34.95								
Brownish red slightly clayey fine to coarse SAND. (WEATHERED CHESTER FORMATION)			(0.45)				3.60 - 4.00	D	1			
		4.00		34.50						4.00	SPT(C) 50 (25 for 105mm/50 for 85mm)	
Borehole complete at 4.00 m bgl.												

Remarks:

1. Logged in general accordance with BS5930:2015+A1:2020. Consistency is based on finger test as defined by BS EN ISO 14688-1:2002 where applicable.
2. Borehole cleared for services prior to excavating a hand dug inspection pit to 1.2 m bgl.
3. Elevation and location data obtained from third-party survey.
4. SPT Hammer ID DART380 (Energy Ratio= 66 %).
5. Borehole was installed with a combined groundwater and ground gas monitoring standpipe.

Water Level Observations

Date	Depth Strike (m)	Duration (min)	Standing (m)

Coordinates:	Elevation (mAOD):	Drilled By:	Plant Used:	Logged:	Checked:	Approved:	Scale:
E384805.47 N396849.83	38.50	VC Drilling Ltd.	Archway Dart	TB	RD	MB	1:40

DeltaSimons
Head Office
3 Henley Way, Doddington Road
Lincoln, LN6 3QR
Tel: +44 (0) 1522 882555
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Project No: 101718.591891 | Hole ID: DS2 | Page: 1 of 1

Project: Upper Brook Street

Dynamic Sampler Log

Date: 01/12/2023 | Client: HDR Inc.

Description of Strata	Legend	Strata Depth (m bgl)	Strata Thickness (m)	Reduced Level (mAOD)	Casing Diameter (mm)	Water	Sample Details: Depth (m)	Sample Details: Type	Sample Details: Ref	Test Details: Depth (m)	Test Details: Results	Backfill
MADE GROUND: Black macadam.		0.07		38.43								
MADE GROUND: Brownish grey very sandy fine to coarse angular to subangular GRAVEL of roadstone, concrete and sandstone. Sand is fine to coarse.		0.49	(0.42)	38.01			0.50 - 1.00	ES	1	0.50	PID=0.0ppmv	
MADE GROUND: Multicoloured sandy very clayey angular to rounded fine to coarse GRAVEL of red brick, concrete and sandstone with rare glass and medium angular cobble content of red brick with 5 cm pockets of stiff very gravelly clay. Sand is fine to coarse.		1.00	(0.51)	37.50			1.00 - 2.00	ES	2	1.00	PID=0.0ppmv	
Black textile membrane at 0.49 m bgl.										1.20	SPT(C) N=18 (4,4/6,4,4,4)	
MADE GROUND: Multicoloured very sandy angular to rounded fine to coarse GRAVEL of red brick, concrete and sandstone with rare glass, tile and ceramic and with medium angular cobble content of red brick. Sand is fine to coarse.		2.30	(1.30)	36.20						2.00	SPT(C) N=21 (6,6/5,6,5,5)	
Brown gravelly fine to coarse SAND. Gravel is angular to rounded fine to coarse of sandstone. (DEVENSIAN TILL)		3.00	(0.70)	35.50			2.50 - 3.00	D	1	3.00	SPT(C) N=22 (5,5/6,6,5,5)	
Brown and greyish brown SAND and GRAVEL. Sand is fine to coarse. Gravel is angular to rounded fine to coarse of sandstone, siltstone, mudstone and quartz. (DEVENSIAN TILL)		3.70	(0.70)	34.80								
Firm brown slightly gravelly sandy CLAY. Sand is fine to coarse. Gravel is angular to rounded fine to coarse of sandstone. (WEATHERED CHESTER FORMATION)		4.00	(0.30)	34.50						4.00	SPT(C) 50 (25 for 95mm/50 for 155mm)	
Borehole complete at 4.00 m bgl.												

Remarks:

1. Logged in general accordance with BS5930:2015+A1:2020. Consistency is based on finger test as defined by BS EN ISO 14688-1:2002 where applicable.
2. Borehole cleared for services prior to excavating a hand dug inspection pit to 1.2 m bgl.
3. Elevation and location data obtained from third-party survey.
4. SPT Hammer ID DART380 (Energy Ratio= 66 %).
5. Borehole was installed with a combined groundwater and ground gas monitoring standpipe.

Water Level Observations

Date	Depth Strike (m)	Duration (min)	Standing (m)

Coordinates:	Elevation (mAOD):	Drilled By:	Plant Used:	Logged:	Checked:	Approved:	Scale:
E384821.82 N396825.99	38.50	VC Drilling Ltd.	Archway Dart	TB	RD	MB	1:40

DeltaSimons
Head Office
3 Henley Way, Doddington Road
Lincoln, LN6 3QR
Tel: +44 (0) 1522 882555
Email: info@deltasimons.com

Project No:	Hole ID:	Page:
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Project: **Upper Brook Street**

Dynamic Sampler Log

Date: **30/11/2023**

Client: **HDR Inc.**

Description of Strata	Legend	Strata Depth (m bgl)	Strata Thickness (m)	Reduced Level (mAOD)	Casing Diameter (mm)	Water	Sample Details: Depth (m)	Sample Details: Type	Sample Details: Ref	Test Details: Depth (m)	Test Details: Results	Backfill
MADE GROUND: Grass over greyish brown slightly gravelly clayey fine to medium SAND with frequent fine roots. Gravel is angular to rounded fine to coarse of red brick fragments and sandstone. (TOPSOIL)		0.17	(0.17)	38.74								
MADE GROUND: Dark greyish brown sandy clayey angular to rounded fine to coarse GRAVEL of red brick, concrete and sandstone with glass, cloth and plastic with low to medium angular cobble content of red brick and sandstone. Sand is fine to coarse.		1.10	(0.93)	37.81			0.50 - 1.00	ES	1	0.50	PID=0.1ppmv	
MADE GROUND: Soft greyish brown slightly sandy gravelly CLAY. Sand is fine to coarse. Gravel is angular to rounded fine to coarse of mudstone with rare red brick fragments and coal.		1.30	(0.20)	37.61			1.10 - 1.30	ES	2	1.10	PID=0.0ppmv	
		1.95	(0.65)	36.96			1.40 - 1.80	D	1	1.20	SPT(C) N=8 (2,2/2,2,2,2)	
Soft brown slightly sandy gravelly CLAY. Sand is fine to coarse. Gravel is angular to rounded fine to coarse of sandstone, siltstone, mudstone and coal. (DEVENSIAN TILL)										2.00	SPT(C) N=17 (3,3/3,4,5,5)	
Brown and greyish brown slightly clayey SAND and GRAVEL. Sand is fine to coarse. Gravel is angular to rounded fine to coarse of sandstone, siltstone, mudstone and quartz. (DEVENSIAN TILL)		3.15	(1.20)	35.76			2.50 - 3.00	D	2			
Firm reddish brown slightly sandy gravelly CLAY. Sand is fine to coarse. Gravel is angular to rounded fine to coarse of mudstone and sandstone. (WEATHERED CHESTER FORMATION)		3.40	(0.25)	35.51						3.00	SPT(C) N=19 (7,6/6,4,5,4)	
Brownish red slightly clayey fine to medium SAND. (WEATHERED CHESTER FORMATION)		4.00	(0.60)	34.91			3.50 - 4.00	D	3			
Borehole complete at 4.00 m bgl.										4.00	SPT(C) N=50 (4,6/50 for 230mm)	

Remarks:

1. Logged in general accordance with BS5930:2015+A1:2020. Consistency is based on finger test as defined by BS EN ISO 14688-1:2002 where applicable.
2. Borehole cleared for services prior to excavating a hand dug inspection pit to 1.2 m bgl.
3. Elevation and location data obtained from third-party survey.
4. SPT Hammer ID DART380 (Energy Ratio= 66 %).
5. Borehole was installed with a combined groundwater and ground gas monitoring standpipe.

Water Level Observations

Date	Depth Strike (m)	Duration (min)	Standing (m)

Coordinates:	Elevation (mAOD):	Drilled By:	Plant Used:	Logged:	Checked:	Approved:	Scale:
E384843.74 N396839.36	38.91	VC Drilling Ltd.	Archway Dart	TB	RD	MB	1:40

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Head Office
3 Henley Way, Doddington Road
Lincoln, LN6 3QR
Tel: +44 (0) 1522 882555
Email: info@deltasimons.com

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Project: **Upper Brook Street**

Dynamic Sampler Log

Date: **01/12/2023**

Client: **HDR Inc.**

Description of Strata	Legend	Strata Depth (m bgl)	Strata Thickness (m)	Reduced Level (mAOD)	Casing Diameter (mm)	Water	Sample Details			Test Details		Backfill
							Depth (m)	Type	Ref	Depth (m)	Results	
MADE GROUND: Grass over greyish brown slightly gravelly clayey fine to medium SAND with frequent fine to medium roots. Gravel is angular to rounded fine to coarse of red brick fragments and sandstone. (TOPSOIL)		0.12	(0.12)	38.65								
		0.35	(0.23)	38.42								
MADE GROUND: Dark greyish brown sandy very clayey angular to rounded fine to coarse GRAVEL of sandstone and red brick fragments with rare glass. Sand is fine to coarse.		0.65	(0.30)	38.12			0.70 - 1.00	ES	1	0.70	PID=0.0ppmv	
MADE GROUND: Red and grey angular COBBLES of red bricks and concrete.		1.15	(0.50)	37.62			1.20 - 1.40	ES	2	1.20 1.20	SPT(C) N=8 (3,3/2,2,2,2) PID=0.0ppmv	
MADE GROUND: Multicoloured sandy very clayey angular to rounded fine to coarse GRAVEL of concrete and red brick fragments with rare glass and low to medium angular cobble content of red brick.		1.55	(0.40)	37.22								
MADE GROUND: Soft greyish brown slightly sandy gravelly CLAY. Sand is fine to coarse. Gravel is angular to rounded fine to coarse of mudstone with rare red brick fragments and coal.		1.80	(0.25)	36.97								
Soft brown slightly sandy gravelly CLAY. Sand is fine to coarse. Gravel is angular to rounded fine to coarse of sandstone, siltstone, mudstone and coal. (DEVENSIAN TILL)		2.20	(0.40)	36.57						2.00	SPT(C) N=44 (13,8/18,12,7,7)	
			(1.35)				2.20 - 2.40	D	1			
Brown gravelly fine to coarse SAND. Gravel is angular to rounded fine to coarse of sandstone and siltstone. (DEVENSIAN TILL)		3.55		35.22						3.00	SPT(C) N=24 (8,7/6,6,6,6)	
Brown and greyish brown slightly clayey SAND and GRAVEL. Sand is fine to coarse. Gravel is angular to rounded fine to coarse of sandstone, siltstone, mudstone and quartz. (DEVENSIAN TILL)		4.00	(0.45)	34.77			3.60 - 4.00	D	2	4.00	SPT(C) 50 (25 for 80mm/50 for 40mm)	
Brownish red clayey fine to medium SAND. (WEATHERED CHESTER FORMATION)												
Borehole complete at 4.00 m bgl.												

Remarks:

1. Logged in general accordance with BS5930:2015+A1:2020. Consistency is based on finger test as defined by BS EN ISO 14688-1:2002 where applicable.
2. Borehole cleared for services prior to excavating a hand dug inspection pit to 1.2 m bgl.
3. Elevation and location data obtained from third-party survey.
4. SPT Hammer ID DART380 (Energy Ratio= 66 %).
5. Borehole was installed with a combined groundwater and ground gas monitoring standpipe.

Water Level Observations

Date	Depth Strike (m)	Duration (min)	Standing (m)

Coordinates:	Elevation (mAOD):	Drilled By:	Plant Used:	Logged:	Checked:	Approved:	Scale:
E384838.48 N396862.26	38.77	VC Drilling Ltd.	Archway Dart	TB	RD	MB	1:40

DeltaSimons
Head Office
3 Henley Way, Doddington Road
Lincoln, LN6 3QR
Tel: +44 (0) 1522 882555
Email: info@deltasimons.com

Project No: 101718.591891 | Hole ID: DS5 | Page: 1 of 1

Project: Upper Brook Street

Dynamic Sampler Log

Date: 30/11/2023 | Client: HDR Inc.

Description of Strata	Legend	Strata Depth (m bgl)	Strata Thickness (m)	Reduced Level (mAOD)	Casing Diameter (mm)	Water	Sample Details: Depth (m)	Sample Details: Type	Sample Details: Ref	Test Details: Depth (m)	Test Details: Results	Backfill
MADE GROUND: Grass over greyish brown slightly gravelly clayey fine to medium SAND with frequent fine roots. Gravel is angular to rounded fine to coarse of red brick fragments and sandstone. (TOPSOIL)		0.12	(0.12)	38.73			0.20 - 0.40	ES	1	0.20	PID=0.0ppmv	
MADE GROUND: Dark greyish brown sandy clayey angular to rounded fine to coarse GRAVEL of red brick, concrete and sandstone with glass, cloth and plastic. Sand is fine to coarse.			(1.43)				1.00 - 1.20	ES	2	1.00	PID=0.0ppmv	
										1.20	SPT(C) N=16 (2,3/4,4,4,4)	
Pocket of firm dark brown CLAY from 1.44 to 1.55 m bgl.		1.55		37.30								
MADE GROUND: Black slightly sandy angular to subangular fine to coarse GRAVEL of concrete and red brick fragments. Sand is fine to coarse.		1.80	(0.25)	37.05			1.60 - 1.80	ES	3	1.60	PID=0.0ppmv	
MADE GROUND: Red and brown gravelly sandy angular COBBLES of red brick and concrete. Sand is fine to coarse. Gravel is angular to rounded fine to coarse of red brick fragments and concrete.			(1.10)							2.00	SPT(C) N=8 (1,2/2,2,2,2)	
		2.90		35.95								
Brown and greyish brown SAND and GRAVEL. Sand is fine to coarse. Gravel is angular to rounded fine to coarse of sandstone, siltstone, mudstone and quartz. (DEVENSIAN TILL)		3.40	(0.50)	35.45						3.00	SPT(C) N=12 (5,4/3,3,3,3)	
Soft to firm reddish brown slightly sandy gravelly CLAY. Sand is fine to coarse. Gravel is angular to rounded fine to coarse of mudstone and sandstone. (DEVENSIAN TILL)		3.90	(0.50)	34.95			3.50 - 3.80	D	1			
Brownish red fine to medium SAND. (WEATHERED CHESTER FORMATION)		4.00	(0.10)	34.85						4.00	SPT(C) 50 (25 for 115mm/50 for 105mm)	
Borehole complete at 4.00 m bgl.												

Remarks:

1. Logged in general accordance with BS5930:2015+A1:2020. Consistency is based on finger test as defined by BS EN ISO 14688-1:2002 where applicable.
2. Borehole cleared for services prior to excavating a hand dug inspection pit to 1.2 m bgl.
3. Elevation and location data obtained from third-party survey.
4. SPT Hammer ID DART380 (Energy Ratio= 66 %).
5. Borehole was installed with a combined groundwater and ground gas monitoring standpipe.

Water Level Observations

Date	Depth Strike (m)	Duration (min)	Standing (m)

Coordinates:	Elevation (mAOD):	Drilled By:	Plant Used:	Logged:	Checked:	Approved:	Scale:
E384869.68 N396827.42	38.85	VC Drilling Ltd.	Archway Dart	TB	RD	MB	1:40

DeltaSimons
Head Office
3 Henley Way, Doddington Road
Lincoln, LN6 3QR
Tel: +44 (0) 1522 882555
Email: info@deltasimons.com

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Project: **Upper Brook Street**

Dynamic Sampler Log

Date: **01/12/2023**

Client: **HDR Inc.**

Description of Strata	Legend	Strata Depth (m bgl)	Strata Thickness (m)	Reduced Level (mAOD)	Casing Diameter (mm)	Water	Sample Details: Depth (m)	Sample Details: Type	Sample Details: Ref	Test Details: Depth (m)	Test Details: Results	Backfill
MADE GROUND: Grass over greyish brown slightly gravelly clayey fine to medium SAND with frequent medium roots. Gravel is angular to rounded fine to coarse of red brick fragments and sandstone. (TOPSOIL)		0.19	(0.19)	38.85			0.20 - 0.40	ES	1	0.20	PID=0.0ppmv	
MADE GROUND: Soft greyish brown slightly sandy gravelly CLAY with low angular cobble content of sandstone and red bricks. Sand is fine to coarse. Gravel is angular to rounded fine to coarse of mudstone with rare red brick fragments and coal.		1.40	(1.21)	37.64			0.80 - 1.00	ES	2	0.80	PID=0.0ppmv	
										1.20	SPT(C) N=8 (2,2/2,2,2,2)	
Brown slightly gravelly very clayey fine to coarse SAND. Gravel is angular to rounded fine to coarse of sandstone and siltstone with rare coal. (DEVENSIAN TILL)		1.80	(0.40)	37.24								
Brown and greyish brown slightly clayey SAND and GRAVEL. Sand is fine to coarse. Gravel is angular to rounded fine to coarse of sandstone, siltstone, mudstone and quartz. (DEVENSIAN TILL)		3.50	(1.70)	35.54			2.00 - 3.00	D	1	2.00	SPT(C) N=16 (3,4/4,4,4,4)	
										3.00	SPT(C) N=27 (3,5/6,7,7,7)	
Brownish red clayey fine to medium SAND. (WEATHERED CHESTER FORMATION)		4.00	(0.50)	35.04			3.50 - 4.00	D	2			
Borehole complete at 4.00 m bgl.										4.00	SPT(C) 50 (8,14/50 for 105mm)	

Remarks:

1. Logged in general accordance with BS5930:2015+A1:2020. Consistency is based on finger test as defined by BS EN ISO 14688-1:2002 where applicable.
2. Borehole cleared for services prior to excavating a hand dug inspection pit to 1.2 m bgl.
3. Elevation and location data obtained from third-party survey.
4. SPT Hammer ID DART380 (Energy Ratio= 66 %).
5. Borehole was installed with a combined groundwater and ground gas monitoring standpipe.

Water Level Observations

Date	Depth Strike (m)	Duration (min)	Standing (m)

Coordinates:	Elevation (mAOD):	Drilled By:	Plant Used:	Logged:	Checked:	Approved:	Scale:
E384864.49 N396880.91	39.04	VC Drilling Ltd.	Archway Dart	TB	RD	MB	1:40

DeltaSimons
Head Office
3 Henley Way, Doddington Road
Lincoln, LN6 3QR
Tel: +44 (0) 1522 882555
Email: info@deltasimons.com

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Project: Upper Brook Street

Dynamic Sampler Log

Date: 30/11/2023 | Client: HDR Inc.

Description of Strata	Legend	Strata Depth (m bgl)	Strata Thickness (m)	Reduced Level (mAOD)	Casing Diameter (mm)	Water	Sample Details: Depth (m)	Sample Details: Type	Sample Details: Ref	Test Details: Depth (m)	Test Details: Results	Backfill
MADE GROUND: Black macadam.		0.04	(0.11)	38.81								
MADE GROUND: Dark grey sandy angular to rounded fine to coarse GRAVEL of macadam, roadstone and concrete. Sand is fine to coarse.		0.15		38.70								
MADE GROUND: Light grey sandy angular to rounded fine to coarse GRAVEL of roadstone and concrete. Sand is fine to coarse.		0.40	(0.25)	38.45			0.40 - 0.60	ES	1	0.40	PID=0.0ppmv	
MADE GROUND: Multicoloured slightly sandy angular to subangular fine to coarse GRAVEL of red brick fragments, concrete, slate and sandstone with a high cobble content of angular red bricks and pyritic sandstone flags. Sand is fine to coarse.			(1.70)							1.20	SPT(C) N=2 (1,1/1,1,0,0)	
		2.10		36.75			2.00 - 2.50	ES	2	2.00	SPT(C) N=18 (2,2/6,2,8,2)	
MADE GROUND: Multicoloured sandy very clayey angular to rounded fine to coarse GRAVEL of red brick, concrete, mudstone and sandstone. Sand is fine to coarse.		2.50	(0.40)	36.35						2.00	PID=0.0ppmv	
Brown and greyish brown SAND and GRAVEL. Sand is fine to coarse. Gravel is angular to rounded fine to coarse of sandstone, siltstone, mudstone and quartz. (DEVENSIAN TILL)		3.00	(0.50)	35.85						3.00	SPT(C) N=20 (3,4/4,7,5,4)	
Firm to stiff reddish brown slightly sandy gravelly CLAY. Sand is fine to coarse. Gravel is angular to rounded fine to coarse of mudstone and sandstone. (WEATHERED CHESTER FORMATION)		3.25	(0.25)	35.60								
Brownish red slightly clayey fine to medium SAND. (WEATHERED CHESTER FORMATION)		4.00	(0.75)	34.85			3.50 - 4.00	D	1	4.00	SPT(C) 50 (25 for 105mm/50 for 80mm)	
Borehole complete at 4.00 m bgl.												

Remarks:

1. Logged in general accordance with BS5930:2015+A1:2020. Consistency is based on finger test as defined by BS EN ISO 14688-1:2002 where applicable.
2. Borehole cleared for services prior to excavating a hand dug inspection pit to 1.2 m bgl.
3. Elevation and location data obtained from third-party survey.
4. SPT Hammer ID DART380 (Energy Ratio= 66 %).
5. Borehole was installed with a combined groundwater and ground gas monitoring standpipe.

Water Level Observations

Date	Depth Strike (m)	Duration (min)	Standing (m)

Coordinates:	Elevation (mAOD):	Drilled By:	Plant Used:	Logged:	Checked:	Approved:	Scale:
E384900.20 N396852.28	38.85	VC Drilling Ltd.	Archway Dart	TB	RD	MB	1:40

DeltaSimons
Head Office
3 Henley Way, Doddington Road
Lincoln, LN6 3QR
Tel: +44 (0) 1522 882555
Email: info@deltasimons.com

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Project: **Upper Brook Street**

Rotary Core Borehole Log

Date: **27/11/2023 - 29/11/2023**

Client: **HDR Inc.**

Description of Strata	Legend	Strata Depth (m)	Strata Thickness (m)	Reduced Level (mAOD)	Casing Diameter (mm)	Water	Core Recovery: Run (m)	Core Recovery: TCR% SCR% RQD%	Core Recovery: Min. FI Av. FI Max. FI	Sample Details: Depth (m)	Sample Details: Type Ref	Test Details: Depth (m)	Test Details: Results	Backfill
MADE GROUND: Grass over very soft greyish brown very gravelly CLAY with frequent fine roots. Gravel is angular to rounded fine to coarse of red brick fragments, concrete and sandstone. (TOPSOIL)		0.18		39.53						0.20 - 0.40	ES ES1	0.20	PID=0.0ppmv	
MADE GROUND: Greyish brown slightly sandy very clayey angular to rounded fine to coarse GRAVEL of red brick fragments, concrete and sandstone with rare cloth, metal and plastic with low to medium angular cobble content of concrete and red bricks. Sand is fine to coarse.		0.80	(0.62)	38.91						1.00 - 1.20	ES ES2	1.00	PID=0.0ppmv	
												1.20	SPT(S) N=17 (3,4/3,4,6,4)	
MADE GROUND: Greyish brown sandy clayey angular to rounded fine to coarse GRAVEL of red brick fragments, concrete and sandstone with frequent glass with low to medium angular cobble content of concrete and red bricks. Sand is fine to coarse.		1.60	(0.80)	38.11						1.40 - 1.60	ES ES3	1.40	PID=0.0ppmv	
MADE GROUND: Suspected angular COBBLES of red brick and concrete recovered as angular gravels of red brick fragments and concrete.		2.40	(0.80)	37.31										
Light grey and brown SAND and GRAVEL. Sand is fine to coarse. Gravel is angular to rounded fine to coarse of sandstone, siltstone, mudstone and quartz. (DEVENSIAN TILL)		3.70	(1.30)	36.01						3.00 - 3.20	D D1	3.00	SPT(S) N=19 (4,4/6,4,5,4)	
Firm slightly sandy slightly gravelly CLAY. Sand is fine to medium. Gravel is angular to rounded fine to medium of sandstone, siltstone and mudstone. (DEVENSIAN TILL)		4.70	(1.00)	35.01						4.00 - 4.20	D D2			
												4.50	SPT(S) N=50 (11,14/50 for 235mm)	
Weathered SANDSTONE recovered as brownish red gravelly fine to medium sand. Gravel is angular to rounded fine to coarse of sandstone and siltstone. (WEATHERED CHESTER FORMATION)														

Remarks:

1. Logged in general accordance with BS5930:2015+A1:2020. Consistency is based on finger test as defined by BS EN ISO 14688-1:2002 where applicable.
2. Borehole cleared for services prior to excavating a hand dug inspection pit to 1.2 m bgl.
3. Elevation and location data obtained from third-party survey.
4. SPT Hammer ID AR3711 (Energy Ratio= 68%).
5. Borehole was installed with a combined groundwater and ground gas monitoring standpipe.

Water Level Observataions

Date	Depth Strike (m)	Duration (min)	Standing (m)

Coordinates:	Elevation (mAOD):	Drilled By:	Plant Used:	Logged:	Checked:	Approved:	Scale (m):
E384844.55 N396811.84	39.71	VC Drilling Ltd.	Teredo 4.8	TB	RD	MB	1:30

DeltaSimons
Head Office
3 Henley Way, Doddington Road
Lincoln, LN6 3QR
Tel: +44 (0) 1522 882555
Email: info@deltasimons.com

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Project: Upper Brook Street

Rotary Core Borehole Log

Date: 27/11/2023 - 29/11/2023 | Client: HDR Inc.

Description of Strata	Legend	Strata Depth (m)	Strata Thickness (m)	Reduced Level (mAOD)	Casing Diameter (mm)	Water	Core Recovery: Run (m)	Core Recovery: TCR% SCR% RQD%	Core Recovery: Min. FI Av. FI Max. FI	Sample Details: Depth (m)	Sample Details: Type Ref	Test Details: Depth (m)	Test Details: Results	Backfill
Weathered SANDSTONE recovered as brownish red gravelly fine to medium sand. Gravel is angular to rounded fine to coarse of sandstone and siltstone. (WEATHERED CHESTER FORMATION)			(3.30)							7.50 - 8.00	D D3	6.50	SPT(S) 50 (25 for 75mm/50 for 50mm)	
		8.00		31.71										
Weathered SANDSTONE recovered as brownish red slightly gravelly slightly clayey fine to medium sand. Gravel is angular to rounded fine to coarse of sandstone and siltstone. (WEATHERED CHESTER FORMATION)			(1.70)							9.00 - 9.50	D D4			
		9.70		30.01										
Weak reddish brown fine grained SANDSTONE. Bedding and fractures non-apparent. Partially weathered to sandy clay. (CHESTER FORMATION)			(0.40)									10.00	SPT(S) 50 (25 for 50mm/50 for 50mm)	
		10.10		29.61										
Weak thinly bedded reddish brown medium grained SANDSTONE. Fractures are sub horizontal (20°) medium spaced planar rough moderately open with occasional sandy infill. (CHESTER FORMATION)			(2.00)				1.3	100 97 66	0 140 260					

Remarks:

1. Logged in general accordance with BS5930:2015+A1:2020. Consistency is based on finger test as defined by BS EN ISO 14688-1:2002 where applicable.
2. Borehole cleared for services prior to excavating a hand dug inspection pit to 1.2 m bgl.
3. Elevation and location data obtained from third-party survey.
4. SPT Hammer ID AR3711 (Energy Ratio= 68%).
5. Borehole was installed with a combined groundwater and ground gas monitoring standpipe.

Water Level Observataions

Date	Depth Strike (m)	Duration (min)	Standing (m)

Coordinates:	Elevation (mAOD):	Drilled By:	Plant Used:	Logged:	Checked:	Approved:	Scale (m):
E384844.55 N396811.84	39.71	VC Drilling Ltd.	Teredo 4.8	TB	RD	MB	1:30

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Head Office
3 Henley Way, Doddington Road
Lincoln, LN6 3QR
Tel: +44 (0) 1522 882555
Email: info@deltasimons.com

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Project: Upper Brook Street

Rotary Core Borehole Log

Date: 27/11/2023 - 29/11/2023 | Client: HDR Inc.

Description of Strata	Legend	Strata Depth (m)	Strata Thickness (m)	Reduced Level (mAOD)	Casing Diameter (mm)	Water	Core Recovery: Run (m)	Core Recovery: TCR% SCR% RQD%	Core Recovery: Min. FI Av. FI Max. FI	Sample Details: Depth (m)	Sample Details: Type	Sample Details: Ref	Test Details: Depth (m)	Test Details: Results	Backfill
Weak thinly bedded reddish brown medium grained SANDSTONE. Fractures are sub horizontal (20˚) medium spaced planar rough moderately open with occasional sandy infill. (CHESTER FORMATION)		12.10		27.61			1.5	80 76 62	5 125 220	12.00 - 12.40	C	C1 D5			
Moderately weak thinly bedded reddish brown medium grained SANDSTONE. Fractures are sub horizontal (15 - 25˚) closely spaced planar rough moderately open with sandy infill. Some thin (10 - 15 cm) sandy horizons have been washed away during the drilling process. (CHESTER FORMATION)		13.80	(1.70)	25.91			1.5	76 73 32	15 85 230	12.00 - 12.50 12.30 - 12.52	D C	 C2			
Moderately weak thinly bedded reddish brown medium grained SANDSTONE with rare rounded gravel inclusions of mudstone and quartzite. Fractures are sub horizontal (5 - 10˚) to inclined (40˚) very closely spaced planar rough and tight. (CHESTER FORMATION)		15.90	(2.10)	23.81			1.5	98 88 28	10 80 170	15.00 - 15.20	D	D6			
Moderately weak thinly bedded reddish brown medium grained SANDSTONE with rare rounded gravel inclusions of mudstone and quartzite. Fractures are sub horizontal (10 - 20˚) closely spaced planar rough and tight. (CHESTER FORMATION)			(1.40)				1.5	96 92 50	0 75 145	16.20 - 16.37 17.00 - 17.70 17.20 - 17.50	C D C	C3 D7 C6			

Remarks:

1. Logged in general accordance with BS5930:2015+A1:2020. Consistency is based on finger test as defined by BS EN ISO 14688-1:2002 where applicable.
2. Borehole cleared for services prior to excavating a hand dug inspection pit to 1.2 m bgl.
3. Elevation and location data obtained from third-party survey.
4. SPT Hammer ID AR3711 (Energy Ratio= 68%).
5. Borehole was installed with a combined groundwater and ground gas monitoring standpipe.

Water Level Observataions

Date	Depth Strike (m)	Duration (min)	Standing (m)

Coordinates:	Elevation (mAOD):	Drilled By:	Plant Used:	Logged:	Checked:	Approved:	Scale (m):
E384844.55 N396811.84	39.71	VC Drilling Ltd.	Teredo 4.8	TB	RD	MB	1:30

DeltaSimons
Head Office
3 Henley Way, Doddington Road
Lincoln, LN6 3QR
Tel: +44 (0) 1522 882555
Email: info@deltasimons.com

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Project: **Upper Brook Street**

Rotary Core Borehole Log

Date: **27/11/2023 - 29/11/2023**

Client: **HDR Inc.**

Description of Strata	Legend	Strata Depth (m)	Strata Thickness (m)	Reduced Level (mAOD)	Casing Diameter (mm)	Water	Core Recovery: Run (m)	Core Recovery: TCR% SCR% RQD%	Core Recovery: Min. FI Av. FI Max. FI	Sample Details: Depth (m)	Sample Details: Type Ref	Test Details: Depth (m)	Test Details: Results	Backfill
Moderately weak thinly bedded reddish brown medium grained SANDSTONE with rare rounded gravel inclusions of mudstone and quartzite. Fractures are sub horizontal (10 - 20˚) closely spaced planar rough and tight. (CHESTER FORMATION)		17.30		22.41										
Moderately strong thinly bedded reddish brown medium grained SANDSTONE. Fractures are sub horizontal (10 - 20˚) medium spaced planar rough and open. (CHESTER FORMATION)			(1.30)				1.5	98 98 70	30 120 320	18.00 - 18.17	C C4			
Moderately strong thinly bedded reddish brown medium grained SANDSTONE. Fractures are horizontal and sub horizontal (10 - 15˚) medium spaced planar rough and moderately tight. (CHESTER FORMATION)		18.60	(1.40)	21.11			1.5	100 91 43	5 60 410	18.90 - 19.00 19.00 - 20.00 19.39 - 19.50	C C5 D D8 C C7			
Borehole complete at 20.00 m bgl.		20.00		19.71										

Remarks:

1. Logged in general accordance with BS5930:2015+A1:2020. Consistency is based on finger test as defined by BS EN ISO 14688-1:2002 where applicable.
2. Borehole cleared for services prior to excavating a hand dug inspection pit to 1.2 m bgl.
3. Elevation and location data obtained from third-party survey.
4. SPT Hammer ID AR3711 (Energy Ratio= 68%).
5. Borehole was installed with a combined groundwater and ground gas monitoring standpipe.

Water Level Observataions

Date	Depth Strike (m)	Duration (min)	Standing (m)

Coordinates:	Elevation (mAOD):	Drilled By:	Plant Used:	Logged:	Checked:	Approved:	Scale (m):
E384844.55 N396811.84	39.71	VC Drilling Ltd.	Teredo 4.8	TB	RD	MB	1:30

DeltaSimons
Head Office
3 Henley Way, Doddington Road
Lincoln, LN6 3QR
Tel: +44 (0) 1522 882555
Email: info@deltasimons.com

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Project: **Upper Brook Street**

Rotary Core Borehole Log

Date: **29/11/2023 - 01/12/2023**

Client: **HDR Inc.**

Description of Strata	Legend	Strata Depth (m)	Strata Thickness (m)	Reduced Level (mAOD)	Casing Diameter (mm)	Water	Core Recovery: Run (m)	Core Recovery: TCR% SCR% RQD%	Core Recovery: Min. FI Av. FI Max. FI	Sample Details: Depth (m)	Sample Details: Type Ref	Test Details: Depth (m)	Test Details: Results	Backfill
MADE GROUND: Grass over very soft greyish brown slightly gravelly sandy CLAY with frequent fine roots. Gravel is angular to rounded fine to coarse of red brick fragments, concrete and sandstone. (TOPSOIL)		0.09		39.12						0.20 - 0.40	ES ES1	0.20	PID=0.0ppmv	
MADE GROUND: Multicoloured sandy very clayey angular to rounded fine to coarse GRAVEL of red brick fragments, concrete and sandstone with rubber, plastic, glass and rare suspected asbestos fragments (up to 6 cm) with medium to high angular cobble content of red brick and concrete.		1.05	(0.96)	38.16						0.80 - 1.00	ES ES2	0.80	PID=0.0ppmv	
MADE GROUND: Suspected angular COBBLES of red brick and concrete recovered as angular gravels of red brick fragments and concrete with soft brown clay.		4.50	(3.45)	34.71						4.00 - 4.30	D D1	1.20	SPT(S) N=18 (2,3/4,5,4,5)	
												2.00	PID=0.0ppmv	
												2.50	SPT(S) N=40 (4,6/8,12,10,10)	
												4.00	SPT(S) 50 (5,8/50 for 225mm)	
Suspected natural deposits of slightly sandy gravelly CLAY. (Inferred from drilling). (DEVENSIAN TILL)		5.00	(0.50)	34.21										
Weathered reddish brown SANDSTONE recovered as slightly gravelly fine to medium sand. Gravel is angular to rounded fine to coarse of mudstone, siltstone and sandstone. (WEATHERED CHESTER FORMATION)														

Remarks:

1. Logged in general accordance with BS5930:2015+A1:2020. Consistency is based on finger test as defined by BS EN ISO 14688-1:2002 where applicable.
2. Borehole cleared for services prior to excavating a hand dug inspection pit to 1.2 m bgl.
3. Elevation and location data obtained from third-party survey.
4. SPT Hammer ID AR3711 (Energy Ratio= 68%).
5. Borehole was installed with a combined groundwater and ground gas monitoring standpipe.

Water Level Observataions

Date	Depth Strike (m)	Duration (min)	Standing (m)

Coordinates:	Elevation (mAOD):	Drilled By:	Plant Used:	Logged:	Checked:	Approved:	Scale (m):
E384821.08 N396851.84	39.21	VC Drilling Ltd.	Teredo 4.8	TB	RD	MB	1:30

DeltaSimons
Head Office
3 Henley Way, Doddington Road
Lincoln, LN6 3QR
Tel: +44 (0) 1522 882555
Email: info@deltasimons.com

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Project: **Upper Brook Street**

Rotary Core Borehole Log

Date: **29/11/2023 - 01/12/2023**

Client: **HDR Inc.**

Description of Strata	Legend	Strata Depth (m)	Strata Thickness (m)	Reduced Level (mAOD)	Casing Diameter (mm)	Water	Core Recovery: Run (m)	Core Recovery: TCR% SCR% RQD%	Core Recovery: Min. FI Av. FI Max. FI	Sample Details: Depth (m)	Sample Details: Type Ref	Test Details: Depth (m)	Test Details: Results	Backfill
Weathered reddish brown SANDSTONE recovered as slightly gravelly fine to medium sand. Gravel is angular to rounded fine to coarse of mudstone, siltstone and sandstone. (WEATHERED CHESTER FORMATION)			(5.35)									6.00	SPT(S) 50 (25 for 50mm/50 for 50mm)	
												10.00	SPT(S) 50 (25 for 75mm/50 for 75mm)	
		10.35		28.86										
Very weak thinly bedded reddish brown medium grained SANDSTONE. Fractures are sub horizontal (5 - 20°) medium spaced planar rough and moderately open. (CHESTER FORMATION)							1.2	98 81 32	0 75 130	11.00 - 11.50 11.10 - 11.23	D D2 C C8			

Remarks:

1. Logged in general accordance with BS5930:2015+A1:2020. Consistency is based on finger test as defined by BS EN ISO 14688-1:2002 where applicable.
2. Borehole cleared for services prior to excavating a hand dug inspection pit to 1.2 m bgl.
3. Elevation and location data obtained from third-party survey.
4. SPT Hammer ID AR3711 (Energy Ratio= 68%).
5. Borehole was installed with a combined groundwater and ground gas monitoring standpipe.

Water Level Observataions

Date	Depth Strike (m)	Duration (min)	Standing (m)

Coordinates:	Elevation (mAOD):	Drilled By:	Plant Used:	Logged:	Checked:	Approved:	Scale (m):
E384821.08 N396851.84	39.21	VC Drilling Ltd.	Teredo 4.8	TB	RD	MB	1:30

DeltaSimons
Head Office
3 Henley Way, Doddington Road
Lincoln, LN6 3QR
Tel: +44 (0) 1522 882555
Email: info@deltasimons.com

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Project: **Upper Brook Street**

Rotary Core Borehole Log

Date: 29/11/2023 - 01/12/2023

Client: HDR Inc.

Description of Strata	Legend	Strata Depth (m)	Strata Thickness (m)	Reduced Level (mAOD)	Casing Diameter (mm)	Water	Core Recovery: Run (m)	Core Recovery: TCR% SCR% RQD%	Core Recovery: Min. Fl Av. Fl Max. Fl	Sample Details: Depth (m)	Sample Details: Type	Sample Details: Ref	Test Details: Depth (m)	Test Details: Results	Backfill
Very weak thinly bedded reddish brown medium grained SANDSTONE. Fractures are sub horizontal (5 - 20˚) medium spaced planar rough and moderately open. (CHESTER FORMATION)			(2.85)				1.5	89 80 57	0 110 470	12.60 - 12.80	C	C1			
		13.20		26.01											
Moderately weak thinly bedded reddish brown medium grained SANDSTONE. Fractures are sub horizontal (5 - 20˚) medium spaced planar rough and moderately open. (CHESTER FORMATION)			(2.80)				1.5	100 87 48	15 115 250	14.10 - 14.22	C	C2			
							1.5	87 82 63	90 140 280	15.00 - 15.18	C	C5			
										15.50 - 16.00	D	D3			
		16.00		23.21											
Moderately weak thinly bedded reddish brown medium grained SANDSTONE with occasional rounded gravel inclusions of mudstone and quartzite. Fractures are sub horizontal (5 - 20˚) medium spaced planar rough and moderately open. (CHESTER FORMATION)							1.5	78 70 55	0 160 420	16.80 - 17.00	C	C7			
										17.00 - 17.24	C	C6			

Remarks:

1. Logged in general accordance with BS5930:2015+A1:2020. Consistency is based on finger test as defined by BS EN ISO 14688-1:2002 where applicable.
2. Borehole cleared for services prior to excavating a hand dug inspection pit to 1.2 m bgl.
3. Elevation and location data obtained from third-party survey.
4. SPT Hammer ID AR3711 (Energy Ratio= 68%).
5. Borehole was installed with a combined groundwater and ground gas monitoring standpipe.

Water Level Observataions

Date	Depth Strike (m)	Duration (min)	Standing (m)

Coordinates:	Elevation (mAOD):	Drilled By:	Plant Used:	Logged:	Checked:	Approved:	Scale (m):
E384821.08 N396851.84	39.21	VC Drilling Ltd.	Teredo 4.8	TB	RD	MB	1:30

DeltaSimons
Head Office
3 Henley Way, Doddington Road
Lincoln, LN6 3QR
Tel: +44 (0) 1522 882555
Email: info@deltasimons.com

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Rotary Core Borehole Log

Date: **29/11/2023 - 01/12/2023**

Client: **HDR Inc.**

Description of Strata	Legend	Strata Depth (m)	Strata Thickness (m)	Reduced Level (mAOD)	Casing Diameter (mm)	Water	Core Recovery: Run (m)	Core Recovery: TCR% SCR% RQD%	Core Recovery: Min. FI Av. FI Max. FI	Sample Details: Depth (m)	Sample Details: Type Ref	Test Details: Depth (m)	Test Details: Results	Backfill
Moderately weak thinly bedded reddish brown medium grained SANDSTONE with occasional rounded gravel inclusions of mudstone and quartzite. Fractures are sub horizontal (5 - 20°) medium spaced planar rough and moderately open. (CHESTER FORMATION)			(3.80)				1.5	100 87 70	25 175 425	18.80 - 19.00	C C3			
Gravel band comprising medium to coarse GRAVEL of mudstone, siltstone and quartz.		19.80		19.41			1.5	85 42 12	0 55 175	19.60 - 19.77	C C4			
Weathered SANDSTONE recovered as fine to medium sand. (CHESTER FORMATION)			(0.70)							20.00 - 20.50	D D4			
Borehole complete at 20.50 m bgl.		20.50		18.71										

Remarks:

1. Logged in general accordance with BS5930:2015+A1:2020. Consistency is based on finger test as defined by BS EN ISO 14688-1:2002 where applicable.
2. Borehole cleared for services prior to excavating a hand dug inspection pit to 1.2 m bgl.
3. Elevation and location data obtained from third-party survey.
4. SPT Hammer ID AR3711 (Energy Ratio= 68%).
5. Borehole was installed with a combined groundwater and ground gas monitoring standpipe.

Water Level Observataions

Date	Depth Strike (m)	Duration (min)	Standing (m)

Coordinates:	Elevation (mAOD):	Drilled By:	Plant Used:	Logged:	Checked:	Approved:	Scale (m):
E384821.08 N396851.84	39.21	VC Drilling Ltd.	Teredo 4.8	TB	RD	MB	1:30

DeltaSimons
Head Office
3 Henley Way, Doddington Road
Lincoln, LN6 3QR
Tel: +44 (0) 1522 882555
Email: info@deltasimons.com

Project No:	Hole ID:	Page:
101718.591891	RO3	1 of 4

Project: **Upper Brook Street**

Rotary Core Borehole Log

Date: **01/12/2023 - 05/12/2023**

Client: **HDR Inc.**

Description of Strata	Legend	Strata Depth (m)	Strata Thickness (m)	Reduced Level (mAOD)	Casing Diameter (mm)	Water	Core Recovery: Run (m)	Core Recovery: TCR% SCR% RQD%	Core Recovery: Min. FI Av. FI Max. FI	Sample Details: Depth (m)	Sample Details: Type Ref	Test Details: Depth (m)	Test Details: Results	Backfill
MADE GROUND: Greyish brown paving slab (2 x 0.04 cm).		0.08		38.74										
MADE GROUND: Light grey sandy angular to rounded fine to coarse GRAVEL of roadstone and concrete. Sand is fine to coarse.		0.25		38.57						0.30 - 0.70	ES ES1	0.30	PID=0.0ppmv	
MADE GROUND: Grey sandy clayey angular to rounded fine to coarse GRAVEL of roadstone, concrete and sandstone. Sand is fine to coarse.		0.95	(0.70)	37.87						1.00 - 1.20	ES ES2	1.00	PID=0.0ppmv	
Concrete cobble.												1.20	SPT(C) N=3 (1,1/1,0,1,1)	
MADE GROUND: Soft to firm dark brown and dark greyish brown slightly sandy gravelly CLAY. Sand is fine to coarse. Gravel is angular to rounded fine to coarse of concrete and red brick fragments.		1.35	(0.40)	37.47										
Brown gravelly very clayey fine to coarse SAND. Gravel is angular to rounded fine to medium of sandstone, siltstone and mudstone. (DEVENSIAN TILL)		1.90	(0.55)	36.92						1.50 - 1.80	D D1			
Brown and greyish brown slightly clayey SAND and GRAVEL. Sand is fine to coarse. Gravel is angular to rounded fine to coarse of sandstone, siltstone, mudstone and quartz. (DEVENSIAN TILL)		3.15	(1.25)	35.67								2.00	SPT(C) N=29 (5,6/6,7,8,8)	
												3.00	SPT(C) N=17 (4,5/6,4,3,4)	
Brown gravelly very clayey fine to coarse SAND. Gravel is angular to rounded fine to medium of sandstone, siltstone and mudstone. (DEVENSIAN TILL)		3.60	(0.45)	35.22										
Weathered SANDSTONE recovered as brownish red clayey fine to medium sand. (Inferred from SPT spoon and flush returns). (WEATHERED CHESTER FORMATION)										3.60 - 4.00	D D2			
												4.00	SPT(C) 50 (7,10/50 for 125mm)	
												5.50	SPT(S) 50 (25 for 50mm/50 for 50mm)	

Remarks:

1. Logged in general accordance with BS5930:2015+A1:2020. Consistency is based on finger test as defined by BS EN ISO 14688-1:2002 where applicable.
2. Borehole cleared for services prior to excavating a hand dug inspection pit to 1.2 m bgl.
3. Elevation and location data obtained from third-party survey.
4. Borehole was advanced via dynamic sampling techniques to 4.0 m bgl with rotary follow on.
5. SPT Hammer ID DART380 (Energy Ratio= 66 %) for dynamic sampling and ID AR3711 (Energy Ratio= 68 %) for rotary drilling.
6. Borehole was installed with a combined groundwater and ground gas monitoring standpipe.

Water Level Observataions

Date	Depth Strike (m)	Duration (min)	Standing (m)

Coordinates:	Elevation (mAOD):	Drilled By:	Plant Used:	Logged:	Checked:	Approved:	Scale (m):
E384864.05 N396845.57	38.82	VC Drilling Ltd.	Teredo 4.8	TB	RD	MB	1:30

DeltaSimons
Head Office
3 Henley Way, Doddington Road
Lincoln, LN6 3QR
Tel: +44 (0) 1522 882555
Email: info@deltasimons.com

Project No:	Hole ID:	Page:
101718.591891	RO3	2 of 4

Project: **Upper Brook Street**

Rotary Core Borehole Log

Date: 01/12/2023 - 05/12/2023

Client: HDR Inc.

Description of Strata	Legend	Strata Depth (m)	Strata Thickness (m)	Reduced Level (mAOD)	Casing Diameter (mm)	Water	Core Recovery Run (m)	Core Recovery TCR% SCR% RQD%	Core Recovery Min. FI Av. FI Max. FI	Sample Details Depth (m)	Sample Details Type	Sample Details Ref	Test Details Depth (m)	Test Details Results	Backfill
Weathered SANDSTONE recovered as brownish red clayey fine to medium sand. (Inferred from SPT spoon and flush returns). (WEATHERED CHESTER FORMATION)		10.50	(6.90)	28.32									10.00	SPT(S) 50 (25 for 50mm/50 for 50mm)	
Weak thinly bedded reddish brown medium grained SANDSTONE. Fractures are sub horizontal (5 - 20°) medium spaced planar rough and moderately open. (CHESTER FORMATION)							1.0	100 100 71	75 140 370	10.70 - 10.90 11.00 - 11.50	C D	C1 D3			

Remarks:

1. Logged in general accordance with BS5930:2015+A1:2020. Consistency is based on finger test as defined by BS EN ISO 14688-1:2002 where applicable.
2. Borehole cleared for services prior to excavating a hand dug inspection pit to 1.2 m bgl.
3. Elevation and location data obtained from third-party survey.
4. Borehole was advanced via dynamic sampling techniques to 4.0 m bgl with rotary follow on.
5. SPT Hammer ID DART380 (Energy Ratio= 66 %) for dynamic sampling and ID AR3711 (Energy Ratio= 68 %) for rotary drilling.
6. Borehole was installed with a combined groundwater and ground gas monitoring standpipe.

Water Level Observataions

Date	Depth Strike (m)	Duration (min)	Standing (m)

Coordinates:	Elevation (mAOD):	Drilled By:	Plant Used:	Logged:	Checked:	Approved:	Scale (m):
E384864.05 N396845.57	38.82	VC Drilling Ltd.	Teredo 4.8	TB	RD	MB	1:30

DeltaSimons
Head Office
3 Henley Way, Doddington Road
Lincoln, LN6 3QR
Tel: +44 (0) 1522 882555
Email: info@deltasimons.com

Project No:	Hole ID:	Page:
101718.591891	RO3	3 of 4

Project: **Upper Brook Street**

Rotary Core Borehole Log

Date: 01/12/2023 - 05/12/2023

Client: HDR Inc.

Description of Strata	Legend	Strata Depth (m)	Strata Thickness (m)	Reduced Level (mAOD)	Casing Diameter (mm)	Water	Core Recovery: Run (m)	Core Recovery: TCR% SCR% RQD%	Core Recovery: Min. FI Av. FI Max. FI	Sample Details: Depth (m)	Sample Details: Type	Sample Details: Ref	Test Details: Depth (m)	Test Details: Results	Backfill
Weak thinly bedded reddish brown medium grained SANDSTONE. Fractures are sub horizontal (5 - 20˚) medium spaced planar rough and moderately open. (CHESTER FORMATION)							1.5	87 87 67	0 110 285	12.30 - 12.52	C	C2			
										12.86 - 13.00	C	C3			
			(5.80)				1.5	89 87 52	0 90 210						
										14.30 - 14.42	C	C4			
							1.5	91 89 58	0 110 240	15.32 - 15.46	C	C5			
										15.50 - 16.00	D	D4			
		16.30		22.52											
Moderately weak thinly bedded reddish brown medium grained SANDSTONE. Fractures are sub horizontal (5 - 20˚) medium spaced planar rough and moderately open with rare clay infill. (CHESTER FORMATION)							1.5	89 80 77	0 120 320	16.50 - 16.73	C	C7			
										17.00 - 17.18	C	C6			

Remarks:

1. Logged in general accordance with BS5930:2015+A1:2020. Consistency is based on finger test as defined by BS EN ISO 14688-1:2002 where applicable.
2. Borehole cleared for services prior to excavating a hand dug inspection pit to 1.2 m bgl.
3. Elevation and location data obtained from third-party survey.
4. Borehole was advanced via dynamic sampling techniques to 4.0 m bgl with rotary follow on.
5. SPT Hammer ID DART380 (Energy Ratio= 66 %) for dynamic sampling and ID AR3711 (Energy Ratio= 68 %) for rotary drilling.
6. Borehole was installed with a combined groundwater and ground gas monitoring standpipe.

Water Level Observataions

Date	Depth Strike (m)	Duration (min)	Standing (m)

Coordinates:	Elevation (mAOD):	Drilled By:	Plant Used:	Logged:	Checked:	Approved:	Scale (m):
E384864.05 N396845.57	38.82	VC Drilling Ltd.	Teredo 4.8	TB	RD	MB	1:30

DeltaSimons
Head Office
3 Henley Way, Doddington Road
Lincoln, LN6 3QR
Tel: +44 (0) 1522 882555
Email: info@deltasimons.com

Project No:	Hole ID:	Page:
101718.591891	RO3	4 of 4

Project: **Upper Brook Street**

Rotary Core Borehole Log

Date: 01/12/2023 - 05/12/2023

Client: HDR Inc.

Description of Strata	Legend	Strata Depth (m)	Strata Thickness (m)	Reduced Level (mAOD)	Casing Diameter (mm)	Water	Core Recovery Run (m)	Core Recovery TCR% SCR% RQD%	Core Recovery Min. FI Av. FI Max. FI	Sample Details Depth (m)	Sample Details Type Ref	Test Details Depth (m)	Test Details Results	Backfill
Moderately weak thinly bedded reddish brown medium grained SANDSTONE. Fractures are sub horizontal (5 - 20°) medium spaced planar rough and moderately open with rare clay infill. (CHESTER FORMATION)			(3.20)				1.5	97 92 75	0 105 390					
		19.50		19.32										
Moderately strong thinly bedded reddish brown medium grained SANDSTONE. Fractures are sub horizontal (5 - 20°) medium spaced planar rough and moderately open. (CHESTER FORMATION)			(1.00)				1.5	95 95 80	10 230 400	19.80 - 20.10 20.26 - 20.40	C C8 C C9			
		20.50		18.32										
Borehole complete at 20.50 m bgl.														

Remarks:

1. Logged in general accordance with BS5930:2015+A1:2020. Consistency is based on finger test as defined by BS EN ISO 14688-1:2002 where applicable.
2. Borehole cleared for services prior to excavating a hand dug inspection pit to 1.2 m bgl.
3. Elevation and location data obtained from third-party survey.
4. Borehole was advanced via dynamic sampling techniques to 4.0 m bgl with rotary follow on.
5. SPT Hammer ID DART380 (Energy Ratio= 66 %) for dynamic sampling and ID AR3711 (Energy Ratio= 68 %) for rotary drilling.
6. Borehole was installed with a combined groundwater and ground gas monitoring standpipe.

Water Level Observataions

Date	Depth Strike (m)	Duration (min)	Standing (m)

Coordinates:	Elevation (mAOD):	Drilled By:	Plant Used:	Logged:	Checked:	Approved:	Scale (m):
E384864.05 N396845.57	38.82	VC Drilling Ltd.	Teredo 4.8	TB	RD	MB	1:30

SPT Hammer Energy Test Report

in accordance with BSEN ISO 22476-3:2005

ARCHWAY ENGINEERING UK LTD
AINLEYS INDUSTRIAL ESTATE
ELLAND
WEST YORKSHIRE
HX5 9JP

SPT Hammer Ref:	AR3711
Test Date:	25/01/2023
Report Date:	25/01/2023
File Name:	AR3711 (3).spt
Test Operator:	CM

Instrumented Rod Data

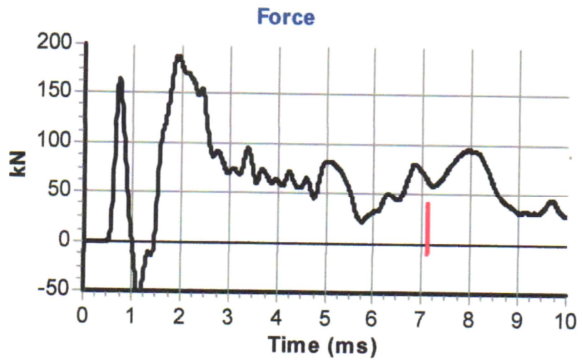
Diameter d_r (mm):	54
Wall Thickness t_r (mm):	6.0
Assumed Modulus E_a (GPa):	200
Accelerometer No.1:	
Accelerometer No.2:	

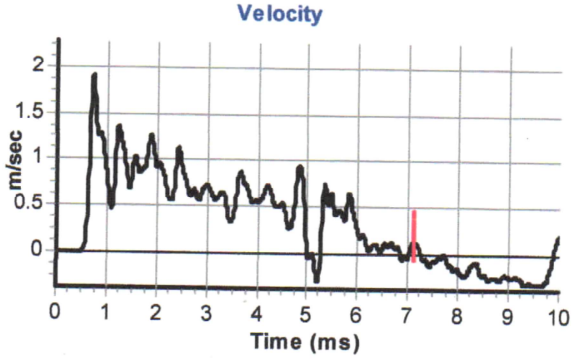
SPT Hammer Information

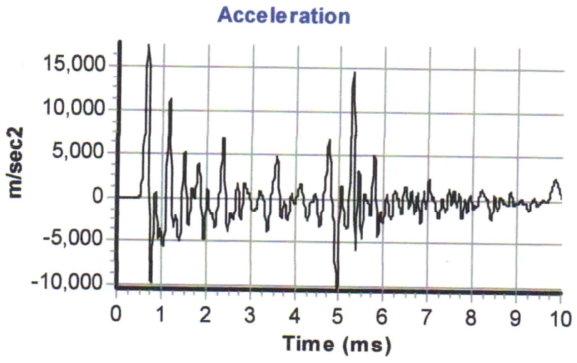
Hammer Mass m (kg):	63.5
Falling Height h (mm):	760
SPT String Length L (m):	10.0

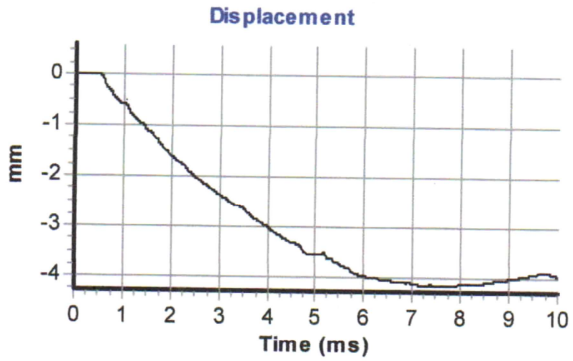
Comments / Location

VC DRILLING LTD - 83450









Calculations

Area of Rod A (mm2):	905
Theoretical Energy E_{theor} (J):	473
Measured Energy E_{meas} (J):	323

Energy Ratio E_r (%): **68**

[redacted]

Signed: J.LOCK

Title: FITTER

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SPT Hammer Energy Test Report

in accordance with BSEN ISO 22476-3:2005

ARCHWAY ENGINEERING (UK) LTD
AINLEYS INDUSTRIAL ESTATE
ELLAND
WEST YORKSHIRE
HX5 9JP

SPT Hammer Ref:	DART380
Test Date:	30/11/2023
Report Date:	30/11/2023
File Name:	DART380.spt
Test Operator:	CM

Instrumented Rod Data

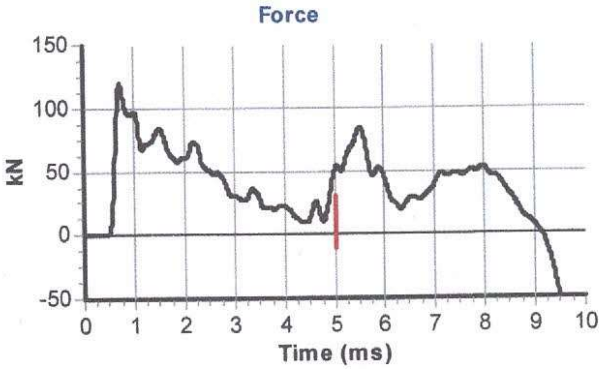
Diameter d_r (mm):	54
Wall Thickness t_r (mm):	6.5
Assumed Modulus E_a (GPa):	208
Accelerometer No.1:	72572
Accelerometer No.2:	72757

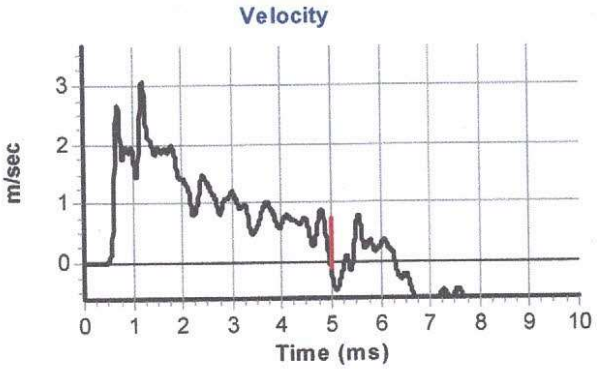
SPT Hammer Information

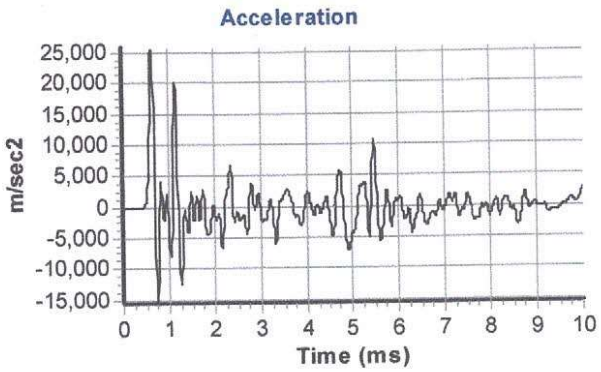
Hammer Mass m (kg):	63.5
Falling Height h (mm):	760
SPT String Length L (m):	10.0

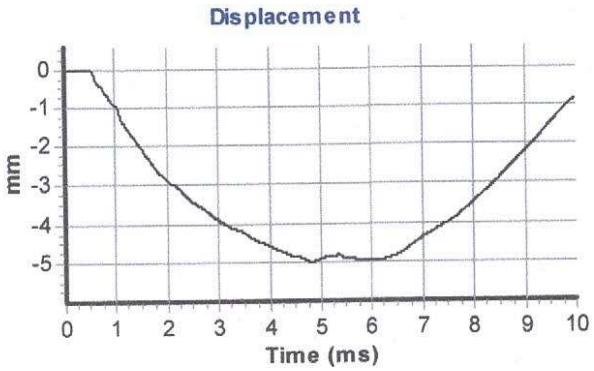
Comments / Location

PM SAMPLING LTD - 87511









Calculations

Area of Rod A (mm2):	970
Theoretical Energy E_{theor} (J):	473
Measured Energy E_{meas} (J):	314

Energy Ratio E_r (%): **66**

[redacted]

Signed: C.McCLUSKEY

Title: FITTER

The recommended calibration interval is 12 months

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Appendix C – Geotechnical Analysis Results

TEST CERTIFICATE

DETERMINATION OF LIQUID AND PLASTIC LIMITS
Tested in Accordance with:BS 1377-2:1990:Clause 4.3 and 5

i2 Analytical Ltd
Unit 8 Harrowden Road
Brackmills Industrial Estate
Northampton NN4 7EB

4041

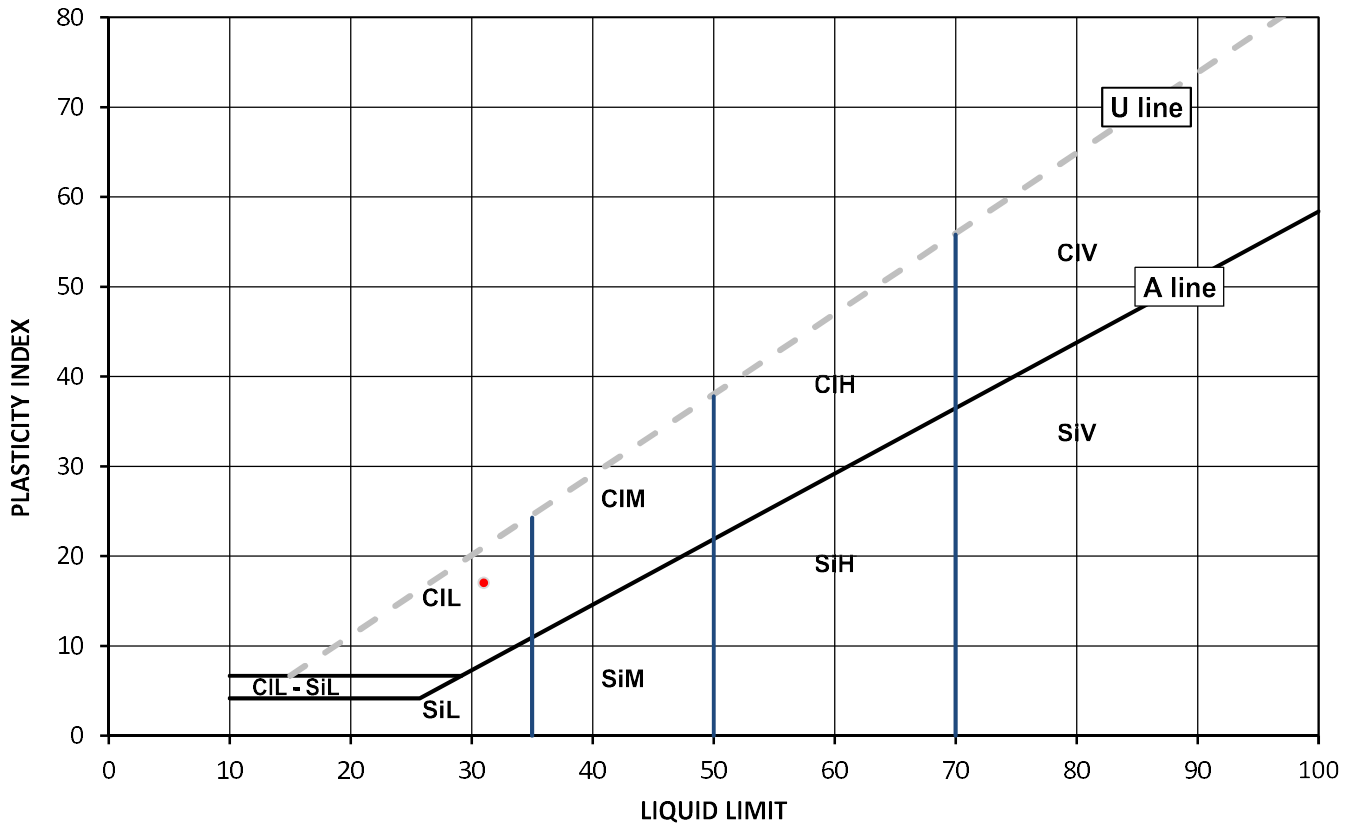
Client:	Delta-Simons	Client Reference:	591891
Client Address:	Suite C1, Joseph's Well, Hanover Walk, Leeds, LS3 1AB	Job Number:	23-74243-1
		Date Sampled:	28/11/2023
		Date Received:	05/12/2023
Contact:	Tom Bywater	Date Tested:	19/12/2023
Site Address:	UBS (Upper Brook Street)	Sampled By:	Not Given

Testing carried out at i2 Analytical Limited, ul. Pionierow, 41-711 Ruda Slaska, Poland

Test Results:

Laboratory Reference:	2907288	Depth Top [m]:	4.00
Hole No.:	RO1	Depth Base [m]:	4.20
Sample Reference:	2	Sample Type:	D
Sample Description:	Brown slightly gravelly very sandy CLAY		
Sample Preparation:	Tested after washing to remove >425um		

As Received Water Content [W] %	Liquid Limit [WL] %	Plastic Limit [Wp] %	Plasticity Index [Ip] %	% Passing 425µm BS Test Sieve
15	31	14	17	88



Legend, based on BS EN ISO 14688 2:2018 Geotechnical investigation and testing – Identification and classification of soil

		Plasticity		Liquid Limit
Cl	Clay	L	Low	below 35
Si	Silt	M	Medium	35 to 50
		H	High	50 to 70
		V	Very high	exceeding 70
		O	Organic	append to classification for organic material (eg ClHO)

Note: Water Content by BS 1377-2: 1990: Clause 3.2

Remarks:

Opinions and interpretations expressed herein are outside of the scope of the UKAS Accreditation. This report may not be reproduced other than in full without the prior written approval of the issuing laboratory. The results included within the report relate only to the sample(s) submitted for testing.

Signed: [redacted]

Katarzyna Banys
Junior Reporting Specialist
for and on behalf of i2 Analytical Ltd

Date Reported: 27/12/2023

GF 236.13

TEST CERTIFICATE

DETERMINATION OF LIQUID AND PLASTIC LIMITS
Tested in Accordance with:BS 1377-2:1990:Clause 4.3 and 5

i2 Analytical Ltd
Unit 8 Harrowden Road
Brackmills Industrial Estate
Northampton NN4 7EB

4041

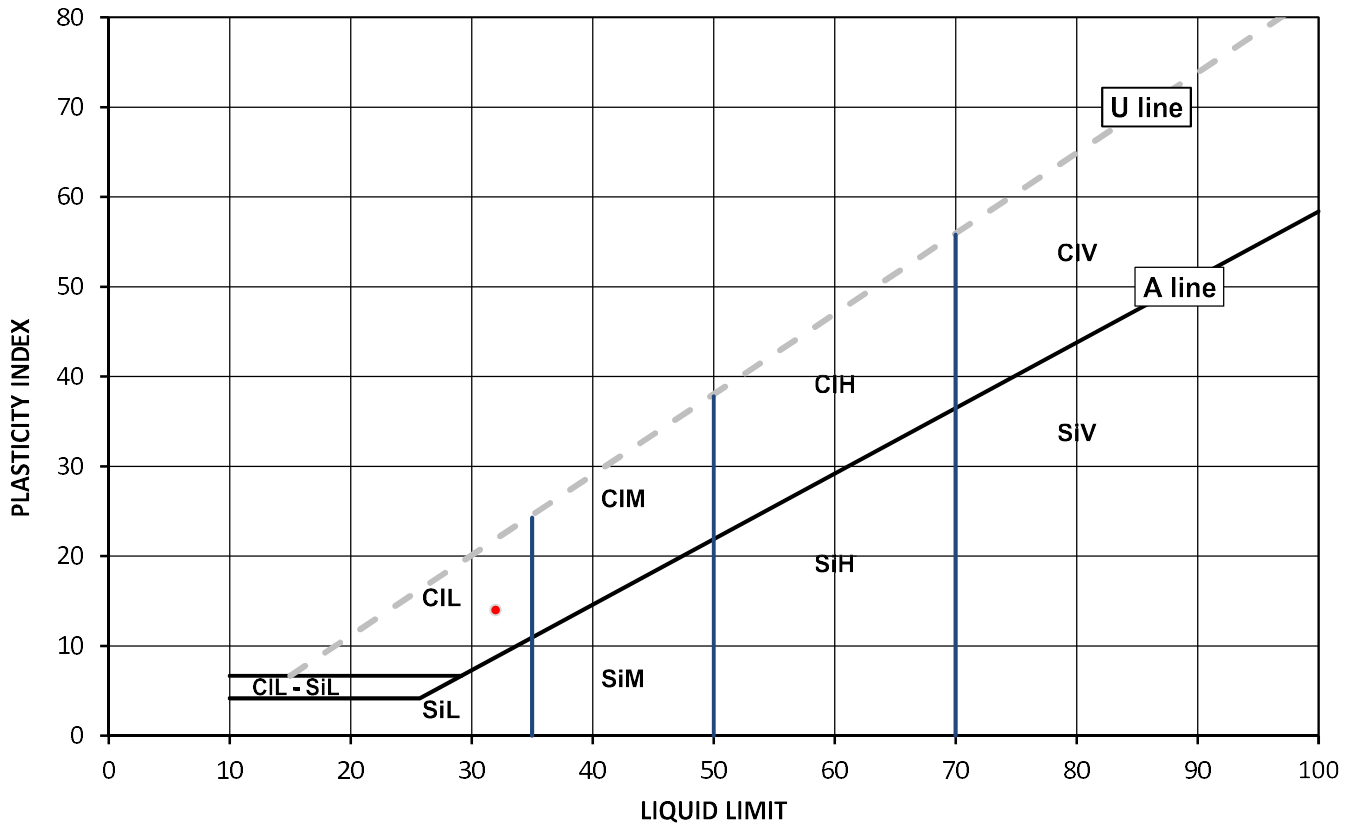
Client:	Delta-Simons	Client Reference:	591891
Client Address:	Suite C1, Joseph's Well, Hanover Walk, Leeds, LS3 1AB	Job Number:	23-74243-1
		Date Sampled:	30/11/2023
		Date Received:	05/12/2023
Contact:	Tom Bywater	Date Tested:	19/12/2023
Site Address:	UBS (Upper Brook Street)	Sampled By:	Not Given

Testing carried out at i2 Analytical Limited, ul. Pionierow, 41-711 Ruda Slaska, Poland

Test Results:

Laboratory Reference:	2907292	Depth Top [m]:	1.40
Hole No.:	DS3	Depth Base [m]:	1.80
Sample Reference:	1	Sample Type:	D
Sample Description:	Brown gravelly very sandy CLAY		
Sample Preparation:	Tested after washing to remove >425um		

As Received Water Content [W] %	Liquid Limit [WL] %	Plastic Limit [Wp] %	Plasticity Index [Ip] %	% Passing 425µm BS Test Sieve
16	32	18	14	65



Legend, based on BS EN ISO 14688 2:2018 Geotechnical investigation and testing – Identification and classification of soil

		Plasticity		Liquid Limit
Cl	Clay	L	Low	below 35
Si	Silt	M	Medium	35 to 50
		H	High	50 to 70
		V	Very high	exceeding 70
		O	Organic	append to classification for organic material (eg ClHO)

Note: Water Content by BS 1377-2: 1990: Clause 3.2

Remarks:

Opinions and interpretations expressed herein are outside of the scope of the UKAS Accreditation. This report may not be reproduced other than in full without the prior written approval of the issuing laboratory. The results included within the report relate only to the sample(s) submitted for testing.

Signed: [redacted]

Katarzyna Banys
Junior Reporting Specialist
for and on behalf of i2 Analytical Ltd

Date Reported: 27/12/2023

GF 236.13

TEST CERTIFICATE

DETERMINATION OF LIQUID AND PLASTIC LIMITS
Tested in Accordance with:BS 1377-2:1990:Clause 4.3 and 5

i2 Analytical Ltd
Unit 8 Harrowden Road
Brackmills Industrial Estate
Northampton NN4 7EB

4041

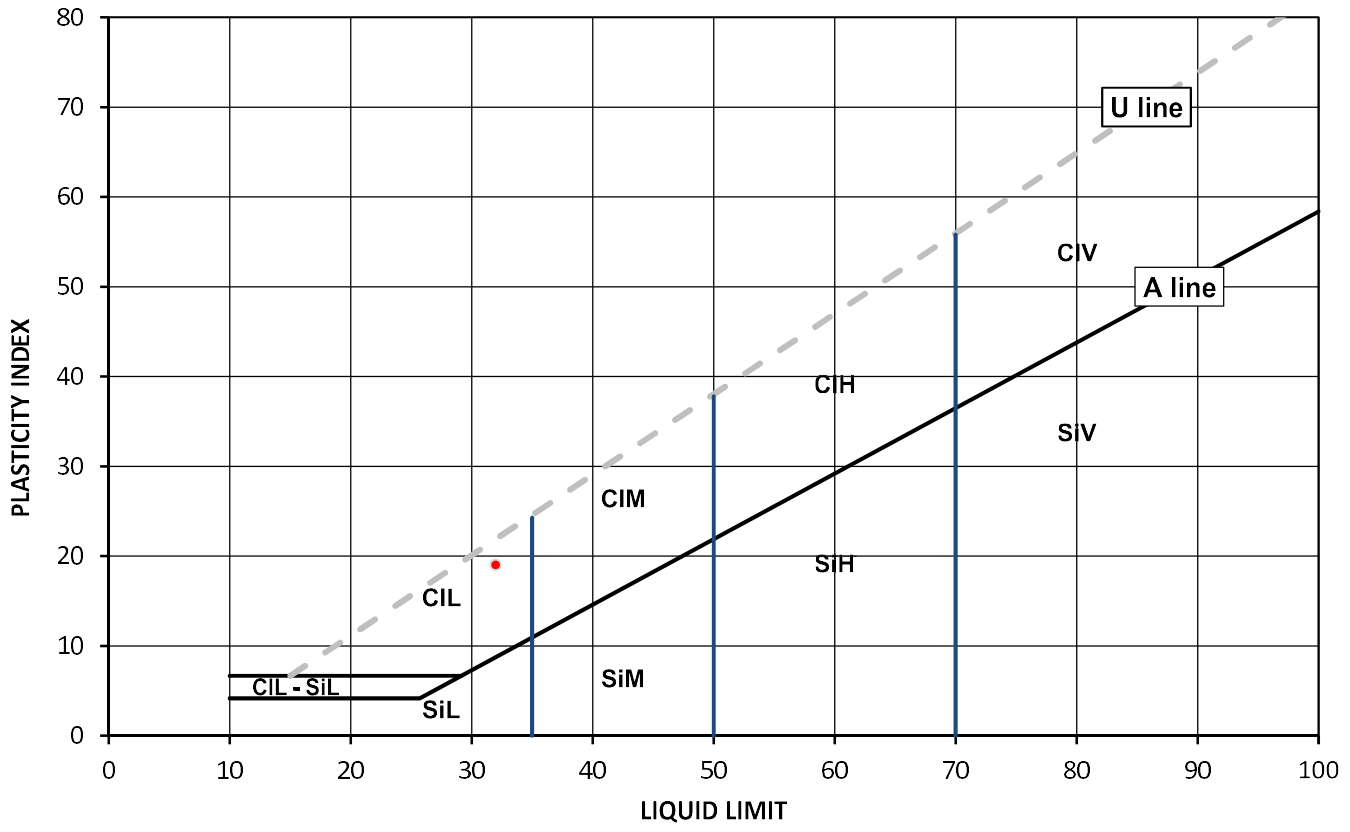
Client:	Delta-Simons	Client Reference:	591891
Client Address:	Suite C1, Joseph's Well, Hanover Walk, Leeds, LS3 1AB	Job Number:	23-74243-1
		Date Sampled:	30/11/2023
		Date Received:	05/12/2023
Contact:	Tom Bywater	Date Tested:	19/12/2023
Site Address:	UBS (Upper Brook Street)	Sampled By:	Not Given

Testing carried out at i2 Analytical Limited, ul. Pionierow, 41-711 Ruda Slaska, Poland

Test Results:

Laboratory Reference:	2907295	Depth Top [m]:	3.50
Hole No.:	DS5	Depth Base [m]:	3.80
Sample Reference:	1	Sample Type:	D
Sample Description:	Dark brown slightly gravelly very sandy CLAY		
Sample Preparation:	Tested after washing to remove >425um		

As Received Water Content [W] %	Liquid Limit [WL] %	Plastic Limit [Wp] %	Plasticity Index [Ip] %	% Passing 425µm BS Test Sieve
17	32	13	19	88



Legend, based on BS EN ISO 14688 2:2018 Geotechnical investigation and testing – Identification and classification of soil

		Plasticity		Liquid Limit
Cl	Clay	L	Low	below 35
Si	Silt	M	Medium	35 to 50
		H	High	50 to 70
		V	Very high	exceeding 70
		O	Organic	append to classification for organic material (eg ClHO)

Note: Water Content by BS 1377-2: 1990: Clause 3.2

Remarks:

Opinions and interpretations expressed herein are outside of the scope of the UKAS Accreditation. This report may not be reproduced other than in full without the prior written approval of the issuing laboratory. The results included within the report relate only to the sample(s) submitted for testing.

Signed: [redacted]

Katarzyna Banys
Junior Reporting Specialist
for and on behalf of i2 Analytical Ltd

Date Reported: 27/12/2023

GF 236.13

SUMMARY REPORT

SUMMARY OF CLASSIFICATION TEST RESULTS

Tested in Accordance with:

Water Content by BS 1377-2:1990: Clause 3.2Atterberg by BS 1377-2: 1990: Clause 4.3 (4 Point Test), Clause 4.4 (1 Point Test) and 5

i2 Analytical Ltd
Unit 8 Harrowden Road
Brackmills Industrial Estate
Northampton NN4 7EB

4041

Client: Delta-Simons

Client Address: Suite C1, Joseph's Well, Hanover Walk, Leeds, LS3 1AB

Contact: Tom Bywater

Site Address: UBS (Upper Brook Street)

Client Reference: 591891
Job Number: 23-74243-1
Date Sampled: 28/11 - 30/11/2023
Date Received: 05/12/2023
Date Tested: 19/12/2023
Sampled By: Not Given

Testing carried out at i2 Analytical Limited, ul. Pionierow, 41-711 Ruda Slaska, Poland

Test results

Laboratory Reference	Hole No.	Sample				Description	Remarks	Water Content BS 1377-2 [W]	Water Content BS EN ISO 17892-2 [W]	Atterberg				Density			Total Porosity#		
		Reference	Depth Top m	Depth Base m	Type			%	%	% Passing 425um %	WL %	Wp %	Ip %	bulk Mg/m3	dry Mg/m3	PD Mg/m3	%		
2907287	RO1	1	3.00	3.20	D	Brown gravelly SAND		13											
2907288	RO1	2	4.00	4.20	D	Brown slightly gravelly very sandy CLAY	Atterberg 4 Point	15		88	31	14	17						
2907289	RO3	1	1.50	1.80	D	Brown gravelly clayey SAND		14											
2907290	RO3	2	3.60	4.00	D	Orangish brown silty CLAY		24											
2907291	DS2	1	2.50	3.00	D	Brown very gravelly SAND		5.9											
2907292	DS3	1	1.40	1.80	D	Brown gravelly very sandy CLAY	Atterberg 4 Point	16		65	32	18	14						
2907293	DS3	2	2.50	3.00	D	Brown gravelly SAND		8.0											
2907294	DS4	1	2.20	2.40	D	Brown gravelly SAND		8.1											
2907295	DS5	1	3.50	3.80	D	Dark brown slightly gravelly very sandy CLAY	Atterberg 4 Point	17		88	32	13	19						

Note: # Non accredited; NP - Non plastic

Comments:

Opinions and interpretations expressed herein are outside of the scope of the UKAS Accreditation. This report may not be reproduced other than in full without the prior written approval of the issuing laboratory. The results included within the report relate only to the sample(s) submitted for testing.

Signed: [redacted]

Katarzyna Banys
Junior Reporting Specialist
for and on behalf of i2 Analytical Ltd

Date Reported: 27/12/2023

SUMMARY REPORT

DETERMINATION OF WATER CONTENT

Tested in Accordance with: BS 1377-2: 1990: Clause 3.2

i2 Analytical Ltd
Unit 8 Harrowden Road
Brackmills Industrial Estate
Northampton NN4 7EB

4041

Client: Delta-Simons

Client Address: Suite C1, Joseph's Well,
Hanover Walk, Leeds,
LS3 1AB

Contact: Tom Bywater

Site Address: UBS (Upper Brook Street)

Client Reference: 591891
Job Number: 23-74243-1
Date Sampled: 28/11 - 30/11/2023
Date Received: 05/12/2023
Date Tested: 19/12/2023
Sampled By: Not Given

Testing carried out at i2 Analytical Limited, ul. Pionierow, 41-711 Ruda Slaska, Poland

Test results

Laboratory Reference	Hole No.	Sample				Description	Remarks	WC	Sample preparation / Oven temperature at the time of testing			
		Reference	Depth Top m	Depth Base m	Type			%				
2907287	RO1	1	3.00	3.20	D	Brown gravelly SAND		13	Sample was quartered, oven dried at 109 °C			
2907288	RO1	2	4.00	4.20	D	Brown slightly gravelly very sandy CLAY		15	Sample was quartered, oven dried at 109 °C			
2907289	RO3	1	1.50	1.80	D	Brown gravelly clayey SAND		14	Sample was quartered, oven dried at 109 °C			
2907290	RO3	2	3.60	4.00	D	Orangish brown silty CLAY		24	Sample was quartered, oven dried at 109 °C			
2907291	DS2	1	2.50	3.00	D	Brown very gravelly SAND		5.9	Sample was quartered, oven dried at 107.3 °C			
2907292	DS3	1	1.40	1.80	D	Brown gravelly very sandy CLAY		16	Sample was quartered, oven dried at 107.3 °C			
2907293	DS3	2	2.50	3.00	D	Brown gravelly SAND		8.0	Sample was quartered, oven dried at 107.3 °C			
2907294	DS4	1	2.20	2.40	D	Brown gravelly SAND		8.1	Sample was quartered, oven dried at 107.3 °C			
2907295	DS5	1	3.50	3.80	D	Dark brown slightly gravelly very sandy CLAY		17	Sample was quartered, oven dried at 107.3 °C			

Comments:

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Signed: [redacted]

Katarzyna Banys
Junior Reporting Specialist
for and on behalf of i2 Analytical Ltd

Date Reported: 27/12/2023

SUMMARY REPORT

DETERMINATION OF POINT LOAD STRENGTH

Tested in Accordance with: ISRM: 2007, pages 125-132

i2 Analytical Ltd
Unit 8 Harrowden Road
Brackmills Industrial Estate
Northampton NN4 7EB

4041

Client: Delta-Simons

Client Address: Suite C1, Joseph's Well, Hanover Walk, Leeds, LS3 1AB

Contact: Tom Bywater

Site Address: UBS (Upper Brook Street)

Client Reference: 591891
Job Number: 23-74243-1
Date Sampled: 30/11/2023
Date Received: 05/12/2023
Date Tested: 22/12/2023
Sampled By: Not Given

Testing carried out at i2 Analytical Limited, ul. Pionierow, 41-711 Ruda Slaska, Poland

Test results

Laboratory Reference	Hole No.	Sample				Description	Remarks # (including water content if measured)	Specimen Reference	Test Type see ISRM		Failure Valid (Y/N)	Dimensions				Force P	Equivalent diameter, De	Point Load Strength Index	
		Reference	Depth Top m	Depth Base m	Type				Type (D, A, I, B)	Direction (L, P or U)		Lne mm	W mm	Dps mm	Dps' mm	kN	mm	Is MPa	Is(50) MPa
2907296	RO1	Not Given	12.00	12.40	C	Brown SANDSTONE	WC = 11.7%	1	A	U	YES	-	90.2	85.0	74.0	1.4	92.2	0.16	0.22
2907297	RO1	Not Given	12.30	12.52	C	Brown SANDSTONE	WC = 11.3%	1	A	U	YES	-	90.3	78.0	70.0	1.3	89.7	0.16	0.21
2907298	RO1	Not Given	16.20	16.37	C	Brown SANDSTONE	WC = 15.1%	1	A	U	YES	-	87.3	81.0	74.0	1.3	90.7	0.15	0.20
2907301	RO1	Not Given	17.20	17.50	C	Brown SANDSTONE	WC = 11.3%	1	A	U	YES	-	89.8	62.0	52.0	1.3	77.1	0.21	0.26
2907299	RO1	Not Given	18.00	18.17	C	Brown SANDSTONE	WC = 13.9%	1	A	U	YES	-	90.4	69.0	63.0	1.5	85.2	0.21	0.26
2907300	RO1	Not Given	18.90	19.00	C	Brown SANDSTONE	WC = 11.2%	1	A	U	YES	-	89.7	58.0	54.0	1.4	78.5	0.23	0.28
2907302	RO1	Not Given	19.39	19.50	C	Brown SANDSTONE	WC = 9.9%	1	A	U	YES	-	90.2	63.0	56.0	1.6	80.2	0.24	0.30
2907310	RO2	Not Given	11.10	11.23	C	Brown SANDSTONE	WC = 15.7%	1	A	U	YES	-	89.8	51.0	47.0	0.5	73.3	0.08	0.10
2907303	RO2	Not Given	12.60	12.80	C	Brown SANDSTONE	WC = 12.0%	1	A	U	YES	-	90.7	77.0	58.0	0.9	81.8	0.13	0.17
2907304	RO2	Not Given	14.10	14.22	C	Brown SANDSTONE	WC = 12.3%	1	A	U	YES	-	90.1	53.0	46.0	0.9	72.7	0.16	0.19

Note: # non accredited; Test Type: D - Diametral, A - Axial, I - Irregular Lump, B - Block; Direction: L - parallel to planes of weakness, P - perpendicular to planes of weakness, U - unknown or random; Dimensions: Dps - Distance between platens (platen separation), Dps' - at failure (see ISRM note 6), Lne - Length from platens to nearest free end W - Width of shortest dimension perpendicular to load, P; Detailed legend for test and dimensions, based on ISRM, is shown above; Size factor, F = (De/50)0.45 for all tests

Equipment No.: i2 4341 Calibration Date: 14/03/2023 - 14/03/2024

Comments:

Signed: [redacted]

Katarzyna Banys
Junior Reporting Specialist
for and on behalf of i2 Analytical Ltd

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Date Reported: 27/12/2023

GF 134.15

SUMMARY REPORT

DETERMINATION OF POINT LOAD STRENGTH

Tested in Accordance with: ISRM: 2007, pages 125-132

i2 Analytical Ltd
Unit 8 Harrowden Road
Brackmills Industrial Estate
Northampton NN4 7EB

4041

Client: Delta-Simons

Client Address: Suite C1, Joseph's Well, Hanover Walk, Leeds, LS3 1AB

Contact: Tom Bywater

Site Address: UBS (Upper Brook Street)

Client Reference: 591891
Job Number: 23-74243-1
Date Sampled: 30/11/2023
Date Received: 05/12/2023
Date Tested: 22/12/2023
Sampled By: Not Given

Testing carried out at i2 Analytical Limited, ul. Pionierow, 41-711 Ruda Slaska, Poland

Test results

Laboratory Reference	Hole No.	Sample				Description	Remarks # (including water content if measured)	Specimen Reference	Test Type see ISRM		Failure Valid (Y/N)	Dimensions				Force P	Equivalent diameter, De	Point Load Strength Index	
		Reference	Depth Top m	Depth Base m	Type				Type (D, A, I, B)	Direction (L, P or U)		Lne mm	W mm	Dps mm	Dps' mm	kN	mm	Is MPa	Is(50) MPa
2907307	RO2	Not Given	15.00	15.18	C	Brown SANDSTONE	WC = 13.7%	1	A	U	YES	-	89.3	84.0	76.0	0.9	92.9	0.10	0.13
2907309	RO2	Not Given	16.80	17.00	C	Brown SANDSTONE	WC = 12.6%	1	A	U	YES	-	90.5	65.0	61.0	0.9	83.9	0.12	0.15
2907308	RO2	Not Given	17.00	17.24	C	Brown SANDSTONE	WC = 12.3%	1	A	U	YES	-	89.3	75.0	67.0	1.2	87.3	0.15	0.19
2907305	RO2	Not Given	18.80	19.00	C	Brown SANDSTONE	WC = 12.7%	1	A	U	YES	-	90.0	72.0	61.0	1.0	83.6	0.14	0.18
2907306	RO2	Not Given	19.60	19.77	C	Brown SANDSTONE	WC = 13.3%	1	A	U	YES	-	90.1	66.0	58.0	0.8	81.6	0.12	0.15
2907311	RO3	Not Given	10.70	10.90	C	Brown SANDSTONE	WC = 15.5%	1	A	U	YES	-	89.3	55.0	51.0	0.9	76.2	0.15	0.18
2907312	RO3	Not Given	12.30	12.52	C	Brown SANDSTONE	WC = 12.1%	1	A	U	YES	-	90.9	55.0	61.0	1.3	84.0	0.18	0.23
2907313	RO3	Not Given	12.86	13.00	C	Brown SANDSTONE	WC = 13.4%	1	A	U	YES	-	90.1	58.0	51.0	1.4	76.5	0.23	0.28
2907314	RO3	Not Given	14.30	14.42	C	Brown SANDSTONE	WC = 11.9%	1	A	U	YES	-	89.8	62.0	56.0	1.8	80.0	0.28	0.35
2907315	RO3	Not Given	15.32	15.46	C	Brown SANDSTONE	WC = 10.5%	1	A	U	YES	-	90.5	53.0	49.0	2.0	75.1	0.35	0.41

Note: # non accredited; Test Type: D - Diametral, A - Axial, I - Irregular Lump, B - Block; Direction: L - parallel to planes of weakness, P - perpendicular to planes of weakness, U - unknown or random; Dimensions: Dps - Distance between platens (platen separation), Dps' - at failure (see ISRM note 6), Lne - Length from platens to nearest free end W - Width of shortest dimension perpendicular to load, P; Detailed legend for test and dimensions, based on ISRM, is shown above; Size factor, F = (De/50)0.45 for all tests

Equipment No.: i2 4341 Calibration Date: 14/03/2023 - 14/03/2024

Comments:

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Signed: [redacted]

Katarzyna Banys
Junior Reporting Specialist
for and on behalf of i2 Analytical Ltd

Date Reported: 27/12/2023

SUMMARY REPORT

DETERMINATION OF POINT LOAD STRENGTH

Tested in Accordance with: ISRM: 2007, pages 125-132

i2 Analytical Ltd
Unit 8 Harrowden Road
Brackmills Industrial Estate
Northampton NN4 7EB

4041

Client: Delta-Simons

Client Address: Suite C1, Joseph's Well,
Hanover Walk, Leeds,
LS3 1AB

Contact: Tom Bywater

Site Address: UBS (Upper Brook Street)

Testing carried out at i2 Analytical Limited, ul. Pionierow, 41-711 Ruda Slaska, Poland

Client Reference: 591891
Job Number: 23-74243-1
Date Sampled: 30/11/2023
Date Received: 05/12/2023
Date Tested: 22/12/2023
Sampled By: Not Given

Test results

Laboratory Reference	Hole No.	Sample				Description	Remarks # (including water content if measured)	Specimen Reference	Test Type see ISRM		Failure Valid (Y/N)	Dimensions				Force P	Equivalent diameter, De	Point Load Strength Index	
		Reference	Depth Top	Depth Base	Type				Type (D, A, I, B)	Direction (L, P or U)		Lne	W	Dps	Dps'			Is	Is(50)
			m	m								mm	mm	mm	mm	kN	mm	MPa	MPa
2907317	RO3	Not Given	16.50	16.73	C	Brown SANDSTONE	WC = 15.4%	1	A	U	YES	-	89.2	69.0	62.0	1.4	83.9	0.19	0.24
2907316	RO3	Not Given	17.00	17.18	C	Brown SANDSTONE	WC = 13.7%	1	A	U	YES	-	90.8	52.0	47.0	1.1	73.7	0.19	0.23
2907319	RO3	Not Given	20.26	20.40	C	Brown SANDSTONE	WC = 12.4%	1	A	U	YES	-	90.1	58.0	39.0	1.9	66.9	0.41	0.47

Note: # non accredited; Test Type: D - Diametral, A - Axial, I - Irregular Lump, B - Block; Direction: L - parallel to planes of weakness, P - perpendicular to planes of weakness, U - unknown or random;
Dimensions: Dps - Distance between platens (platen separation), Dps' - at failure (see ISRM note 6), Lne - Length from platens to nearest free end W - Width of shortest dimension perpendicular to load, P;
Detailed legend for test and dimensions, based on ISRM, is shown above; Size factor, F = (De/50)0.45 for all tests

Equipment No.: i2 4341 Calibration Date: 14/03/2023 - 14/03/2024

Comments:

Opinions and interpretations expressed herein are outside of the scope of the UKAS Accreditation. This report may not be reproduced other than in full without the prior written approval of the issuing laboratory. The results included within the report relate only to the sample(s) submitted for testing.

Signed: [redacted]

Katarzyna Banys
Junior Reporting Specialist
for and on behalf of i2 Analytical Ltd

Date Reported: 27/12/2023

GF 134.15

SUMMARY REPORT

DETERMINATION OF UNIAXIAL COMPRESSIVE STRENGTH OF ROCK MATERIALS

Tested in Accordance with: ISRM, 2007, p153, part 1

i2 Analytical Ltd
Unit 8 Harrowden Road
Brackmills Industrial Estate
Northampton NN4 7EB

4041

Client: Delta-Simons

Client Address: Suite C1, Joseph's Well,
Hanover Walk, Leeds,
LS3 1AB

Contact: Tom Bywater

Site Address: UBS (Upper Brook Street)

Testing carried out at i2 Analytical Limited, ul. Pionierow, 41-711 Ruda Slaska, Poland

Client Reference: 591891
Job Number: 23-74243-1
Date Sampled: 30/11/2023
Date Received: 05/12/2023
Date Tested: 22/12/2023
Sampled By: Not Given

Test results

Laboratory Reference	Hole No.	Sample				Description	Remarks	Specimen Dimensions (2)				Bulk density (2)	Water Content (1)	Uniaxial Compression (3)			
		Reference	Depth Top m	Depth Base m	Type			Diameter mm	Length mm	H/D	Orientation of sample	Mg/m3	%	Condition	Stress Rate Mpa/s	Mode of failure	UCS Mpa
2907318	RO3	Not Given	19.80	20.10	C	Brown SANDSTONE	Duration of test fell below time specified in ISRM method, 2007, p153, part1.	89.7	233.7	2.6	Vertical	2.16	12.9	as received	0.0158	S	4.56

Note: 1 - ISRM p87 test 1, water content at 105 ± 3 °C - not accredited, specimen as tested for UCS, 2 - ISRM p86 clause (vii), Caliper method used for determination of bulk volume and derivation of bulk density, 3 - ISRM p153 part 1, determination of Uniaxial Compressive Strength (UCS) of Rock Materials, above notes apply unless annotated otherwise in the remarks. Compaction machine: VJ Tech AUTOCON - VJT 51-3011; Mode of failure legend: S - Single shear, MS - multiple shear, AC - Axial cleavage, F - Fragmented

Comments:

Opinions and interpretations expressed herein are outside of the scope of the UKAS Accreditation. This report may not be reproduced other than in full without the prior written approval of the issuing laboratory. The results included within the report relate only to the sample(s) submitted for testing.

Signed: [redacted]

Katarzyna Banys
Junior Reporting Specialist
for and on behalf of i2 Analytical Ltd

Date Reported: 27/12/2023

GF 223.16

Appendix D – Soil Chemical Analysis Results

Tom Bywater
Delta-Simons
Suite C1
Joseph's Well
Hanover Walk
Leeds
LS3 1AB

[redacted]

i2 Analytical Ltd.
7 Woodshots Meadow,
Croxley Green
Business Park,
Watford,
Herts,
WD18 8YS

t: 01923 225404
f: 01923 237404
e: reception@i2analytical.com

Analytical Report Number : 23-73170

Project / Site name:	Upper Brook Street	**Samples received on:**	05/12/2023
Your job number:	591891	**Samples instructed on/ Analysis started on:**	05/12/2023
Your order number:	DS76861	**Analysis completed by:**	13/12/2023
Report Issue Number:	1	**Report issued on:**	13/12/2023
Samples Analysed:	10 soil samples		

[redacted]

Signed:

Joanna Wawrzeczko
Senior Reporting Specialist
For & on behalf of i2 Analytical Ltd.

Standard Geotechnical, Asbestos and Chemical Testing Laboratory located at: ul. Pionierów 39, 41-711 Ruda Śląska, Poland.

Accredited tests are defined within the report, opinions and interpretations expressed herein are outside the scope of accreditation.

Standard sample disposal times, unless otherwise agreed with the laboratory, are :

soils	- 4 weeks from reporting
leachates	- 2 weeks from reporting
waters	- 2 weeks from reporting
asbestos	- 6 months from reporting

Excel copies of reports are only valid when accompanied by this PDF certificate.

Any assessments of compliance with specifications are based on actual analytical results with no contribution from uncertainty of measurement.
Application of uncertainty of measurement would provide a range within which the true result lies.
An estimate of measurement uncertainty can be provided on request.

This certificate should not be reproduced, except in full, without the express permission of the laboratory.
The results included within the report relate only to the sample(s) submitted for testing.

Analytical Report Number: 23-73170
Project / Site name: Upper Brook Street
Your Order No: DS76861

Lab Sample Number				2901119	2901120	2901121	2901122	2901123
Sample Reference				RO1	RO2	RO3	DS1	DS2
Sample Number				ES2	ES2	ES1	ES1	ES2
Depth (m)				1.00-1.20	0.80-1.00	0.30-0.70	0.60-1.00	1.00-2.00
Date Sampled				27/11/2023	27/11/2023	27/11/2023	30/11/2023	30/11/2023
Time Taken				None Supplied	None Supplied	None Supplied	None Supplied	None Supplied
Analytical Parameter (Soil Analysis)	**Units**	**Limit of detection**	**Accreditation Status**					
Stone Content	%	0.1	NONE	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Moisture Content	%	0.01	NONE	13	18	14	15	13
Total mass of sample received	kg	0.001	NONE	0.8	0.8	0.8	0.8	0.8
Asbestos in Soil Screen / Identification Name	Type	N/A	ISO 17025	-	-	Amosite- Loose Fibrous Debris	-	-
Asbestos in Soil	Type	N/A	ISO 17025	Not-detected	Not-detected	Detected	Not-detected	Not-detected
Asbestos Analyst ID	N/A	N/A	N/A	IZJ	DSA	DSA	DSA	DSA

General Inorganics

pH - Automated	pH Units	N/A	MCERTS	8.2	8.3	11.6	8.6	7.9
Total Cyanide	mg/kg	1	MCERTS	-	-	< 1.0	-	-
Complex Cyanide	mg/kg	1	MCERTS	-	-	< 1.0	-	-
Free Cyanide	mg/kg	1	MCERTS	-	-	< 1.0	-	-
Water Soluble Sulphate as SO4 16hr extraction (2:1)	mg/kg	2.5	MCERTS	370	3300	260	620	490
Water Soluble SO4 16hr extraction (2:1 Leachate Equivalent)	g/l	0.00125	MCERTS	0.183	1.66	0.132	0.312	0.246
Water Soluble SO4 16hr extraction (2:1 Leachate Equivalent)	mg/l	1.25	MCERTS	183	1660	132	312	246
Total Organic Carbon (TOC) - Automated	%	0.1	MCERTS	1.6	1.9	1.1	1.1	0.7

Phenols by GC-MS

Phenol	mg/kg	0.2	ISO 17025	-	-	< 0.2	-	-
2,4,5-Trichlorophenol	mg/kg	0.2	NONE	-	-	< 0.2	-	-
2,4,6-Trichlorophenol	mg/kg	0.1	NONE	-	-	< 0.1	-	-
2,4-Dichlorophenol	mg/kg	0.3	MCERTS	-	-	< 0.3	-	-
2,4-Dimethylphenol	mg/kg	0.3	MCERTS	-	-	< 0.3	-	-
2-Chlorophenol	mg/kg	0.1	MCERTS	-	-	< 0.1	-	-
2-Methylphenol	mg/kg	0.3	MCERTS	-	-	< 0.3	-	-
2-Nitrophenol	mg/kg	0.3	NONE	-	-	< 0.3	-	-
4-Chloro-3-methylphenol	mg/kg	0.1	NONE	-	-	< 0.1	-	-
4-Methylphenol	mg/kg	0.2	NONE	-	-	< 0.2	-	-

Total Phenols

Total Phenols (GC-MS)	mg/kg	1	NONE	-	-	< 1.0	-	-

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The results included within the report relate only to the sample(s) submitted for testing.

Analytical Report Number: 23-73170
Project / Site name: Upper Brook Street
Your Order No: DS76861

Lab Sample Number				2901119	2901120	2901121	2901122	2901123
Sample Reference				RO1	RO2	RO3	DS1	DS2
Sample Number				ES2	ES2	ES1	ES1	ES2
Depth (m)				1.00-1.20	0.80-1.00	0.30-0.70	0.60-1.00	1.00-2.00
Date Sampled				27/11/2023	27/11/2023	27/11/2023	30/11/2023	30/11/2023
Time Taken				None Supplied	None Supplied	None Supplied	None Supplied	None Supplied
Analytical Parameter (Soil Analysis)	**Units**	**Limit of detection**	**Accreditation Status**					
Speciated PAHs								
Naphthalene	mg/kg	0.05	MCERTS	2.2	1.8	5.4	0.11	0.19
Acenaphthylene	mg/kg	0.05	MCERTS	0.17	0.35	0.66	< 0.05	< 0.05
Acenaphthene	mg/kg	0.05	MCERTS	3.8	3.9	0.48	0.3	0.06
Fluorene	mg/kg	0.05	MCERTS	3.1	2.7	0.75	0.17	0.05
Phenanthrene	mg/kg	0.05	MCERTS	24	25	2.2	1.8	0.55
Anthracene	mg/kg	0.05	MCERTS	5.9	6.1	0.38	0.4	0.09
Fluoranthene	mg/kg	0.05	MCERTS	24	33	3.3	3.2	0.67
Pyrene	mg/kg	0.05	MCERTS	22	30	3.6	3.1	0.65
Benzo(a)anthracene	mg/kg	0.05	MCERTS	9.3	13	1.9	1.5	0.32
Chrysene	mg/kg	0.05	MCERTS	9.4	13	2.6	1.6	0.35
Benzo(b)fluoranthene	mg/kg	0.05	ISO 17025	9.3	15	3.7	2	0.44
Benzo(k)fluoranthene	mg/kg	0.05	ISO 17025	4.4	5.4	1.8	0.63	0.12
Benzo(a)pyrene	mg/kg	0.05	MCERTS	9.1	14	3.1	1.6	0.33
Indeno(1,2,3-cd)pyrene	mg/kg	0.05	MCERTS	3.8	5.4	1.8	0.86	0.19
Dibenz(a,h)anthracene	mg/kg	0.05	MCERTS	< 0.05	1.6	0.53	0.22	0.06
Benzo(ghi)perylene	mg/kg	0.05	MCERTS	4.1	6.1	2	0.94	0.21
Total PAH								
Speciated Total EPA-16 PAHs	mg/kg	0.8	ISO 17025	134	176	34.1	18.2	4.28
Heavy Metals / Metalloids								
Arsenic (aqua regia extractable)	mg/kg	1	MCERTS	19	19	7.2	39	17
Cadmium (aqua regia extractable)	mg/kg	0.2	MCERTS	0.9	1.3	0.5	< 0.2	< 0.2
Chromium (hexavalent)	mg/kg	1.8	MCERTS	< 1.8	< 1.8	< 1.8	< 1.8	< 1.8
Chromium (III)	mg/kg	1	NONE	27	35	14	25	13
Chromium (aqua regia extractable)	mg/kg	1	MCERTS	27	36	14	25	13
Copper (aqua regia extractable)	mg/kg	1	MCERTS	85	150	33	48	82
Lead (aqua regia extractable)	mg/kg	1	MCERTS	250	230	99	230	470
Mercury (aqua regia extractable)	mg/kg	0.3	MCERTS	< 0.3	< 0.3	< 0.3	< 0.3	0.8
Nickel (aqua regia extractable)	mg/kg	1	MCERTS	29	27	15	33	11
Zinc (aqua regia extractable)	mg/kg	1	MCERTS	170	370	96	95	120
Monoaromatics & Oxygenates								
Benzene	mg/kg	0.005	MCERTS	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Toluene	mg/kg	0.005	MCERTS	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Ethylbenzene	mg/kg	0.005	MCERTS	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
p & m-xylene	mg/kg	0.005	MCERTS	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
o-xylene	mg/kg	0.005	MCERTS	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
MTBE (Methyl Tertiary Butyl Ether)	mg/kg	0.005	NONE	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005

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The results included within the report relate only to the sample(s) submitted for testing.

Analytical Report Number: 23-73170
Project / Site name: Upper Brook Street
Your Order No: DS76861

Lab Sample Number				2901119	2901120	2901121	2901122	2901123
Sample Reference				RO1	RO2	RO3	DS1	DS2
Sample Number				ES2	ES2	ES1	ES1	ES2
Depth (m)				1.00-1.20	0.80-1.00	0.30-0.70	0.60-1.00	1.00-2.00
Date Sampled				27/11/2023	27/11/2023	27/11/2023	30/11/2023	30/11/2023
Time Taken				None Supplied	None Supplied	None Supplied	None Supplied	None Supplied
Analytical Parameter (Soil Analysis)	**Units**	**Limit of detection**	**Accreditation Status**					
Petroleum Hydrocarbons								
TPH-CWG - Aliphatic >EC5 - EC6 HS_1D_AL	mg/kg	0.02	NONE	< 0.020	< 0.020	< 0.020	< 0.020	< 0.020
TPH-CWG - Aliphatic >EC6 - EC8 HS_1D_AL	mg/kg	0.02	NONE	< 0.020	< 0.020	< 0.020	< 0.020	< 0.020
TPH-CWG - Aliphatic >EC8 - EC10 HS_1D_AL	mg/kg	0.05	NONE	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050
TPH-CWG - Aliphatic >EC10 - EC12 EH_CU_1D_AL	mg/kg	1	MCERTS	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
TPH-CWG - Aliphatic >EC12 - EC16 EH_CU_1D_AL	mg/kg	2	MCERTS	3.3	< 2.0	2.1	< 2.0	< 2.0
TPH-CWG - Aliphatic >EC16 - EC21 EH_CU_1D_AL	mg/kg	8	MCERTS	< 8.0	< 8.0	< 8.0	< 8.0	< 8.0
TPH-CWG - Aliphatic >EC21 - EC35 EH_CU_1D_AL	mg/kg	8	MCERTS	16	43	< 8.0	< 8.0	< 8.0
TPH-CWG - Aliphatic >EC35 - EC40 EH_CU_1D_AL	mg/kg	10	NONE	< 10	< 10	11	< 10	< 10
TPH-CWG - Aliphatic (EC5 - EC35) EH_CU+HS_1D_AL	mg/kg	10	NONE	24	49	< 10	< 10	< 10
TPH-CWG - Aromatic >EC5 - EC7 HS_1D_AR	mg/kg	0.01	NONE	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
TPH-CWG - Aromatic >EC7 - EC8 HS_1D_AR	mg/kg	0.01	NONE	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
TPH-CWG - Aromatic >EC8 - EC10 HS_1D_AR	mg/kg	0.05	NONE	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050
TPH-CWG - Aromatic >EC10 - EC12 EH_CU_1D_AR	mg/kg	1	MCERTS	1.2	< 1.0	2.7	< 1.0	< 1.0
TPH-CWG - Aromatic >EC12 - EC16 EH_CU_1D_AR	mg/kg	2	MCERTS	9.5	15	4.7	< 2.0	< 2.0
TPH-CWG - Aromatic >EC16 - EC21 EH_CU_1D_AR	mg/kg	10	MCERTS	42	66	20	< 10	< 10
TPH-CWG - Aromatic >EC21 - EC35 EH_CU_1D_AR	mg/kg	10	MCERTS	48	81	18	10	< 10
TPH-CWG - Aromatic >EC35 - EC40 EH_CU_1D_AR	mg/kg	10	NONE	< 10	13	16	< 10	< 10
TPH-CWG - Aromatic (EC5 - EC35) EH_CU+HS_1D_AR	mg/kg	10	NONE	100	160	45	17	< 10
TPH (C35 - C40) EH_CU_1D_TOTAL	mg/kg	10	NONE	13	20	28	< 10	< 10
VOCs								
Chloromethane	mg/kg	0.005	ISO 17025	-	-	-	< 0.0050	< 0.0050
Chloroethane	mg/kg	0.005	NONE	-	-	-	< 0.0050	< 0.0050
Bromomethane	mg/kg	0.005	ISO 17025	-	-	-	< 0.0050	< 0.0050
Vinyl Chloride	mg/kg	0.005	NONE	-	-	-	< 0.0050	< 0.0050
Trichlorofluoromethane	mg/kg	0.005	NONE	-	-	-	< 0.0050	< 0.0050
1,1-Dichloroethene	mg/kg	0.005	NONE	-	-	-	< 0.0050	< 0.0050
1,1,2-Trichloro 1,2,2-Trifluoroethane	mg/kg	0.005	NONE	-	-	-	< 0.0050	< 0.0050
Cis-1,2-dichloroethene	mg/kg	0.005	ISO 17025	-	-	-	< 0.0050	< 0.0050
MTBE (Methyl Tertiary Butyl Ether)	mg/kg	0.005	NONE	-	-	-	< 0.0050	< 0.0050
1,1-Dichloroethane	mg/kg	0.005	ISO 17025	-	-	-	< 0.0050	< 0.0050
2,2-Dichloropropane	mg/kg	0.005	ISO 17025	-	-	-	< 0.0050	< 0.0050
Trichloromethane	mg/kg	0.005	NONE	-	-	-	< 0.0050	< 0.0050
1,1,1-Trichloroethane	mg/kg	0.005	ISO 17025	-	-	-	< 0.0050	< 0.0050
1,2-Dichloroethane	mg/kg	0.005	ISO 17025	-	-	-	< 0.0050	< 0.0050
1,1-Dichloropropene	mg/kg	0.005	ISO 17025	-	-	-	< 0.0050	< 0.0050
Trans 1,2-dichloroethylene	mg/kg	0.005	NONE	-	-	-	< 0.0050	< 0.0050
Benzene	mg/kg	0.005	MCERTS	-	-	-	< 0.0050	< 0.0050
Tetrachloromethane	mg/kg	0.005	NONE	-	-	-	< 0.0050	< 0.0050
1,2-Dichloropropane	mg/kg	0.005	ISO 17025	-	-	-	< 0.0050	< 0.0050
Trichloroethene	mg/kg	0.005	ISO 17025	-	-	-	< 0.0050	< 0.0050
Dibromomethane	mg/kg	0.005	ISO 17025	-	-	-	< 0.0050	< 0.0050
Bromodichloromethane	mg/kg	0.005	ISO 17025	-	-	-	< 0.0050	< 0.0050
Cis-1,3-dichloropropene	mg/kg	0.005	ISO 17025	-	-	-	< 0.0050	< 0.0050
Trans-1,3-dichloropropene	mg/kg	0.005	ISO 17025	-	-	-	< 0.0050	< 0.0050
Toluene	mg/kg	0.005	MCERTS	-	-	-	< 0.0050	< 0.0050
1,1,2-Trichloroethane	mg/kg	0.005	ISO 17025	-	-	-	< 0.0050	< 0.0050
1,3-Dichloropropane	mg/kg	0.005	ISO 17025	-	-	-	< 0.0050	< 0.0050
Dibromochloromethane	mg/kg	0.005	ISO 17025	-	-	-	< 0.0050	< 0.0050

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Analytical Report Number: 23-73170
Project / Site name: Upper Brook Street
Your Order No: DS76861

Lab Sample Number				2901119	2901120	2901121	2901122	2901123
Sample Reference				RO1	RO2	RO3	DS1	DS2
Sample Number				ES2	ES2	ES1	ES1	ES2
Depth (m)				1.00-1.20	0.80-1.00	0.30-0.70	0.60-1.00	1.00-2.00
Date Sampled				27/11/2023	27/11/2023	27/11/2023	30/11/2023	30/11/2023
Time Taken				None Supplied	None Supplied	None Supplied	None Supplied	None Supplied
Analytical Parameter (Soil Analysis)	Units	Limit of detection	Accreditation Status					
Tetrachloroethene	mg/kg	0.005	NONE	-	-	-	< 0.0050	< 0.0050
1,2-Dibromoethane	mg/kg	0.005	ISO 17025	-	-	-	< 0.0050	< 0.0050
Chlorobenzene	mg/kg	0.005	ISO 17025	-	-	-	< 0.0050	< 0.0050
1,1,1,2-Tetrachloroethane	mg/kg	0.005	ISO 17025	-	-	-	< 0.0050	< 0.0050
Ethylbenzene	mg/kg	0.005	MCERTS	-	-	-	< 0.0050	< 0.0050
p & m-Xylene	mg/kg	0.005	MCERTS	-	-	-	< 0.0050	< 0.0050
Styrene	mg/kg	0.005	ISO 17025	-	-	-	< 0.005	< 0.005
Tribromomethane	mg/kg	0.005	NONE	-	-	-	< 0.0050	< 0.0050
o-Xylene	mg/kg	0.005	MCERTS	-	-	-	< 0.0050	< 0.0050
1,1,2,2-Tetrachloroethane	mg/kg	0.005	ISO 17025	-	-	-	< 0.0050	< 0.0050
Isopropylbenzene	mg/kg	0.005	ISO 17025	-	-	-	< 0.0050	< 0.0050
Bromobenzene	mg/kg	0.005	NONE	-	-	-	< 0.0050	< 0.0050
n-Propylbenzene	mg/kg	0.005	ISO 17025	-	-	-	< 0.0050	< 0.0050
2-Chlorotoluene	mg/kg	0.005	ISO 17025	-	-	-	< 0.0050	< 0.0050
4-Chlorotoluene	mg/kg	0.005	ISO 17025	-	-	-	< 0.0050	< 0.0050
1,3,5-Trimethylbenzene	mg/kg	0.005	ISO 17025	-	-	-	< 0.0050	< 0.0050
tert-Butylbenzene	mg/kg	0.005	ISO 17025	-	-	-	< 0.0050	< 0.0050
1,2,4-Trimethylbenzene	mg/kg	0.005	ISO 17025	-	-	-	< 0.0050	< 0.0050
sec-Butylbenzene	mg/kg	0.005	ISO 17025	-	-	-	< 0.0050	< 0.0050
1,3-Dichlorobenzene	mg/kg	0.005	ISO 17025	-	-	-	< 0.0050	< 0.0050
p-Isopropyltoluene	mg/kg	0.005	ISO 17025	-	-	-	< 0.0050	< 0.0050
1,2-Dichlorobenzene	mg/kg	0.005	ISO 17025	-	-	-	< 0.0050	< 0.0050
1,4-Dichlorobenzene	mg/kg	0.005	ISO 17025	-	-	-	< 0.0050	< 0.0050
Butylbenzene	mg/kg	0.005	NONE	-	-	-	< 0.0050	< 0.0050
1,2-Dibromo-3-chloropropane	mg/kg	0.005	ISO 17025	-	-	-	< 0.0050	< 0.0050
1,2,4-Trichlorobenzene	mg/kg	0.005	ISO 17025	-	-	-	< 0.0050	< 0.0050
Hexachlorobutadiene	mg/kg	0.005	NONE	-	-	-	< 0.0050	< 0.0050
1,2,3-Trichlorobenzene	mg/kg	0.005	ISO 17025	-	-	-	< 0.0050	< 0.0050

SVOCs

Aniline	mg/kg	0.1	NONE	-	-	-	< 0.1	< 0.1
Phenol	mg/kg	0.2	ISO 17025	-	-	-	< 0.2	< 0.2
2-Chlorophenol	mg/kg	0.1	MCERTS	-	-	-	< 0.1	< 0.1
Bis(2-chloroethyl)ether	mg/kg	0.2	MCERTS	-	-	-	< 0.2	< 0.2
1,3-Dichlorobenzene	mg/kg	0.2	MCERTS	-	-	-	< 0.2	< 0.2
1,2-Dichlorobenzene	mg/kg	0.1	MCERTS	-	-	-	< 0.1	< 0.1
1,4-Dichlorobenzene	mg/kg	0.2	MCERTS	-	-	-	< 0.2	< 0.2
Bis(2-chloroisopropyl)ether	mg/kg	0.1	MCERTS	-	-	-	< 0.1	< 0.1
2-Methylphenol	mg/kg	0.3	MCERTS	-	-	-	< 0.3	< 0.3
Hexachloroethane	mg/kg	0.05	ISO 17025	-	-	-	< 0.05	< 0.05
Nitrobenzene	mg/kg	0.3	MCERTS	-	-	-	< 0.3	< 0.3
4-Methylphenol	mg/kg	0.2	NONE	-	-	-	< 0.2	< 0.2
Isophorone	mg/kg	0.2	MCERTS	-	-	-	< 0.2	< 0.2
2-Nitrophenol	mg/kg	0.3	NONE	-	-	-	< 0.3	< 0.3
2,4-Dimethylphenol	mg/kg	0.3	MCERTS	-	-	-	< 0.3	< 0.3
Bis(2-chloroethoxy)methane	mg/kg	0.3	MCERTS	-	-	-	< 0.3	< 0.3
1,2,4-Trichlorobenzene	mg/kg	0.3	MCERTS	-	-	-	< 0.3	< 0.3
Naphthalene	mg/kg	0.05	MCERTS	-	-	-	0.11	0.19
2,4-Dichlorophenol	mg/kg	0.3	MCERTS	-	-	-	< 0.3	< 0.3
4-Chloroaniline	mg/kg	0.1	NONE	-	-	-	< 0.1	< 0.1
Hexachlorobutadiene	mg/kg	0.1	MCERTS	-	-	-	< 0.1	< 0.1
4-Chloro-3-methylphenol	mg/kg	0.1	NONE	-	-	-	< 0.1	< 0.1

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Analytical Report Number: 23-73170
Project / Site name: Upper Brook Street
Your Order No: DS76861

Lab Sample Number				2901119	2901120	2901121	2901122	2901123
Sample Reference				RO1	RO2	RO3	DS1	DS2
Sample Number				ES2	ES2	ES1	ES1	ES2
Depth (m)				1.00-1.20	0.80-1.00	0.30-0.70	0.60-1.00	1.00-2.00
Date Sampled				27/11/2023	27/11/2023	27/11/2023	30/11/2023	30/11/2023
Time Taken				None Supplied	None Supplied	None Supplied	None Supplied	None Supplied
Analytical Parameter (Soil Analysis)	Units	Limit of detection	Accreditation Status					
2,4,6-Trichlorophenol	mg/kg	0.1	NONE	-	-	-	< 0.1	< 0.1
2,4,5-Trichlorophenol	mg/kg	0.2	NONE	-	-	-	< 0.2	< 0.2
2-Methylnaphthalene	mg/kg	0.1	NONE	-	-	-	< 0.1	0.1
2-Chloronaphthalene	mg/kg	0.1	MCERTS	-	-	-	< 0.1	< 0.1
Dimethylphthalate	mg/kg	0.1	MCERTS	-	-	-	< 0.1	< 0.1
2,6-Dinitrotoluene	mg/kg	0.1	NONE	-	-	-	< 0.1	< 0.1
Acenaphthylene	mg/kg	0.05	MCERTS	-	-	-	< 0.05	< 0.05
Acenaphthene	mg/kg	0.05	MCERTS	-	-	-	0.3	0.06
2,4-Dinitrotoluene	mg/kg	0.2	NONE	-	-	-	< 0.2	< 0.2
Dibenzofuran	mg/kg	0.2	MCERTS	-	-	-	< 0.2	< 0.2
4-Chlorophenyl phenyl ether	mg/kg	0.3	MCERTS	-	-	-	< 0.3	< 0.3
Diethyl phthalate	mg/kg	0.2	MCERTS	-	-	-	< 0.2	< 0.2
4-Nitroaniline	mg/kg	0.2	NONE	-	-	-	< 0.2	< 0.2
Fluorene	mg/kg	0.05	MCERTS	-	-	-	0.17	0.05
Azobenzene	mg/kg	0.3	NONE	-	-	-	< 0.3	< 0.3
Bromophenyl phenyl ether	mg/kg	0.2	MCERTS	-	-	-	< 0.2	< 0.2
Hexachlorobenzene	mg/kg	0.3	MCERTS	-	-	-	< 0.3	< 0.3
Phenanthrene	mg/kg	0.05	MCERTS	-	-	-	1.8	0.55
Anthracene	mg/kg	0.05	MCERTS	-	-	-	0.4	0.09
Carbazole	mg/kg	0.3	MCERTS	-	-	-	< 0.3	< 0.3
Dibutyl phthalate	mg/kg	0.2	NONE	-	-	-	< 0.2	< 0.2
Anthraquinone	mg/kg	0.3	NONE	-	-	-	< 0.3	< 0.3
Fluoranthene	mg/kg	0.05	MCERTS	-	-	-	3.2	0.67
Pyrene	mg/kg	0.05	MCERTS	-	-	-	3.1	0.65
Butyl benzyl phthalate	mg/kg	0.3	NONE	-	-	-	< 0.3	< 0.3
Benzo(a)anthracene	mg/kg	0.05	MCERTS	-	-	-	1.5	0.32
Chrysene	mg/kg	0.05	MCERTS	-	-	-	1.6	0.35
Benzo(b)fluoranthene	mg/kg	0.05	ISO 17025	-	-	-	2	0.44
Benzo(k)fluoranthene	mg/kg	0.05	ISO 17025	-	-	-	0.63	0.12
Benzo(a)pyrene	mg/kg	0.05	MCERTS	-	-	-	1.6	0.33
Indeno(1,2,3-cd)pyrene	mg/kg	0.05	MCERTS	-	-	-	0.86	0.19
Dibenz(a,h)anthracene	mg/kg	0.05	MCERTS	-	-	-	0.22	0.06
Benzo(ghi)perylene	mg/kg	0.05	MCERTS	-	-	-	0.94	0.21

U/S = Unsuitable Sample I/S = Insufficient Sample ND = Not detected

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Analytical Report Number: 23-73170
Project / Site name: Upper Brook Street
Your Order No: DS76861

Lab Sample Number				2901124	2901125	2901126	2901127	2901128
Sample Reference				DS3	DS4	DS5	DS6	DS7
Sample Number				ES2	ES1	ES1	ES1	ES1
Depth (m)				1.10-1.30	0.70-1.00	0.20-0.40	0.20-0.40	0.40-0.60
Date Sampled				30/11/2023	30/11/2023	30/11/2023	30/11/2023	30/11/2023
Time Taken				None Supplied	None Supplied	None Supplied	None Supplied	None Supplied
Analytical Parameter (Soil Analysis)	**Units**	**Limit of detection**	**Accreditation Status**					
Stone Content	%	0.1	NONE	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Moisture Content	%	0.01	NONE	17	15	15	16	6.7
Total mass of sample received	kg	0.001	NONE	0.8	0.8	0.8	0.8	0.5
Asbestos in Soil Screen / Identification Name	Type	N/A	ISO 17025	-	-	Amosite- Loose Fibres	Amosite- Loose Fibres	-
Asbestos in Soil	Type	N/A	ISO 17025	Not-detected	Not-detected	Detected	Detected	Not-detected
Asbestos Analyst ID	N/A	N/A	N/A	DSA	DSA	DSA	DSA	DSA
General Inorganics								
pH - Automated	pH Units	N/A	MCERTS	7.4	8.3	8.2	8.7	11.7
Total Cyanide	mg/kg	1	MCERTS	-	< 1.0	-	< 1.0	-
Complex Cyanide	mg/kg	1	MCERTS	-	< 1.0	-	< 1.0	-
Free Cyanide	mg/kg	1	MCERTS	-	< 1.0	-	< 1.0	-
Water Soluble Sulphate as SO4 16hr extraction (2:1)	mg/kg	2.5	MCERTS	23	49	31	160	79
Water Soluble SO4 16hr extraction (2:1 Leachate Equivalent)	g/l	0.00125	MCERTS	0.0113	0.0247	0.0156	0.0791	0.0394
Water Soluble SO4 16hr extraction (2:1 Leachate Equivalent)	mg/l	1.25	MCERTS	11.3	24.7	15.6	79.1	39.4
Total Organic Carbon (TOC) - Automated	%	0.1	MCERTS	1	1.6	2	2.7	0.6
Phenols by GC-MS								
Phenol	mg/kg	0.2	ISO 17025	-	< 0.2	-	0.2	-
2,4,5-Trichlorophenol	mg/kg	0.2	NONE	-	< 0.2	-	< 0.2	-
2,4,6-Trichlorophenol	mg/kg	0.1	NONE	-	< 0.1	-	< 0.1	-
2,4-Dichlorophenol	mg/kg	0.3	MCERTS	-	< 0.3	-	< 0.3	-
2,4-Dimethylphenol	mg/kg	0.3	MCERTS	-	< 0.3	-	0.5	-
2-Chlorophenol	mg/kg	0.1	MCERTS	-	< 0.1	-	< 0.1	-
2-Methylphenol	mg/kg	0.3	MCERTS	-	< 0.3	-	< 0.3	-
2-Nitrophenol	mg/kg	0.3	NONE	-	< 0.3	-	< 0.3	-
4-Chloro-3-methylphenol	mg/kg	0.1	NONE	-	< 0.1	-	< 0.1	-
4-Methylphenol	mg/kg	0.2	NONE	-	< 0.2	-	0.5	-
Total Phenols								
Total Phenols (GC-MS)	mg/kg	1	NONE	-	< 1.0	-	1.2	-

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Analytical Report Number: 23-73170
Project / Site name: Upper Brook Street
Your Order No: DS76861

Lab Sample Number				2901124	2901125	2901126	2901127	2901128
Sample Reference				DS3	DS4	DS5	DS6	DS7
Sample Number				ES2	ES1	ES1	ES1	ES1
Depth (m)				1.10-1.30	0.70-1.00	0.20-0.40	0.20-0.40	0.40-0.60
Date Sampled				30/11/2023	30/11/2023	30/11/2023	30/11/2023	30/11/2023
Time Taken				None Supplied	None Supplied	None Supplied	None Supplied	None Supplied
Analytical Parameter (Soil Analysis)	**Units**	**Limit of detection**	**Accreditation Status**					
Speciated PAHs								
Naphthalene	mg/kg	0.05	MCERTS	< 0.05	0.39	3.6	12	< 0.05
Acenaphthylene	mg/kg	0.05	MCERTS	< 0.05	0.54	0.16	5.9	< 0.05
Acenaphthene	mg/kg	0.05	MCERTS	0.07	1.9	4.2	15	< 0.05
Fluorene	mg/kg	0.05	MCERTS	0.06	1.4	2.9	15	< 0.05
Phenanthrene	mg/kg	0.05	MCERTS	0.59	17	19	110	0.09
Anthracene	mg/kg	0.05	MCERTS	0.1	4.2	3.4	28	< 0.05
Fluoranthene	mg/kg	0.05	MCERTS	0.69	25	22	120	0.79
Pyrene	mg/kg	0.05	MCERTS	0.67	26	20	120	1.1
Benzo(a)anthracene	mg/kg	0.05	MCERTS	0.28	13	9	47	0.37
Chrysene	mg/kg	0.05	MCERTS	0.34	14	9.7	54	0.35
Benzo(b)fluoranthene	mg/kg	0.05	ISO 17025	0.33	13	11	49	1
Benzo(k)fluoranthene	mg/kg	0.05	ISO 17025	0.14	5.2	5	29	0.25
Benzo(a)pyrene	mg/kg	0.05	MCERTS	0.29	12	9.8	46	0.65
Indeno(1,2,3-cd)pyrene	mg/kg	0.05	MCERTS	0.13	5.4	3.9	30	0.38
Dibenz(a,h)anthracene	mg/kg	0.05	MCERTS	< 0.05	1.9	1.2	8.7	0.1
Benzo(ghi)perylene	mg/kg	0.05	MCERTS	0.14	6.3	4.4	35	0.46
Total PAH								
Speciated Total EPA-16 PAHs	mg/kg	0.8	ISO 17025	3.84	146	129	725	5.52
Heavy Metals / Metalloids								
Arsenic (aqua regia extractable)	mg/kg	1	MCERTS	17	26	17	68	9
Cadmium (aqua regia extractable)	mg/kg	0.2	MCERTS	< 0.2	< 0.2	< 0.2	< 0.2	0.6
Chromium (hexavalent)	mg/kg	1.8	MCERTS	< 1.8	< 1.8	< 1.8	< 1.8	< 1.8
Chromium (III)	mg/kg	1	NONE	24	22	21	33	22
Chromium (aqua regia extractable)	mg/kg	1	MCERTS	25	23	21	33	22
Copper (aqua regia extractable)	mg/kg	1	MCERTS	38	170	48	290	11
Lead (aqua regia extractable)	mg/kg	1	MCERTS	65	380	180	670	280
Mercury (aqua regia extractable)	mg/kg	0.3	MCERTS	< 0.3	0.8	< 0.3	0.6	< 0.3
Nickel (aqua regia extractable)	mg/kg	1	MCERTS	23	23	23	38	7.8
Zinc (aqua regia extractable)	mg/kg	1	MCERTS	120	130	160	510	51
Monoaromatics & Oxygenates								
Benzene	mg/kg	0.005	MCERTS	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Toluene	mg/kg	0.005	MCERTS	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Ethylbenzene	mg/kg	0.005	MCERTS	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
p & m-xylene	mg/kg	0.005	MCERTS	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
o-xylene	mg/kg	0.005	MCERTS	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
MTBE (Methyl Tertiary Butyl Ether)	mg/kg	0.005	NONE	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005

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Analytical Report Number: 23-73170
Project / Site name: Upper Brook Street
Your Order No: DS76861

Lab Sample Number				2901124	2901125	2901126	2901127	2901128
Sample Reference				DS3	DS4	DS5	DS6	DS7
Sample Number				ES2	ES1	ES1	ES1	ES1
Depth (m)				1.10-1.30	0.70-1.00	0.20-0.40	0.20-0.40	0.40-0.60
Date Sampled				30/11/2023	30/11/2023	30/11/2023	30/11/2023	30/11/2023
Time Taken				None Supplied	None Supplied	None Supplied	None Supplied	None Supplied
Analytical Parameter (Soil Analysis)	**Units**	**Limit of detection**	**Accreditation Status**					
Petroleum Hydrocarbons								
TPH-CWG - Aliphatic >EC5 - EC6 $_{HS_1D_AL}$	mg/kg	0.02	NONE	< 0.020	< 0.020	< 0.020	< 0.020	< 0.020
TPH-CWG - Aliphatic >EC6 - EC8 $_{HS_1D_AL}$	mg/kg	0.02	NONE	< 0.020	< 0.020	< 0.020	< 0.020	< 0.020
TPH-CWG - Aliphatic >EC8 - EC10 $_{HS_1D_AL}$	mg/kg	0.05	NONE	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050
TPH-CWG - Aliphatic >EC10 - EC12 $_{EH_CU_1D_AL}$	mg/kg	1	MCERTS	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
TPH-CWG - Aliphatic >EC12 - EC16 $_{EH_CU_1D_AL}$	mg/kg	2	MCERTS	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
TPH-CWG - Aliphatic >EC16 - EC21 $_{EH_CU_1D_AL}$	mg/kg	8	MCERTS	< 8.0	< 8.0	< 8.0	< 8.0	< 8.0
TPH-CWG - Aliphatic >EC21 - EC35 $_{EH_CU_1D_AL}$	mg/kg	8	MCERTS	< 8.0	< 8.0	22	24	16
TPH-CWG - Aliphatic >EC35 - EC40 $_{EH_CU_1D_AL}$	mg/kg	10	NONE	< 10	< 10	12	< 10	27
TPH-CWG - Aliphatic (EC5 - EC35) $_{EH_CU+HS_1D_AL}$	mg/kg	10	NONE	< 10	< 10	25	30	19
TPH-CWG - Aromatic >EC5 - EC7 $_{HS_1D_AR}$	mg/kg	0.01	NONE	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
TPH-CWG - Aromatic >EC7 - EC8 $_{HS_1D_AR}$	mg/kg	0.01	NONE	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
TPH-CWG - Aromatic >EC8 - EC10 $_{HS_1D_AR}$	mg/kg	0.05	NONE	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050
TPH-CWG - Aromatic >EC10 - EC12 $_{EH_CU_1D_AR}$	mg/kg	1	MCERTS	< 1.0	< 1.0	1.2	2.9	< 1.0
TPH-CWG - Aromatic >EC12 - EC16 $_{EH_CU_1D_AR}$	mg/kg	2	MCERTS	< 2.0	17	13	38	< 2.0
TPH-CWG - Aromatic >EC16 - EC21 $_{EH_CU_1D_AR}$	mg/kg	10	MCERTS	< 10	83	45	220	13
TPH-CWG - Aromatic >EC21 - EC35 $_{EH_CU_1D_AR}$	mg/kg	10	MCERTS	< 10	87	65	300	45
TPH-CWG - Aromatic >EC35 - EC40 $_{EH_CU_1D_AR}$	mg/kg	10	NONE	< 10	< 10	13	32	34
TPH-CWG - Aromatic (EC5 - EC35) $_{EH_CU+HS_1D_AR}$	mg/kg	10	NONE	< 10	190	120	560	60
TPH (C35 - C40) $_{EH_CU_1D_TOTAL}$	mg/kg	10	NONE	< 10	< 10	26	35	61
VOCs								
Chloromethane	mg/kg	0.005	ISO 17025	-	-	-	< 0.0050	-
Chloroethane	mg/kg	0.005	NONE	-	-	-	< 0.0050	-
Bromomethane	mg/kg	0.005	ISO 17025	-	-	-	< 0.0050	-
Vinyl Chloride	mg/kg	0.005	NONE	-	-	-	< 0.0050	-
Trichlorofluoromethane	mg/kg	0.005	NONE	-	-	-	< 0.0050	-
1,1-Dichloroethene	mg/kg	0.005	NONE	-	-	-	< 0.0050	-
1,1,2-Trichloro 1,2,2-Trifluoroethane	mg/kg	0.005	NONE	-	-	-	< 0.0050	-
Cis-1,2-dichloroethene	mg/kg	0.005	ISO 17025	-	-	-	< 0.0050	-
MTBE (Methyl Tertiary Butyl Ether)	mg/kg	0.005	NONE	-	-	-	< 0.0050	-
1,1-Dichloroethane	mg/kg	0.005	ISO 17025	-	-	-	< 0.0050	-
2,2-Dichloropropane	mg/kg	0.005	ISO 17025	-	-	-	< 0.0050	-
Trichloromethane	mg/kg	0.005	NONE	-	-	-	< 0.0050	-
1,1,1-Trichloroethane	mg/kg	0.005	ISO 17025	-	-	-	< 0.0050	-
1,2-Dichloroethane	mg/kg	0.005	ISO 17025	-	-	-	< 0.0050	-
1,1-Dichloropropene	mg/kg	0.005	ISO 17025	-	-	-	< 0.0050	-
Trans 1,2-dichloroethylene	mg/kg	0.005	NONE	-	-	-	< 0.0050	-
Benzene	mg/kg	0.005	MCERTS	-	-	-	< 0.0050	-
Tetrachloromethane	mg/kg	0.005	NONE	-	-	-	< 0.0050	-
1,2-Dichloropropane	mg/kg	0.005	ISO 17025	-	-	-	< 0.0050	-
Trichloroethene	mg/kg	0.005	ISO 17025	-	-	-	< 0.0050	-
Dibromomethane	mg/kg	0.005	ISO 17025	-	-	-	< 0.0050	-
Bromodichloromethane	mg/kg	0.005	ISO 17025	-	-	-	< 0.0050	-
Cis-1,3-dichloropropene	mg/kg	0.005	ISO 17025	-	-	-	< 0.0050	-
Trans-1,3-dichloropropene	mg/kg	0.005	ISO 17025	-	-	-	< 0.0050	-
Toluene	mg/kg	0.005	MCERTS	-	-	-	< 0.0050	-
1,1,2-Trichloroethane	mg/kg	0.005	ISO 17025	-	-	-	< 0.0050	-
1,3-Dichloropropane	mg/kg	0.005	ISO 17025	-	-	-	< 0.0050	-
Dibromochloromethane	mg/kg	0.005	ISO 17025	-	-	-	< 0.0050	-

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Analytical Report Number: 23-73170
Project / Site name: Upper Brook Street
Your Order No: DS76861

Lab Sample Number				2901124	2901125	2901126	2901127	2901128
Sample Reference				DS3	DS4	DS5	DS6	DS7
Sample Number				ES2	ES1	ES1	ES1	ES1
Depth (m)				1.10-1.30	0.70-1.00	0.20-0.40	0.20-0.40	0.40-0.60
Date Sampled				30/11/2023	30/11/2023	30/11/2023	30/11/2023	30/11/2023
Time Taken				None Supplied	None Supplied	None Supplied	None Supplied	None Supplied
Analytical Parameter (Soil Analysis)	**Units**	**Limit of detection**	**Accreditation Status**					
Tetrachloroethene	mg/kg	0.005	NONE	-	-	-	< 0.0050	-
1,2-Dibromoethane	mg/kg	0.005	ISO 17025	-	-	-	< 0.0050	-
Chlorobenzene	mg/kg	0.005	ISO 17025	-	-	-	< 0.0050	-
1,1,1,2-Tetrachloroethane	mg/kg	0.005	ISO 17025	-	-	-	< 0.0050	-
Ethylbenzene	mg/kg	0.005	MCERTS	-	-	-	< 0.0050	-
p & m-Xylene	mg/kg	0.005	MCERTS	-	-	-	< 0.0050	-
Styrene	mg/kg	0.005	ISO 17025	-	-	-	< 0.005	-
Tribromomethane	mg/kg	0.005	NONE	-	-	-	< 0.0050	-
o-Xylene	mg/kg	0.005	MCERTS	-	-	-	< 0.0050	-
1,1,2,2-Tetrachloroethane	mg/kg	0.005	ISO 17025	-	-	-	< 0.0050	-
Isopropylbenzene	mg/kg	0.005	ISO 17025	-	-	-	< 0.0050	-
Bromobenzene	mg/kg	0.005	NONE	-	-	-	< 0.0050	-
n-Propylbenzene	mg/kg	0.005	ISO 17025	-	-	-	< 0.0050	-
2-Chlorotoluene	mg/kg	0.005	ISO 17025	-	-	-	< 0.0050	-
4-Chlorotoluene	mg/kg	0.005	ISO 17025	-	-	-	< 0.0050	-
1,3,5-Trimethylbenzene	mg/kg	0.005	ISO 17025	-	-	-	< 0.0050	-
tert-Butylbenzene	mg/kg	0.005	ISO 17025	-	-	-	< 0.0050	-
1,2,4-Trimethylbenzene	mg/kg	0.005	ISO 17025	-	-	-	< 0.0050	-
sec-Butylbenzene	mg/kg	0.005	ISO 17025	-	-	-	< 0.0050	-
1,3-Dichlorobenzene	mg/kg	0.005	ISO 17025	-	-	-	< 0.0050	-
p-Isopropyltoluene	mg/kg	0.005	ISO 17025	-	-	-	< 0.0050	-
1,2-Dichlorobenzene	mg/kg	0.005	ISO 17025	-	-	-	< 0.0050	-
1,4-Dichlorobenzene	mg/kg	0.005	ISO 17025	-	-	-	< 0.0050	-
Butylbenzene	mg/kg	0.005	NONE	-	-	-	< 0.0050	-
1,2-Dibromo-3-chloropropane	mg/kg	0.005	ISO 17025	-	-	-	< 0.0050	-
1,2,4-Trichlorobenzene	mg/kg	0.005	ISO 17025	-	-	-	< 0.0050	-
Hexachlorobutadiene	mg/kg	0.005	NONE	-	-	-	< 0.0050	-
1,2,3-Trichlorobenzene	mg/kg	0.005	ISO 17025	-	-	-	< 0.0050	-

SVOCs

Aniline	mg/kg	0.1	NONE	-	-	-	< 0.1	-
Phenol	mg/kg	0.2	ISO 17025	-	-	-	0.2	-
2-Chlorophenol	mg/kg	0.1	MCERTS	-	-	-	< 0.1	-
Bis(2-chloroethyl)ether	mg/kg	0.2	MCERTS	-	-	-	< 0.2	-
1,3-Dichlorobenzene	mg/kg	0.2	MCERTS	-	-	-	< 0.2	-
1,2-Dichlorobenzene	mg/kg	0.1	MCERTS	-	-	-	< 0.1	-
1,4-Dichlorobenzene	mg/kg	0.2	MCERTS	-	-	-	< 0.2	-
Bis(2-chloroisopropyl)ether	mg/kg	0.1	MCERTS	-	-	-	< 0.1	-
2-Methylphenol	mg/kg	0.3	MCERTS	-	-	-	< 0.3	-
Hexachloroethane	mg/kg	0.05	ISO 17025	-	-	-	< 0.05	-
Nitrobenzene	mg/kg	0.3	MCERTS	-	-	-	< 0.3	-
4-Methylphenol	mg/kg	0.2	NONE	-	-	-	0.5	-
Isophorone	mg/kg	0.2	MCERTS	-	-	-	< 0.2	-
2-Nitrophenol	mg/kg	0.3	NONE	-	-	-	< 0.3	-
2,4-Dimethylphenol	mg/kg	0.3	MCERTS	-	-	-	0.5	-
Bis(2-chloroethoxy)methane	mg/kg	0.3	MCERTS	-	-	-	< 0.3	-
1,2,4-Trichlorobenzene	mg/kg	0.3	MCERTS	-	-	-	< 0.3	-
Naphthalene	mg/kg	0.05	MCERTS	-	-	-	12	-
2,4-Dichlorophenol	mg/kg	0.3	MCERTS	-	-	-	< 0.3	-
4-Chloroaniline	mg/kg	0.1	NONE	-	-	-	< 0.1	-
Hexachlorobutadiene	mg/kg	0.1	MCERTS	-	-	-	< 0.1	-
4-Chloro-3-methylphenol	mg/kg	0.1	NONE	-	-	-	< 0.1	-

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Analytical Report Number: 23-73170
Project / Site name: Upper Brook Street
Your Order No: DS76861

Lab Sample Number				2901124	2901125	2901126	2901127	2901128
Sample Reference				DS3	DS4	DS5	DS6	DS7
Sample Number				ES2	ES1	ES1	ES1	ES1
Depth (m)				1.10-1.30	0.70-1.00	0.20-0.40	0.20-0.40	0.40-0.60
Date Sampled				30/11/2023	30/11/2023	30/11/2023	30/11/2023	30/11/2023
Time Taken				None Supplied	None Supplied	None Supplied	None Supplied	None Supplied
Analytical Parameter (Soil Analysis)	Units	Limit of detection	Accreditation Status					
2,4,6-Trichlorophenol	mg/kg	0.1	NONE	-	-	-	< 0.1	-
2,4,5-Trichlorophenol	mg/kg	0.2	NONE	-	-	-	< 0.2	-
2-Methylnaphthalene	mg/kg	0.1	NONE	-	-	-	8.8	-
2-Chloronaphthalene	mg/kg	0.1	MCERTS	-	-	-	< 0.1	-
Dimethylphthalate	mg/kg	0.1	MCERTS	-	-	-	< 0.1	-
2,6-Dinitrotoluene	mg/kg	0.1	NONE	-	-	-	< 0.1	-
Acenaphthylene	mg/kg	0.05	MCERTS	-	-	-	5.9	-
Acenaphthene	mg/kg	0.05	MCERTS	-	-	-	15	-
2,4-Dinitrotoluene	mg/kg	0.2	NONE	-	-	-	< 0.2	-
Dibenzofuran	mg/kg	0.2	MCERTS	-	-	-	9.2	-
4-Chlorophenyl phenyl ether	mg/kg	0.3	MCERTS	-	-	-	< 0.3	-
Diethyl phthalate	mg/kg	0.2	MCERTS	-	-	-	< 0.2	-
4-Nitroaniline	mg/kg	0.2	NONE	-	-	-	< 0.2	-
Fluorene	mg/kg	0.05	MCERTS	-	-	-	15	-
Azobenzene	mg/kg	0.3	NONE	-	-	-	< 0.3	-
Bromophenyl phenyl ether	mg/kg	0.2	MCERTS	-	-	-	< 0.2	-
Hexachlorobenzene	mg/kg	0.3	MCERTS	-	-	-	< 0.3	-
Phenanthrene	mg/kg	0.05	MCERTS	-	-	-	110	-
Anthracene	mg/kg	0.05	MCERTS	-	-	-	28	-
Carbazole	mg/kg	0.3	MCERTS	-	-	-	6.7	-
Dibutyl phthalate	mg/kg	0.2	NONE	-	-	-	< 0.2	-
Anthraquinone	mg/kg	0.3	NONE	-	-	-	10	-
Fluoranthene	mg/kg	0.05	MCERTS	-	-	-	120	-
Pyrene	mg/kg	0.05	MCERTS	-	-	-	120	-
Butyl benzyl phthalate	mg/kg	0.3	NONE	-	-	-	< 0.3	-
Benzo(a)anthracene	mg/kg	0.05	MCERTS	-	-	-	47	-
Chrysene	mg/kg	0.05	MCERTS	-	-	-	54	-
Benzo(b)fluoranthene	mg/kg	0.05	ISO 17025	-	-	-	49	-
Benzo(k)fluoranthene	mg/kg	0.05	ISO 17025	-	-	-	29	-
Benzo(a)pyrene	mg/kg	0.05	MCERTS	-	-	-	46	-
Indeno(1,2,3-cd)pyrene	mg/kg	0.05	MCERTS	-	-	-	30	-
Dibenz(a,h)anthracene	mg/kg	0.05	MCERTS	-	-	-	8.7	-
Benzo(ghi)perylene	mg/kg	0.05	MCERTS	-	-	-	35	-

U/S = Unsuitable Sample I/S = Insufficient Sample ND = Not detected

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Analytical Report Number : 23-73170
Project / Site name: Upper Brook Street

* These descriptions are only intended to act as a cross check if sample identities are questioned. The major constituent of the sample is intended to act with respect to MCERTS validation. The laboratory is accredited for sand, clay and loam (MCERTS) soil types. Data for unaccredited types of solid should be interpreted with care.

Stone content of a sample is calculated as the % weight of the stones not passing a 10 mm sieve. Results are not corrected for stone content.

Lab Sample Number	Sample Reference	Sample Number	Depth (m)	Sample Description *
2901119	RO1	ES2	1.00-1.20	Brown sand with gravel.
2901120	RO2	ES2	0.80-1.00	Brown clay with gravel.
2901121	RO3	ES1	0.30-0.70	Brown clay and gravel.
2901122	DS1	ES1	0.60-1.00	Brown clay.
2901123	DS2	ES2	1.00-2.00	Brown sand with brick.
2901124	DS3	ES2	1.10-1.30	Brown clay and sand.
2901125	DS4	ES1	0.70-1.00	Brown clay and sand with gravel and brick.
2901126	DS5	ES1	0.20-0.40	Brown sand with gravel and vegetation.
2901127	DS6	ES1	0.20-0.40	Brown sand with gravel and vegetation.
2901128	DS7	ES1	0.40-0.60	Brown gravelly sand with rubble and brick.

Analytical Report Number : 23-73170
Project / Site name: Upper Brook Street

Water matrix abbreviations:
Surface Water (SW) Potable Water (PW) Ground Water (GW) Process Waters (PrW) Final Sewage Effluent (FSE) Landfill Leachate (LL)

Analytical Test Name	Analytical Method Description	Analytical Method Reference	Method number	Wet / Dry Analysis	Accreditation Status
Sulphate, water soluble, in soil (16hr extraction)	Determination of water soluble sulphate by ICP-OES. Results reported directly (leachate equivalent) and corrected for extraction ratio (soil equivalent).	In house method.	L038-PL	D	MCERTS
Metals in soil by ICP-OES	Determination of metals in soil by aqua-regia digestion followed by ICP-OES.	In-house method based on MEWAM 2006 Methods for the Determination of Metals in Soil.	L038-PL	D	MCERTS
Phenols, speciated, in soil, by GCMS	Determination of speciated phenols in soil by extraction in dichloromethane and hexane followed by GC-MS.	In-house method based on USEPA 8270	L064-PL	D	MCERTS
Asbestos identification in soil	Asbestos Identification with the use of polarised light microscopy in conjunction with dispersion staining techniques.	In house method based on HSG 248	A001-PL	D	ISO 17025
Complex Cyanide in soil	Determination of complex cyanide by calculation.	In-house method based on Examination of Water and Wastewater 20th Edition: Clesceri, Greenberg & Eaton (Skalar)	L080-PL	W	MCERTS
Free cyanide in soil	Determination of free cyanide by distillation followed by colorimetry.	In-house method based on Examination of Water and Wastewater 20th Edition: Clesceri, Greenberg & Eaton (Skalar)	L080-PL	W	MCERTS
Moisture Content	Moisture content, determined gravimetrically. (30 oC)	In house method.	L019-UK/PL	W	NONE
Speciated EPA-16 PAHs in soil	Determination of PAH compounds in soil by extraction in dichloromethane and hexane followed by GC-MS with the use of surrogate and internal standards. Refer to CoA for analyte specific accreditation.	In-house method based on USEPA 8270	L064-PL	D	MCERTS
pH in soil (automated)	Determination of pH in soil by addition of water followed by automated electrometric measurement.	In house method.	L099-PL	D	MCERTS
Stones content of soil	Standard preparation for all samples unless otherwise detailed. Gravimetric determination of stone > 10 mm as % dry weight.	In-house method based on British Standard Methods and MCERTS requirements.	L019-UK/PL	D	NONE
Semi-volatile organic compounds in soil	Determination of semi-volatile organic compounds in soil by extraction in dichloromethane and hexane followed by GC-MS.Refer to CoA for analyte specific accreditation.	In-house method based on USEPA 8270	L064-PL	D	MCERTS
Total cyanide in soil	Determination of total cyanide by distillation followed by colorimetry.	In-house method based on Examination of Water and Wastewater 20th Edition: Clesceri, Greenberg & Eaton (Skalar)	L080-PL	W	MCERTS
Total organic carbon (Automated) in soil	Determination of organic matter in soil by oxidising with potassium dichromate followed by titration with iron (II) sulphate.	In house method.	L009-PL	D	MCERTS
TPH Chromatogram in Soil	TPH Chromatogram in Soil.	In-house method	L064-PL	D	NONE
TPH in (Soil)	Determination of TPH bands by HS-GC-MS/GC-FID	In-house method, TPH with carbon banding and silica gel split/cleanup.	L076-PL	D	NONE
Cr (III) in soil	In-house method by calculation from total Cr and Cr VI.	In-house method by calculation	L080-PL	W	NONE

Analytical Report Number : 23-73170
Project / Site name: Upper Brook Street

Water matrix abbreviations:
Surface Water (SW) Potable Water (PW) Ground Water (GW) Process Waters (PrW) Final Sewage Effluent (FSE) Landfill Leachate (LL)

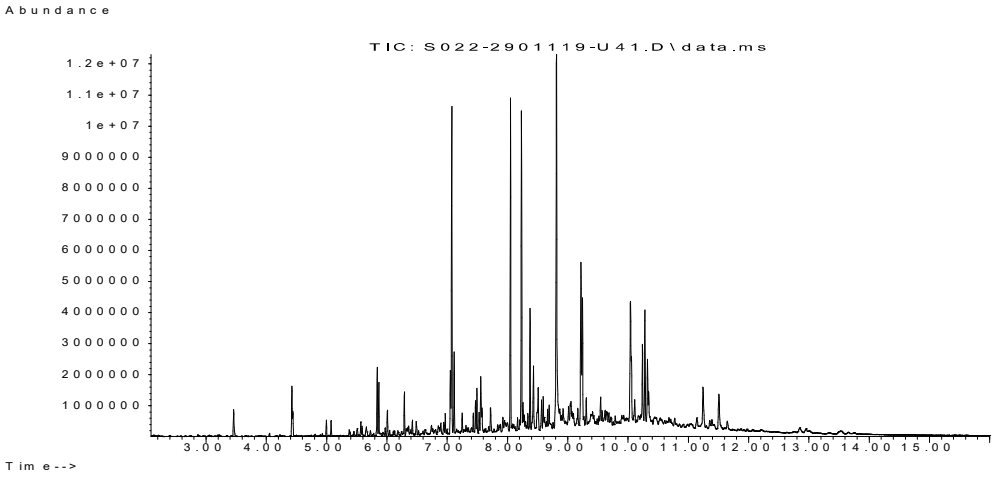
Analytical Test Name	Analytical Method Description	Analytical Method Reference	Method number	Wet / Dry Analysis	Accreditation Status
TPHCWG (Soil)	Determination of hexane extractable hydrocarbons in soil by GC-MS/GC-FID. Refer to CoA for band specific accreditation.	In-house method with silica gel split/clean up.	L088/76-PL	D	MCERTS
Volatile organic compounds in soil	Determination of volatile organic compounds in soil by headspace GC-MS.	In-house method based on USEPA8260	L073B-PL	W	MCERTS
Hexavalent chromium in soil	Determination of hexavalent chromium in soil by extraction in NaOH and addition of 1,5 diphenylcarbazide followed by colorimetry.	In-house method	L080-PL	W	MCERTS
BTEX and MTBE in soil (Monoaromatics)	Determination of BTEX in soil by headspace GC-MS. Individual components MCERTS accredited	In-house method based on USEPA8260. Refer to CoA for analyte specific accreditation	L073B-PL	W	MCERTS
Sulphate, water soluble, in soil	Determination of water soluble sulphate by ICP-OES. Results reported directly (leachate equivalent) and corrected for extraction ratio (soil equivalent).	In house method.	L038-PL	D	MCERTS

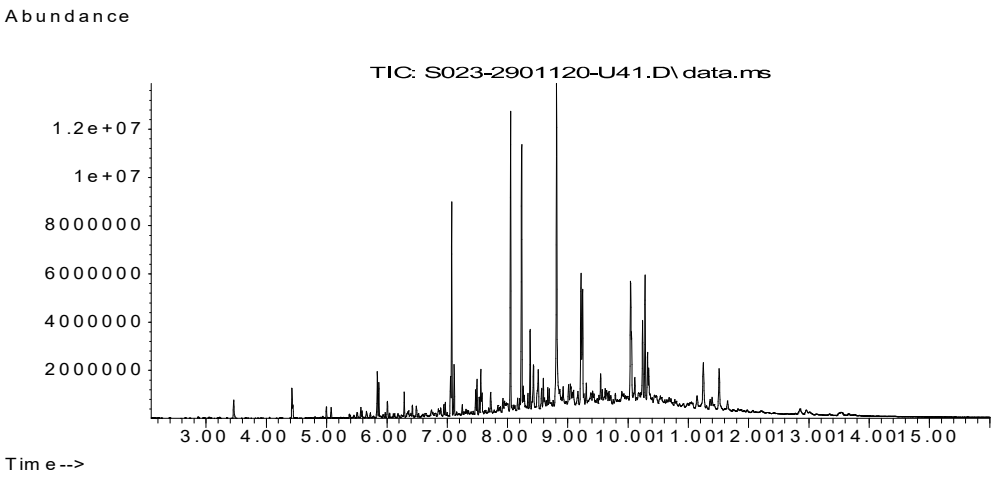
For method numbers ending in 'UK or A' analysis have been carried out in our laboratory in the United Kingdom (WATFORD).
For method numbers ending in 'F' analysis have been carried out in our laboratory in the United Kingdom (East Kilbride).
For method numbers ending in 'PL or B' analysis have been carried out in our laboratory in Poland.
Soil analytical results are expressed on a dry weight basis. Where analysis is carried out on as-received the results obtained are multiplied by a moisture correction factor that is determined gravimetrically using the moisture content which is carried out at a maximum of 30oC.
Unless otherwise indicated, site information, order number, project number, sampling date, time, sample reference and depth are provided by the client. The instructed on date indicates the date on which this information was provided to the laboratory.

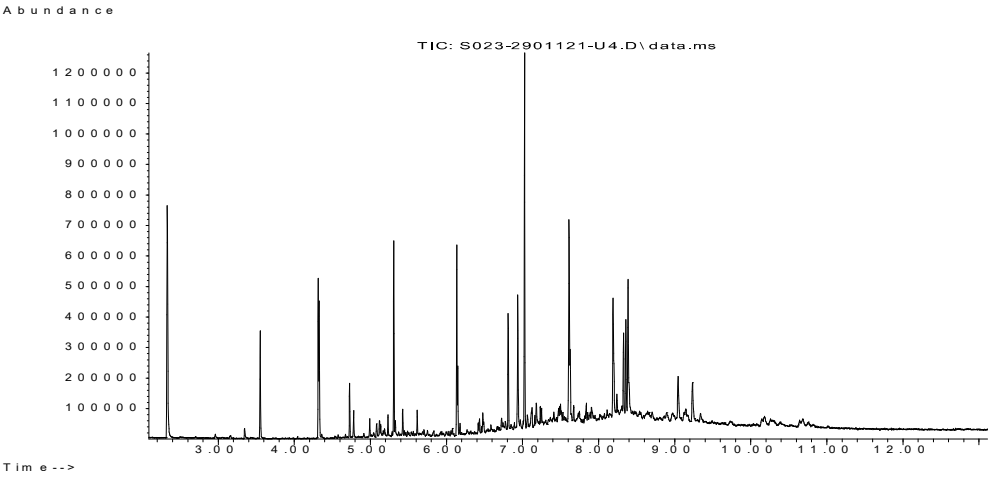
Information in Support of Analytical Results

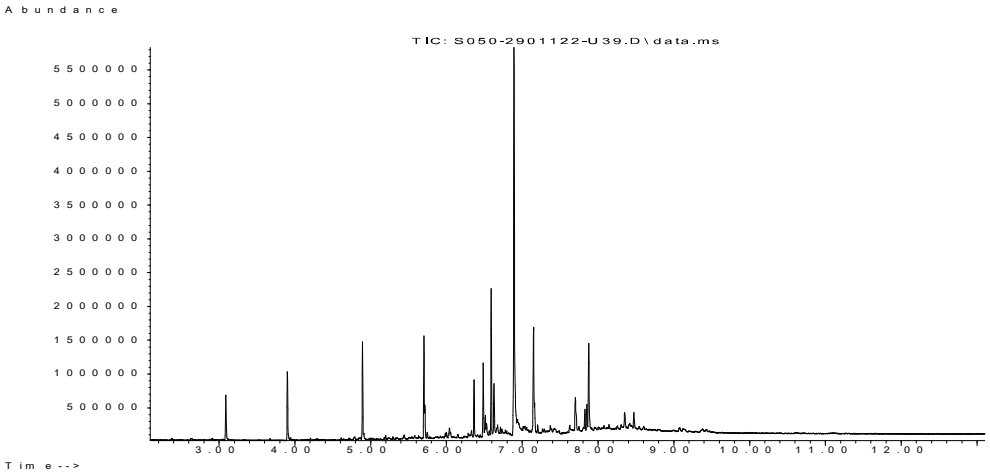
List of HWOL Acronyms and Operators

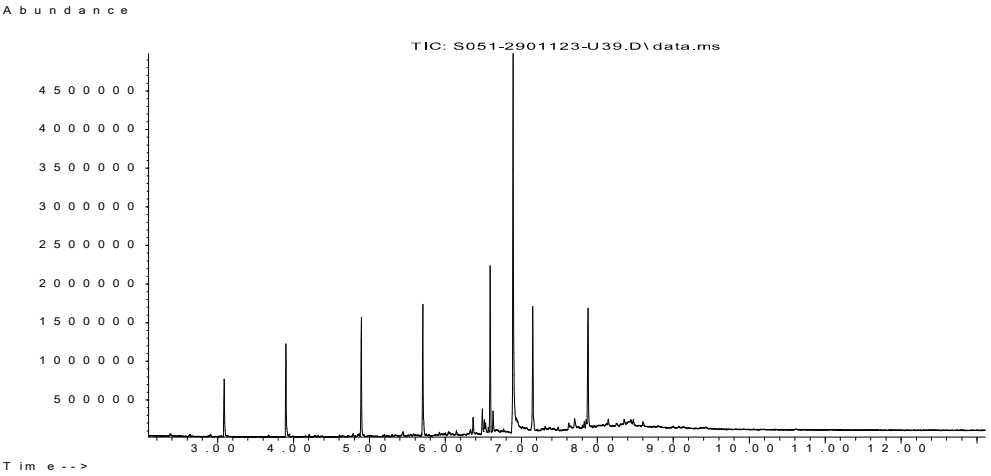
Acronym	Descriptions
HS	Headspace Analysis
MS	Mass spectrometry
FID	Flame Ionisation Detector
GC	Gas Chromatography
EH	Extractable Hydrocarbons (i.e. everything extracted by the solvent(s))
CU	Clean-up - e.g. by Florisil®, silica gel
1D	GC - Single coil/column gas chromatography
2D	GC-GC - Double coil/column gas chromatography
Total	Aliphatics & Aromatics
AL	Aliphatics
AR	Aromatics
#1	EH_2D_Total but with humics mathematically subtracted
#2	EH_2D_Total but with fatty acids mathematically subtracted
_	Operator - understore to separate acronyms (exception for +)
+	Operator to indicate cumulative e.g. EH+HS_Total or EH_CU+HS_Total

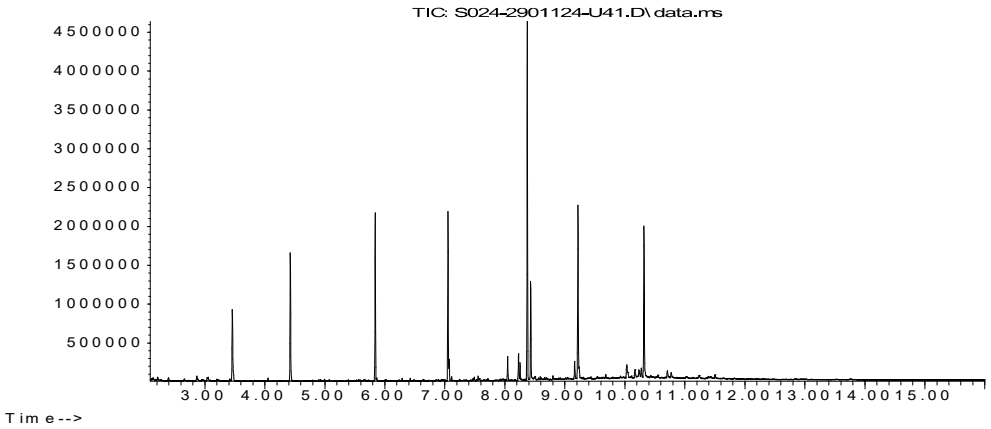

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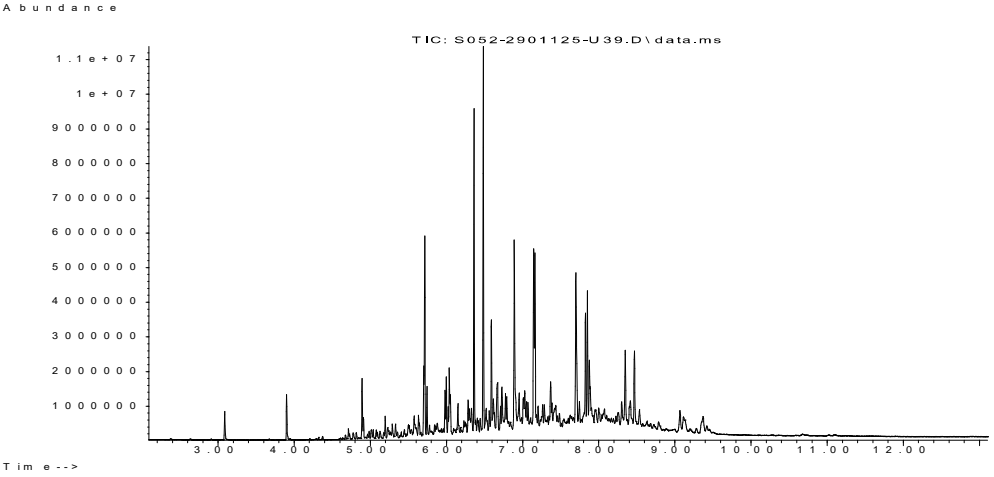

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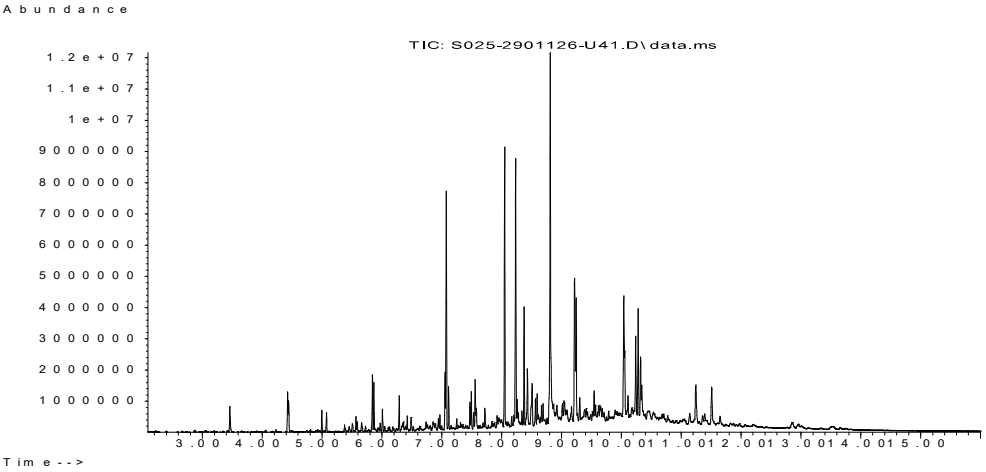

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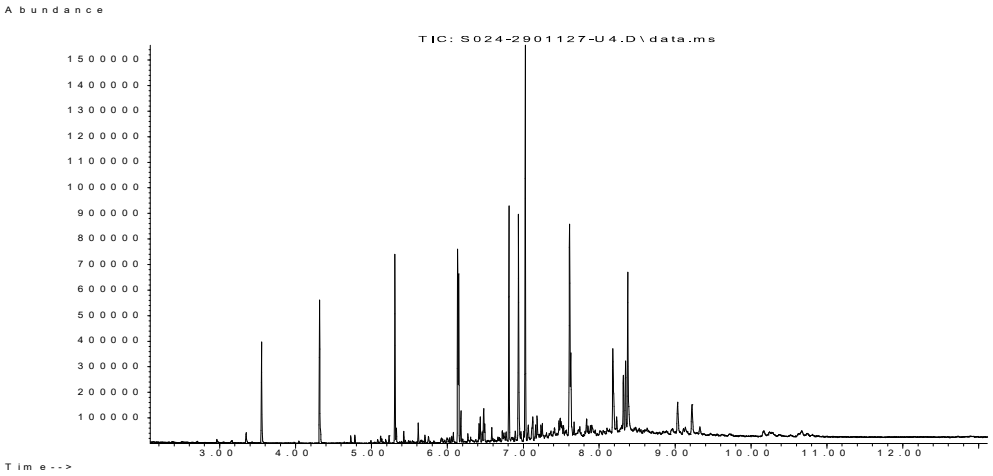

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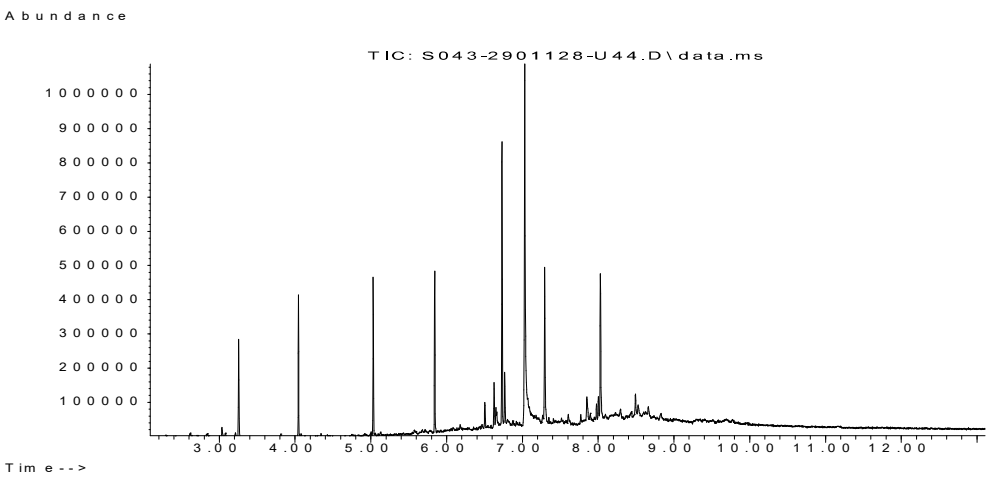

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Sample Deviation Report

Analytical Report Number : 23-73170
Project / Site name: Upper Brook Street

This deviation report indicates the sample and test deviations that apply to the samples submitted for analysis.Please note that the associated result(s) may be unreliable and should be interpreted with care.

Key: a - No sampling date b - Incorrect container c - Holding time d - Headspace e - Temperature

Sample ID	Other ID	Sample Type	Lab Sample Number	Sample Deviation	Test Name	Test Ref	Test Deviation
RO3	ES1	S	2901121	c	Free cyanide in soil	L080-PL	c
RO3	ES1	S	2901121	c	Complex Cyanide in soil	L080-PL	c
RO3	ES1	S	2901121	c	Total cyanide in soil	L080-PL	c

Tom Bywater
Delta-Simons
Suite C1
Joseph's Well
Hanover Walk
Leeds
LS3 1AB

[redacted]

i2 Analytical Ltd.
7 Woodshots Meadow,
Croxley Green
Business Park,
Watford,
Herts,
WD18 8YS

t: 01923 225404
f: 01923 237404
e: reception@i2analytical.com

Analytical Report Number : 23-74125

Project / Site name:	UBS Upper Brook Street	**Samples received on:**	05/12/2023
Your job number:	591891	**Samples instructed on/ Analysis started on:**	11/12/2023
Your order number:	DS76861	**Analysis completed by:**	19/12/2023
Report Issue Number:	1	**Report issued on:**	19/12/2023
Samples Analysed:	2 bulk samples		

Signed [redacted]

Dominika Liana
Junior Reporting Specialist
For & on behalf of i2 Analytical Ltd.

Standard Geotechnical, Asbestos and Chemical Testing Laboratory located at: ul. Pionierów 39, 41-711 Ruda Śląska, Poland.

Accredited tests are defined within the report, opinions and interpretations expressed herein are outside the scope of accreditation.

Standard sample disposal times, unless otherwise agreed with the laboratory, are :

soils	- 4 weeks from reporting
leachates	- 2 weeks from reporting
waters	- 2 weeks from reporting
asbestos	- 6 months from reporting

Excel copies of reports are only valid when accompanied by this PDF certificate.

Any assessments of compliance with specifications are based on actual analytical results with no contribution from uncertainty of measurement.
Application of uncertainty of measurement would provide a range within which the true result lies.
An estimate of measurement uncertainty can be provided on request.

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The results included within the report relate only to the sample(s) submitted for testing.

Analytical Report Number: 23-74125
Project / Site name: UBS Upper Brook Street

Your Order No: DS76861

Lab Sample Number				2906523	2914721
Sample Reference				R02	R02
Sample Number				Chrysotile-Asbestos Cement	Chrysotile, Amosite- Asbestos Cement
Depth (m)				0.20-1.00	0.20-1.00
Date Sampled				Deviating	Deviating
Time Taken				None Supplied	None Supplied
Analytical Parameter (Bulk Analysis)	**Units**	**Limit of detection**	**Accreditation Status**		
Asbestos Identification	Type	N/A	ISO 17025	Chrysotile-Asbestos Cement	Chrysotile, Amosite- Asbestos Cement
Asbestos Analyst ID	N/A	N/A	N/A	SPU	SPU

U/S = Unsuitable Sample I/S = Insufficient Sample ND = Not detected

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The results included within the report relate only to the sample(s) submitted for testing.

Analytical Report Number : 23-74125
Project / Site name: UBS Upper Brook Street

Water matrix abbreviations:
Surface Water (SW) Potable Water (PW) Ground Water (GW) Process Waters (PrW) Final Sewage Effluent (FSE) Landfill Leachate (LL)

Analytical Test Name	Analytical Method Description	Analytical Method Reference	Method number	Wet / Dry Analysis	Accreditation Status
Asbestos identification in Bulks	Asbestos Identification in bulk material with the use of polarised light microscopy in conjunction with dispersion staining techniques.	In house method based on HSG 248	A001-PL	W	ISO 17025

For method numbers ending in 'UK or A' analysis have been carried out in our laboratory in the United Kingdom (WATFORD).
For method numbers ending in 'F' analysis have been carried out in our laboratory in the United Kingdom (East Kilbride).
For method numbers ending in 'PL or B' analysis have been carried out in our laboratory in Poland.
Soil analytical results are expressed on a dry weight basis. Where analysis is carried out on as-received the results obtained are multiplied by a moisture correction factor that is determined gravimetrically using the moisture content which is carried out at a maximum of 30oC.
Unless otherwise indicated, site information, order number, project number, sampling date, time, sample reference and depth are provided by the client. The instructed on date indicates the date on which this information was provided to the laboratory.

Sample Deviation Report

Analytical Report Number : 23-74125
Project / Site name: UBS Upper Brook Street

This deviation report indicates the sample and test deviations that apply to the samples submitted for analysis.Please note that the associated result(s) may be unreliable and should be interpreted with care.

Key: a - No sampling date b - Incorrect container c - Holding time d - Headspace e - Temperature

Sample ID	Other ID	Sample Type	Lab Sample Number	Sample Deviation	Test Name	Test Ref	Test Deviation
R02	Chrysotile, Amosite- Asbestos Cement	B	2914721	a	None Supplied	None Supplied	None Supplied
R02	Chrysotile- Asbestos Cement	B	2906523	a	None Supplied	None Supplied	None Supplied

Tom Bywater
Delta-Simons□
Suite C1
Joseph's Well
Hanover Walk
Leeds
LS3 1AB

[redacted]

i2 Analytical Ltd.
7 Woodshots Meadow,
Croxley Green
Business Park,
Watford,
Herts,
WD18 8YS

t: 01923 225404
f: 01923 237404
e: reception@i2analytical.com

Analytical Report Number : 23-74246

Project / Site name:	UBS (Upper Brook Street)	**Samples received on:**	05/12/2023
Your job number:	591891	**Samples instructed on/ Analysis started on:**	11/12/2023
Your order number:	DS76933	**Analysis completed by:**	20/12/2023
Report Issue Number:	1	**Report issued on:**	21/12/2023
Samples Analysed:	20 soil samples		

Signed: [redacted]

Izabela Wójcik
Senior Reporting Specialist
For & on behalf of i2 Analytical Ltd.

Standard Geotechnical, Asbestos and Chemical Testing Laboratory located at: ul. Pionierów 39, 41-711 Ruda Śląska, Poland.

Accredited tests are defined within the report, opinions and interpretations expressed herein are outside the scope of accreditation.

Standard sample disposal times, unless otherwise agreed with the laboratory, are :

soils	- 4 weeks from reporting
leachates	- 2 weeks from reporting
waters	- 2 weeks from reporting
asbestos	- 6 months from reporting

Excel copies of reports are only valid when accompanied by this PDF certificate.

Any assessments of compliance with specifications are based on actual analytical results with no contribution from uncertainty of measurement.
Application of uncertainty of measurement would provide a range within which the true result lies.
An estimate of measurement uncertainty can be provided on request.

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The results included within the report relate only to the sample(s) submitted for testing.

Analytical Report Number: 23-74246
Project / Site name: UBS (Upper Brook Street)
Your Order No: DS76933

Lab Sample Number				2907327	2907328	2907329	2907330	2907331
Sample Reference				RO1	RO1	RO1	RO1	RO2
Sample Number				1	3	6	8	2
Depth (m)				3.00-3.20	7.50-8.00	15.00-15.20	19.00-20.00	11.00-11.50
Date Sampled				28/11/2023	28/11/2023	29/11/2023	29/11/2023	30/11/2023
Time Taken				None Supplied	None Supplied	None Supplied	None Supplied	None Supplied
Analytical Parameter (Soil Analysis)	**Units**	**Limit of detection**	**Accreditation Status**					
Stone Content	%	0.1	NONE	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Moisture Content	%	0.01	NONE	11	15	15	9.6	14
Total mass of sample received	kg	0.001	NONE	0.3	0.4	0.9	0.6	0.5

General Inorganics

pH - Automated	pH Units	N/A	MCERTS	8.3	8.1	8.5	8.9	7.6
Total Sulphate as SO4	%	0.005	MCERTS	0.01	0.008	0.006	0.012	0.006
Water Soluble Sulphate as SO4 16hr extraction (2:1)	mg/kg	2.5	MCERTS	30	34	9.9	12	13
Water Soluble SO4 16hr extraction (2:1 Leachate Equivalent)	g/l	0.00125	MCERTS	0.0149	0.0168	0.0049	0.0061	0.0067
Water Soluble SO4 16hr extraction (2:1 Leachate Equivalent)	mg/l	1.25	MCERTS	14.9	16.8	4.9	6.1	6.7
Total Sulphur	%	0.005	MCERTS	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005

U/S = Unsuitable Sample I/S = Insufficient Sample ND = Not detected

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The results included within the report relate only to the sample(s) submitted for testing.

Analytical Report Number: 23-74246
Project / Site name: UBS (Upper Brook Street)
Your Order No: DS76933

Lab Sample Number				2907332	2907333	2907334	2907335	2907336
Sample Reference				RO2	RO3	RO3	RO3	DS1
Sample Number				4	1	3	4	1
Depth (m)				20.00-20.50	1.50-1.80	11.00-11.50	15.50-16.00	3.60-4.00
Date Sampled				30/11/2023	30/11/2023	30/11/2023	30/11/2023	30/11/2023
Time Taken				None Supplied	None Supplied	None Supplied	None Supplied	None Supplied
Analytical Parameter (Soil Analysis)	Units	Limit of detection	Accreditation Status					
Stone Content	%	0.1	NONE	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Moisture Content	%	0.01	NONE	15	13	15	13	9.8
Total mass of sample received	kg	0.001	NONE	0.6	0.5	0.6	0.6	0.5

General Inorganics

pH - Automated	pH Units	N/A	MCERTS	7.9	7.4	7.9	8.2	7.8
Total Sulphate as SO4	%	0.005	MCERTS	0.006	0.014	0.006	0.008	0.006
Water Soluble Sulphate as SO4 16hr extraction (2:1)	mg/kg	2.5	MCERTS	9.7	24	17	15	13
Water Soluble SO4 16hr extraction (2:1 Leachate Equivalent)	g/l	0.00125	MCERTS	0.0049	0.0119	0.0087	0.0074	0.0066
Water Soluble SO4 16hr extraction (2:1 Leachate Equivalent)	mg/l	1.25	MCERTS	4.9	11.9	8.7	7.4	6.6
Total Sulphur	%	0.005	MCERTS	< 0.005	0.006	< 0.005	< 0.005	< 0.005

U/S = Unsuitable Sample I/S = Insufficient Sample ND = Not detected

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The results included within the report relate only to the sample(s) submitted for testing.

Analytical Report Number: 23-74246
Project / Site name: UBS (Upper Brook Street)
Your Order No: DS76933

Lab Sample Number				2907337	2907338	2907339	2907340	2907341
Sample Reference				DS3	DS4	DS6	DS6	DS7
Sample Number				1	1	1	2	1
Depth (m)				1.40-1.80	2.20-2.40	2.00-3.00	3.50-4.00	3.50-4.00
Date Sampled				30/11/2023	30/11/2023	30/11/2023	30/11/2023	30/11/2023
Time Taken				None Supplied	None Supplied	None Supplied	None Supplied	None Supplied
Analytical Parameter (Soil Analysis)	**Units**	**Limit of detection**	**Accreditation Status**					
Stone Content	%	0.1	NONE	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Moisture Content	%	0.01	NONE	15	4.3	5.1	12	7.9
Total mass of sample received	kg	0.001	NONE	0.7	0.6	0.5	0.6	0.5

General Inorganics

pH - Automated	pH Units	N/A	MCERTS	7.5	8.2	8.4	8.3	8
Total Sulphate as SO4	%	0.005	MCERTS	0.022	0.026	0.015	< 0.005	0.005
Water Soluble Sulphate as SO4 16hr extraction (2:1)	mg/kg	2.5	MCERTS	30	62	52	8.4	15
Water Soluble SO4 16hr extraction (2:1 Leachate Equivalent)	g/l	0.00125	MCERTS	0.015	0.0312	0.0258	0.0042	0.0075
Water Soluble SO4 16hr extraction (2:1 Leachate Equivalent)	mg/l	1.25	MCERTS	15	31.2	25.8	4.2	7.5
Total Sulphur	%	0.005	MCERTS	0.012	0.013	0.007	< 0.005	< 0.005

U/S = Unsuitable Sample I/S = Insufficient Sample ND = Not detected

This certificate should not be reproduced, except in full, without the express permission of the laboratory.
The results included within the report relate only to the sample(s) submitted for testing.

Analytical Report Number: 23-74246
Project / Site name: UBS (Upper Brook Street)
Your Order No: DS76933

Lab Sample Number				2907830	2907831	2907832	2907833	2907834
Sample Reference				RO1	RO2	RO3	DS6	DS7
Sample Number				ES3	ES3	ES2	ES2	ES2
Depth (m)				1.40-1.60	2.00-2.50	1.00-1.20	0.80-1.00	2.00-2.50
Date Sampled				28/11/2023	30/11/2023	30/11/2023	30/11/2023	30/11/2023
Time Taken				None Supplied	None Supplied	None Supplied	None Supplied	None Supplied
Analytical Parameter (Soil Analysis)	**Units**	**Limit of detection**	**Accreditation Status**					
Stone Content	%	0.1	NONE	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Moisture Content	%	0.01	NONE	15	21	19	13	12
Total mass of sample received	kg	0.001	NONE	0.6	0.6	0.6	0.7	0.5

General Inorganics

pH - Automated	pH Units	N/A	MCERTS	9.2	8.4	7.7	9.9	8.4
Total Sulphate as SO4	%	0.005	MCERTS	0.114	1.98	0.023	0.127	0.044
Water Soluble Sulphate as SO4 16hr extraction (2:1)	mg/kg	2.5	MCERTS	520	3200	46	350	47
Water Soluble SO4 16hr extraction (2:1 Leachate Equivalent)	g/l	0.00125	MCERTS	0.26	1.62	0.0232	0.175	0.0236
Water Soluble SO4 16hr extraction (2:1 Leachate Equivalent)	mg/l	1.25	MCERTS	260	1620	23.2	175	23.6
Total Sulphur	%	0.005	MCERTS	0.088	0.975	0.024	0.066	0.021

U/S = Unsuitable Sample I/S = Insufficient Sample ND = Not detected

This certificate should not be reproduced, except in full, without the express permission of the laboratory.
The results included within the report relate only to the sample(s) submitted for testing.

Analytical Report Number : 23-74246
Project / Site name: UBS (Upper Brook Street)

* These descriptions are only intended to act as a cross check if sample identities are questioned. The major constituent of the sample is intended to act with respect to MCERTS validation. The laboratory is accredited for sand, clay and loam (MCERTS) soil types. Data for unaccredited types of solid should be interpreted with care.

Stone content of a sample is calculated as the % weight of the stones not passing a 10 mm sieve. Results are not corrected for stone content.

Lab Sample Number	Sample Reference	Sample Number	Depth (m)	Sample Description *
2907327	RO1	1	3.00-3.20	Brown sand with gravel.
2907328	RO1	3	7.50-8.00	Brown sand.
2907329	RO1	6	15.00-15.20	Brown sand.
2907330	RO1	8	19.00-20.00	Brown clay and sand.
2907331	RO2	2	11.00-11.50	Brown sand.
2907332	RO2	4	20.00-20.50	Brown clay and sand.
2907333	RO3	1	1.50-1.80	Brown clay and sand.
2907334	RO3	3	11.00-11.50	Brown clay and sand.
2907335	RO3	4	15.50-16.00	Brown clay and sand.
2907336	DS1	1	3.60-4.00	Brown sand.
2907337	DS3	1	1.40-1.80	Brown clay and sand with gravel.
2907338	DS4	1	2.20-2.40	Brown sand with gravel.
2907339	DS6	1	2.00-3.00	Brown sand with gravel.
2907340	DS6	2	3.50-4.00	Brown sand.
2907341	DS7	1	3.50-4.00	Brown sand.
2907830	RO1	ES3	1.40-1.60	Brown clay and loam with gravel and vegetation.
2907831	RO2	ES3	2.00-2.50	Brown clay and loam with gravel and vegetation.
2907832	RO3	ES2	1.00-1.20	Brown clay and sand with gravel.
2907833	DS6	ES2	0.80-1.00	Brown loam and sand with gravel and vegetation.
2907834	DS7	ES2	2.00-2.50	Brown sand with gravel.

Analytical Report Number : 23-74246
Project / Site name: UBS (Upper Brook Street)

Water matrix abbreviations:
Surface Water (SW) Potable Water (PW) Ground Water (GW) Process Waters (PrW) Final Sewage Effluent (FSE) Landfill Leachate (LL)

Analytical Test Name	Analytical Method Description	Analytical Method Reference	Method number	Wet / Dry Analysis	Accreditation Status
Sulphate, water soluble, in soil (16hr extraction)	Determination of water soluble sulphate by ICP-OES. Results reported directly (leachate equivalent) and corrected for extraction ratio (soil equivalent).	In house method.	L038-PL	D	MCERTS
Moisture Content	Moisture content, determined gravimetrically. (30 oC)	In house method.	L019-UK/PL	W	NONE
pH in soil (automated)	Determination of pH in soil by addition of water followed by automated electrometric measurement.	In house method.	L099-PL	D	MCERTS
Stones content of soil	Standard preparation for all samples unless otherwise detailed. Gravimetric determination of stone > 10 mm as % dry weight.	In-house method based on British Standard Methods and MCERTS requirements.	L019-UK/PL	D	NONE
Total Sulphate in soil as %	Determination of total sulphate in soil by extraction with 10% HCl followed by ICP-OES.	In house method.	L038-PL	D	MCERTS
Total Sulphur in soil as %	Determination of total sulphur in soil by extraction with aqua-regia, potassium bromide/bromate followed by ICP-OES.	In house method.	L038-PL	D	MCERTS
Sulphate, water soluble, in soil	Determination of water soluble sulphate by ICP-OES. Results reported directly (leachate equivalent) and corrected for extraction ratio (soil equivalent).	In house method.	L038-PL	D	MCERTS

For method numbers ending in 'UK or A' analysis have been carried out in our laboratory in the United Kingdom (WATFORD).
For method numbers ending in 'F' analysis have been carried out in our laboratory in the United Kingdom (East Kilbride).
For method numbers ending in 'PL or B' analysis have been carried out in our laboratory in Poland.
Soil analytical results are expressed on a dry weight basis. Where analysis is carried out on as-received the results obtained are multiplied by a moisture correction factor that is determined gravimetrically using the moisture content which is carried out at a maximum of 30oC.
Unless otherwise indicated, site information, order number, project number, sampling date, time, sample reference and depth are provided by the client. The instructed on date indicates the date on which this information was provided to the laboratory.

Appendix E – Groundwater Chemical Analysis Results

Melanie Booth
Delta-Simons
Suite C1
Joseph's Well
Hanover Walk
Leeds
LS3 1AB

[redacted]

i2 Analytical Ltd.
7 Woodshots Meadow,
Croxley Green
Business Park,
Watford,
Herts,
WD18 8YS

t: 01923 225404
f: 01923 237404
e: reception@i2analytical.com

Analytical Report Number : 23-75173

Project / Site name:	UBS Upper Brok Street	**Samples received on:**	14/12/2023
Your job number:	591891	**Samples instructed on/ Analysis started on:**	15/12/2023
Your order number:	DS77005	**Analysis completed by:**	29/12/2023
Report Issue Number:	1	**Report issued on:**	29/12/2023
Samples Analysed:	3 water samples		

Signed [redacted]

Dominika Liana
Junior Reporting Specialist
For & on behalf of i2 Analytical Ltd.

Standard Geotechnical, Asbestos and Chemical Testing Laboratory located at: ul. Pionierów 39, 41-711 Ruda Śląska, Poland.

Accredited tests are defined within the report, opinions and interpretations expressed herein are outside the scope of accreditation.

Standard sample disposal times, unless otherwise agreed with the laboratory, are :

soils	- 4 weeks from reporting
leachates	- 2 weeks from reporting
waters	- 2 weeks from reporting
asbestos	- 6 months from reporting

Excel copies of reports are only valid when accompanied by this PDF certificate.

Any assessments of compliance with specifications are based on actual analytical results with no contribution from uncertainty of measurement.
Application of uncertainty of measurement would provide a range within which the true result lies.
An estimate of measurement uncertainty can be provided on request.

This certificate should not be reproduced, except in full, without the express permission of the laboratory.
The results included within the report relate only to the sample(s) submitted for testing.

UKAS TESTING
4041

Analytical i2 Environmental Science

Analytical Report Number: 23-75173
Project / Site name: UBS Upper Brok Street

Your Order No: DS77005

Lab Sample Number				2912395	2912396	2912397
Sample Reference				RO1	RO2	RO3
Sample Number				None Supplied	None Supplied	None Supplied
Depth (m)				8.50	8.50	8.50
Date Sampled				14/12/2023	14/12/2023	14/12/2023
Time Taken				None Supplied	None Supplied	None Supplied
Analytical Parameter (Water Analysis)	**Units**	**Limit of detection**	**Accreditation Status**			
General Inorganics						
pH (L099)	pH Units	N/A	ISO 17025	7.2	7.3	7
Sulphate as SO4	µg/l	45	ISO 17025	167000	278000	54300
Speciated PAHs						
Naphthalene	µg/l	0.01	ISO 17025	< 0.01	< 0.01	< 0.01
Acenaphthylene	µg/l	0.01	ISO 17025	< 0.01	< 0.01	< 0.01
Acenaphthene	µg/l	0.01	ISO 17025	< 0.01	< 0.01	< 0.01
Fluorene	µg/l	0.01	ISO 17025	< 0.01	< 0.01	< 0.01
Phenanthrene	µg/l	0.01	ISO 17025	< 0.01	< 0.01	< 0.01
Anthracene	µg/l	0.01	ISO 17025	< 0.01	< 0.01	< 0.01
Fluoranthene	µg/l	0.01	ISO 17025	< 0.01	< 0.01	< 0.01
Pyrene	µg/l	0.01	ISO 17025	< 0.01	< 0.01	< 0.01
Benzo(a)anthracene	µg/l	0.01	ISO 17025	< 0.01	< 0.01	< 0.01
Chrysene	µg/l	0.01	ISO 17025	< 0.01	< 0.01	< 0.01
Benzo(b)fluoranthene	µg/l	0.01	ISO 17025	< 0.01	< 0.01	< 0.01
Benzo(k)fluoranthene	µg/l	0.01	ISO 17025	< 0.01	< 0.01	< 0.01
Benzo(a)pyrene	µg/l	0.01	ISO 17025	< 0.01	< 0.01	< 0.01
Indeno(1,2,3-cd)pyrene	µg/l	0.01	ISO 17025	< 0.01	< 0.01	< 0.01
Dibenz(a,h)anthracene	µg/l	0.01	ISO 17025	< 0.01	< 0.01	< 0.01
Benzo(ghi)perylene	µg/l	0.01	ISO 17025	< 0.01	< 0.01	< 0.01
Total PAH						
Total EPA-16 PAHs	µg/l	0.16	ISO 17025	< 0.16	< 0.16	< 0.16
Heavy Metals / Metalloids						
Chromium (hexavalent)	µg/l	5	ISO 17025	< 5.0	< 5.0	< 5.0
Arsenic (dissolved)	µg/l	0.15	ISO 17025	0.36	0.44	0.23
Cadmium (dissolved)	µg/l	0.02	ISO 17025	0.05	0.02	< 0.02
Chromium (dissolved)	µg/l	0.2	ISO 17025	0.5	0.3	0.9
Copper (dissolved)	µg/l	0.5	ISO 17025	9.9	5.8	1.3
Lead (dissolved)	µg/l	0.2	ISO 17025	< 0.2	< 0.2	< 0.2
Mercury (dissolved)	µg/l	0.05	ISO 17025	0.12	< 0.05	< 0.05
Nickel (dissolved)	µg/l	0.5	ISO 17025	4.4	1	2
Zinc (dissolved)	µg/l	0.5	ISO 17025	9	4.9	8.6

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Analytical Report Number: 23-75173
Project / Site name: UBS Upper Brok Street

Your Order No: DS77005

Lab Sample Number				2912395	2912396	2912397
Sample Reference				RO1	RO2	RO3
Sample Number				None Supplied	None Supplied	None Supplied
Depth (m)				8.50	8.50	8.50
Date Sampled				14/12/2023	14/12/2023	14/12/2023
Time Taken				None Supplied	None Supplied	None Supplied
Analytical Parameter (Water Analysis)	**Units**	**Limit of detection**	**Accreditation Status**			
Monoaromatics & Oxygenates						
Benzene	µg/l	3	ISO 17025	< 3.0	< 3.0	< 3.0
Toluene	µg/l	3	ISO 17025	< 3.0	< 3.0	< 3.0
Ethylbenzene	µg/l	3	ISO 17025	< 3.0	< 3.0	< 3.0
p & m-xylene	µg/l	3	ISO 17025	< 3.0	< 3.0	< 3.0
o-xylene	µg/l	3	ISO 17025	< 3.0	< 3.0	< 3.0
MTBE (Methyl Tertiary Butyl Ether)	µg/l	3	ISO 17025	< 3.0	< 3.0	< 3.0
Petroleum Hydrocarbons						
TPH-CWG - Aliphatic >C5 - C6 $_{HS_1D_AL}$	µg/l	1	ISO 17025	< 1.0	< 1.0	< 1.0
TPH-CWG - Aliphatic >C6 - C8 $_{HS_1D_AL}$	µg/l	1	ISO 17025	< 1.0	< 1.0	< 1.0
TPH-CWG - Aliphatic >C8 - C10 $_{HS_1D_AL}$	µg/l	1	ISO 17025	< 1.0	< 1.0	< 1.0
Aliphatic >C10 - C12 $_{EH_2D_AL_\#1_\#2}$	µg/l	10	ISO 17025	< 10	< 10	< 10
Aliphatic >C12 - C16 $_{EH_2D_AL_\#1_\#2}$	µg/l	10	ISO 17025	< 10	< 10	< 10
Aliphatic >C16 - C21 $_{EH_2D_AL_\#1_\#2}$	µg/l	10	ISO 17025	< 10	< 10	< 10
Aliphatic >C21 - C35 $_{EH_2D_AL_\#1_\#2}$	µg/l	10	ISO 17025	< 10	< 10	< 10
Aliphatic >C10 - C35 $_{EH_2D_AL_\#1_\#2}$	µg/l	10	ISO 17025	< 10	< 10	< 10
TPH-CWG - Aromatic >C5 - C7 $_{HS_1D_AR}$	µg/l	1	ISO 17025	< 1.0	< 1.0	< 1.0
TPH-CWG - Aromatic >C7 - C8 $_{HS_1D_AR}$	µg/l	1	ISO 17025	< 1.0	< 1.0	< 1.0
TPH-CWG - Aromatic >C8 - C10 $_{HS_1D_AR}$	µg/l	1	ISO 17025	< 1.0	< 1.0	< 1.0
Aromatic >C10 - C12 $_{EH_2D_AR_\#1_\#2}$	µg/l	10	ISO 17025	< 10	< 10	< 10
Aromatic >C12 - C16 $_{EH_2D_AR_\#1_\#2}$	µg/l	10	ISO 17025	< 10	< 10	< 10
Aromatic >C16 - C21 $_{EH_2D_AR_\#1_\#2}$	µg/l	10	ISO 17025	< 10	< 10	< 10
Aromatic >C21 - C35 $_{EH_2D_AR_\#1_\#2}$	µg/l	10	ISO 17025	< 10	< 10	< 10
Aromatic >C10 - C35 $_{EH_2D_AR_\#1_\#2}$	µg/l	10	ISO 17025	< 10	< 10	< 10

U/S = Unsuitable Sample I/S = Insufficient Sample ND = Not detected

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Analytical Report Number : 23-75173
Project / Site name: UBS Upper Brok Street

Water matrix abbreviations:
Surface Water (SW) Potable Water (PW) Ground Water (GW) Process Waters (PrW) Final Sewage Effluent (FSE) Landfill Leachate (LL)

Analytical Test Name	Analytical Method Description	Analytical Method Reference	Method number	Wet / Dry Analysis	Accreditation Status
Metals in water by ICP-MS (dissolved)	Determination of metals in water by acidification followed by ICP-MS. Accredited Matrices: SW, GW, PW except B=SW,GW, Hg=SW,PW, Al=SW,PW.	In-house method based on USEPA Method 6020 & 200.8 "for the determination of trace elements in water by ICP-MS.	L012-PL	W	ISO 17025
Hexavalent chromium in water	Determination of hexavalent chromium in water by acidification, addition of 1,5 diphenylcarbazide followed by colorimetry.	In-house method by continuous flow analyser. Accredited Matrices SW, GW, PW.	L080-PL	W	ISO 17025
Speciated EPA-16 PAHs in water	Determination of PAH compounds in water by extraction in dichloromethane followed by GC-MS with the use of surrogate and internal standards. Accredited matrices: SW PW GW	In-house method based on USEPA 8270	L102B-PL	W	ISO 17025
Sulphate in water	Determination of sulphate in water after filtration by acidification followed by ICP-OES. Accredited Matrices SW, GW, PW.	In-house method based on MEWAM 2006 Methods for the Determination of Metals in Soil.	L039-PL	W	ISO 17025
TPHCWG (Waters)	Determination of dichloromethane extractable hydrocarbons in water by GC-MS, speciation by interpretation.	In-house method	L070-PL	W	ISO 17025
TPH C10-C35 by GCxGC-FID	Determination of total petroleum hydrocarbons in water by GC x GC FID with carbon banding aliphatic and aromatic C10-C35. Accredited Matrices SW,GW,PW.	In-house method	L101B-PL	W	ISO 17025
BTEX and MTBE in water (Monoaromatics)	Determination of BTEX and MTBE in water by headspace GC-MS. Accredited matrices: SW PW GW	In-house method based on USEPA8260. Refer to CoA for analyte specific accreditation	L073B-PL	W	ISO 17025
TPH Chromatogram in Water	TPH Chromatogram in Water.	In-house method	L070-PL	W	NONE

Analytical Report Number : 23-75173
Project / Site name: UBS Upper Brok Street

Water matrix abbreviations:
Surface Water (SW) Potable Water (PW) Ground Water (GW) Process Waters (PrW) Final Sewage Effluent (FSE) Landfill Leachate (LL)

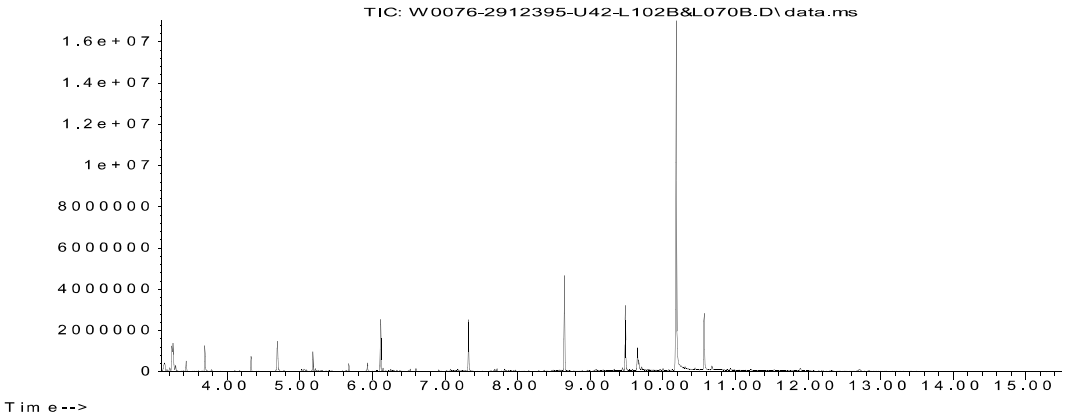
Analytical Test Name	Analytical Method Description	Analytical Method Reference	Method number	Wet / Dry Analysis	Accreditation Status
pH at 20oC in water (automated)	Determination of pH in water by electrometric measurement. Accredited matrices: SW PW GW	In house method.	L099-PL	W	ISO 17025

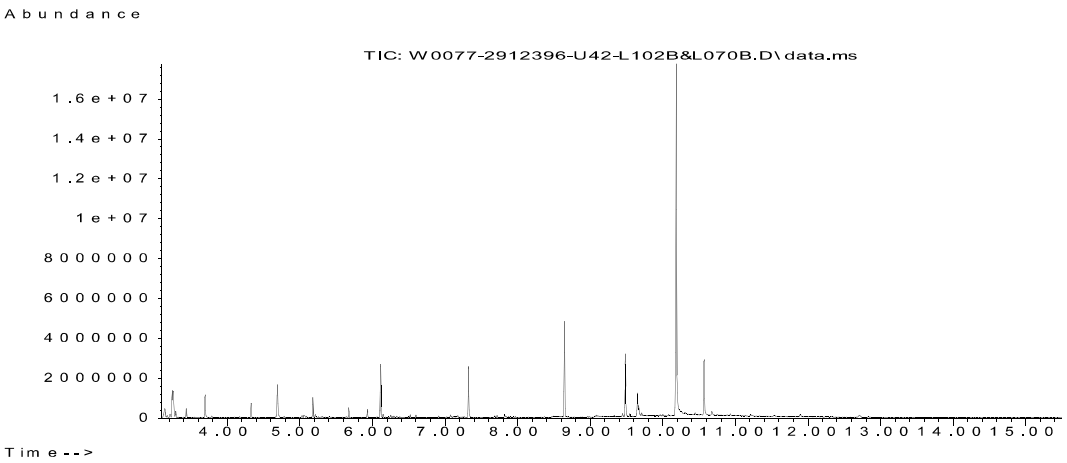
For method numbers ending in 'UK or A' analysis have been carried out in our laboratory in the United Kingdom (WATFORD).
For method numbers ending in 'F' analysis have been carried out in our laboratory in the United Kingdom (East Kilbride).
For method numbers ending in 'PL or B' analysis have been carried out in our laboratory in Poland.
Soil analytical results are expressed on a dry weight basis. Where analysis is carried out on as-received the results obtained are multiplied by a moisture correction factor that is determined gravimetrically using the moisture content which is carried out at a maximum of 30oC.
Unless otherwise indicated, site information, order number, project number, sampling date, time, sample reference and depth are provided by the client. The instructed on date indicates the date on which this information was provided to the laboratory.

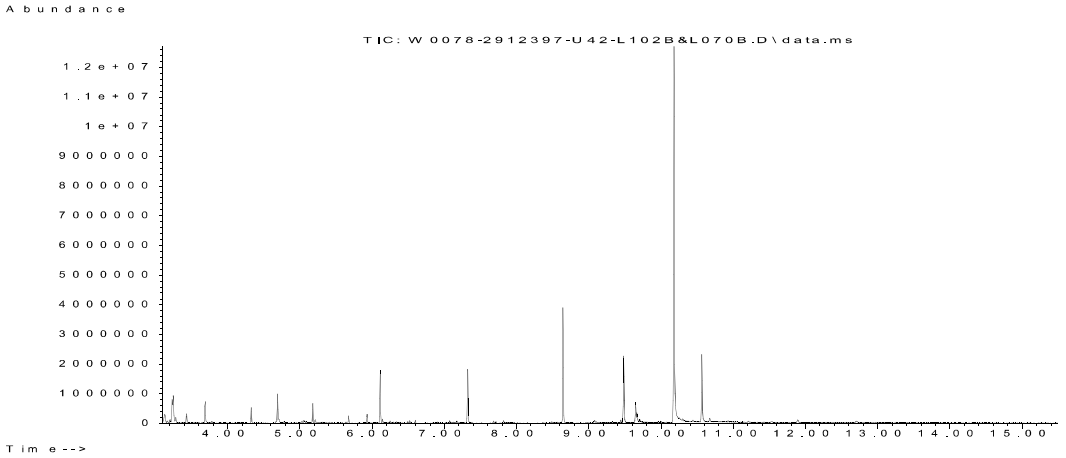
Information in Support of Analytical Results

List of HWOL Acronyms and Operators

Acronym	Descriptions
HS	Headspace Analysis
MS	Mass spectrometry
FID	Flame Ionisation Detector
GC	Gas Chromatography
EH	Extractable Hydrocarbons (i.e. everything extracted by the solvent(s))
CU	Clean-up - e.g. by Florisil®, silica gel
1D	GC - Single coil/column gas chromatography
2D	GC-GC - Double coil/column gas chromatography
Total	Aliphatics & Aromatics
AL	Aliphatics
AR	Aromatics
#1	EH_2D_Total but with humics mathematically subtracted
#2	EH_2D_Total but with fatty acids mathematically subtracted
_	Operator - understore to separate acronyms (exception for +)
+	Operator to indicate cumulative e.g. EH+HS_Total or EH_CU+HS_Total


Abundance
TIC: W0076-2912395-U42-L102B&L070B.D\data.ms
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1.4e+07
1.2e+07
1e+07
8000000
6000000
4000000
2000000
0
4.00
5.00
6.00
7.00
8.00
9.00
10.00
11.00
12.00
13.00
14.00
15.00
Time-->


Abundance
TIC: W0077-2912396-U42-L102B&L070B.D\data.ms
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1.4e+07
1.2e+07
1e+07
8000000
6000000
4000000
2000000
0
4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00 15.00
Time-->


Abundance
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3000000
2000000
1000000
0
4.00
5.00
6.00
7.00
8.00
9.00
10.00
11.00
12.00
13.00
14.00
15.00
Time-->

Appendix F – Field Monitoring Data

Site Name	Upper Brook Street												NexGen ID	101718.591891			
Client	HDR Inc.												Recorded by	TB			
Gas Analyser	GFM436												Visit Number	1			
PID	TigerPID												Date	08/12/2023			
Readings at start	CH_4 (% v/v)	<0.1	CO_2 (% v/v)	<0.1	O_2 (% v/v)	20.6	H_2S (ppm)	<0.1									
General comments																	

WEATHER	Start	End
Time	10:00	11:30
Weather (dry/rain/snow/ice)	Dry	Dry
Pressure (mb)	1000	999
Rising/Falling Trend	Steady	
Wind Speed (mph)	10	9
Wind Dir. (From)	S	S
Temperature °C	7	7
Automate Ground Level Calc?	Yes	

Default = No
Automate Ground Level assumes top of cover = above ground level / top of pipe = below ground level. You must have recorded the distance between top of cover / top of pipe and ground level when monitoring

Groundwater Notes
$ For Depth to water state - Depth to water or Dry or NR (= Not Recorded - provide reason if monitoring was intended)
 # For Depth to Product state - ND (= Not detected - product looked for but absent) or NR (= Not Recorded - instrument used unable to detect product)

Ref	GROUND GAS													GROUNDWATER			
	Flow		CH_4		CO_2		O_2		H_2S	CO	VOC	Differential (Relative) Pressure	Atmos. Pressure	Depth to free product	Depth to water	Depth to base	SWL Measured:
	l/hr		% v/v		% v/v		% v/v		ppm								
	Max	Steady	Max	Steady	Max	Steady	Min	Steady	Max	Max	Max	mb	mb	m	m	m	
The formulae require that only numbers, "<0.1" for ground gas and flow or "DRY" for groundwater are entered in the sheet																	
RO1	<0.1	<0.1	<0.1	<0.1	4.1	4.1	12.4	12.4	<0.1	<0.1	<0.1	<0.1	993.0	ND	8.63	9.42	GL
RO2	<0.1	<0.1	<0.1	<0.1	3.0	3.0	17.3	17.3	<0.1	<0.1	<0.1	<0.1	991.0	ND	8.54	10.30	GL
RO3	<0.1	<0.1	<0.1	<0.1	0.6	0.6	18.9	18.9	<0.1	<0.1	<0.1	<0.1	993.0	ND	8.49	10.47	GL
DS1	<0.1	<0.1	<0.1	<0.1	4.0	3.9	15.8	15.8	<0.1	<0.1	<0.1	<0.1	992.0	ND	DRY	3.53	GL
DS2	<0.1	<0.1	<0.1	<0.1	0.6	0.6	19.7	19.7	<0.1	<0.1	<0.1	<0.1	992.0	ND	DRY	2.19	GL
DS3	<0.1	<0.1	0.6	0.1	4.4	4.0	17.9	18.0	<0.1	<0.1	<0.1	<0.1	991.0	ND	3.55	3.66	GL
DS4	0.9	<0.1	<0.1	<0.1	4.3	4.3	14.4	14.4	<0.1	<0.1	<0.1	<0.1	990.0	ND	DRY	3.63	GL
DS5	<0.1	<0.1	<0.1	<0.1	0.3	0.1	20.3	20.4	<0.1	<0.1	<0.1	<0.1	992.0	ND	DRY	2.71	GL
DS6	<0.1	<0.1	<0.1	<0.1	0.4	0.4	20.0	20.0	<0.1	<0.1	<0.1	<0.1	992.0	ND	DRY	3.56	GL
DS7	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	20.2	20.2	<0.1	<0.1	<0.1	<0.1	992.0	ND	DRY	1.79	GL

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Site Name	Upper Brook Street								NexGen ID	101718.591891							
Client	HDR Inc.								Recorded by	0.00							
Gas Analyser	GFM436								Visit Number	2							
PID	TigerPID								Date	14/12/2023							
Readings at start	CH_4 (% v/v)	<0.1	CO_2 (% v/v)	<0.1	O_2 (% v/v)	20.4	H_2S (ppm)	<0.1									
General comments																	

WEATHER	Start	End
Time	07:45	09:00
Weather (dry/rain/snow/ice)	Rain	Dry
Pressure (mb)	1016	1015
Rising/Falling Trend	Steady	
Wind Speed (mph)	6	5
Wind Dir. (From)	N	N
Temperature °C	5	6
Automate Ground Level Calc?	Yes	

Default = No
Automate Ground Level assumes top of cover = above ground level / top of pipe = below ground level. You must have recorded the distance between top of cover / top of pipe and ground level when monitoring

Groundwater Notes
$ For Depth to water state - Depth to water or Dry or NR (= Not Recorded - provide reason if monitoring was intended)
 # For Depth to Product state - ND (= Not detected - product looked for but absent) or NR (= Not Recorded - instrument used unable to detect product)

Ref	GROUND GAS													GROUNDWATER			
	Flow		CH_4		CO_2		O_2		H_2S	CO	VOC	Differential (Relative) Pressure	Atmos. Pressure	Depth to free product	Depth to water	Depth to base	SWL Measured:
	l/hr		% v/v		% v/v		% v/v		ppm								
	Max	Steady	Max	Steady	Max	Steady	Min	Steady	Max	Max	Max	mb	mb	m	m	m	
The formulae require that only numbers, "<0.1" for ground gas and flow or "DRY" for groundwater are entered in the sheet																	
RO1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	20.2	20.2	<0.1	<0.1	<0.1	<0.1	1010.0	ND	8.44	9.42	GL
RO2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	15.2	15.2	<0.1	<0.1	<0.1	<0.1	1010.0	ND	8.32	10.30	GL
RO3	<0.1	<0.1	<0.1	<0.1	2.5	2.5	16.3	16.3	<0.1	<0.1	<0.1	-10.0	1010.0	ND	8.65	10.47	GL
DS1	<0.1	<0.1	<0.1	<0.1	4.1	4.1	15.1	15.1	<0.1	<0.1	<0.1	<0.1	1010.0	ND	DRY	3.53	GL
DS2	<0.1	<0.1	<0.1	<0.1	0.9	0.9	19.0	19.0	<0.1	<0.1	<0.1	<0.1	1010.0	ND	DRY	2.19	GL
DS3	<0.1	<0.1	<0.1	<0.1	2.4	2.4	18.0	18.0	<0.1	<0.1	<0.1	<0.1	1010.0	ND	3.59	3.66	GL
DS4	<0.1	<0.1	<0.1	<0.1	2.6	2.6	17.1	17.1	<0.1	<0.1	<0.1	<0.1	1010.0	ND	DRY	3.63	GL
DS5	<0.1	<0.1	<0.1	<0.1	0.1	0.1	20.2	20.2	<0.1	<0.1	<0.1	<0.1	1010.0	ND	DRY	2.71	GL
DS6	<0.1	<0.1	<0.1	<0.1	0.1	0.1	20.1	20.1	<0.1	<0.1	<0.1	<0.1	1010.0	ND	DRY	3.56	GL
DS7	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	20.0	20.0	<0.1	<0.1	<0.1	<0.1	1010.0	ND	DRY	1.79	GL

Site Name	Upper Brook Street								NexGen ID	101718.591891					
Client	HDR Inc.								Recorded by	TB					
Gas Analyser	GFM436								Visit Number	3					
PID	TigerPID								Date	19/12/2023					
Readings at start	CH_4(% v/v)	<0.1	CO_2(% v/v)	<0.1	O_2(% v/v)	20.5	H_2S (ppm)	<0.1							
General comments															

WEATHER	Start	End
Time	11:15:00	12:30:00
Weather (dry/rain/snow/ice)	Dry	Dry
Pressure (mb)	1019.00	1019.00
Rising/Falling Trend	Falling	
Wind Speed (mph)	9.00	9.00
Wind Dir. (From)	W	W
Temperature ºC	9.00	9.00
Automate Ground Level Calc?	Yes	

Default = No
Automate Ground Level assumes top of cover = above ground level / top of pipe = below ground level. You must have recorded the distance between top of cover / top of pipe and grounc level when monitoring

Groundwater Notes
$ For Depth to water state - Depth to water or Dry or NR (= Not Recorded - provide reason if monitoring was intended)
 # For Depth to Product state - ND (= Not detected - product looked for but absent) or NR (= Not Recorded - instrument used unable to detect product)

Ref	GROUND GAS													GROUNDWATER			
	Flow		CH_4		CO_2		O_2		H_2S	CO	VOC	Differential (Relative) Pressure	Atmos. Pressure	Depth to free product	Depth to water	Depth to base	SWL Measured:
	l/hr		% v/v		% v/v		% v/v		ppm								
	Max	Steady	Max	Steady	Max	Steady	Min	Steady	Max	Max	Max	mb	mb	m	m	m	
The formulae require that only numbers, "<0.1" for ground gas and flow or "DRY" for groundwater are entered in the sheet																	
RO1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	20.2	20.2	<0.1	<0.1	<0.1	<0.1	1010.0	ND	8.56	9.42	GL
RO2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	15.2	15.2	<0.1	<0.1	<0.1	<0.1	1010.0	ND	8.88	10.30	GL
RO3	<0.1	<0.1	<0.1	<0.1	2.0	2.0	16.2	16.2	<0.1	<0.1	<0.1	<0.1	1010.0	ND	9.02	10.47	GL
DS1	<0.1	<0.1	<0.1	<0.1	4.0	4.0	14.5	14.5	<0.1	<0.1	<0.1	<0.1	1009.0	ND	DRY	3.53	GL
DS2	<0.1	<0.1	<0.1	<0.1	0.7	0.7	18.9	18.9	<0.1	<0.1	<0.1	<0.1	1010.0	ND	DRY	2.19	GL
DS3	<0.1	<0.1	<0.1	<0.1	2.0	2.0	18.1	18.1	<0.1	<0.1	<0.1	<0.1	1010.0	ND	DRY	3.66	GL
DS4	<0.1	<0.1	<0.1	<0.1	2.1	2.1	17.1	17.1	<0.1	<0.1	<0.1	<0.1	1010.0	ND	DRY	3.63	GL
DS5	<0.1	<0.1	<0.1	<0.1	0.2	0.2	20.0	20.0	<0.1	<0.1	<0.1	<0.1	1009.0	ND	DRY	2.71	GL
DS6	<0.1	<0.1	<0.1	<0.1	0.3	0.3	20.0	20.0	<0.1	<0.1	<0.1	<0.1	1010.0	ND	DRY	3.56	GL
DS7	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	20.0	20.0	<0.1	<0.1	<0.1	<0.1	1010.0	ND	DRY	1.79	GL

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Appendix G – Risk Definitions

Contaminated Land Risk Definitions

The following methodology is based on the methodology presented in CIRIA C552 Contaminated Land Risk Assessment: A Guide to Good Practice 2001. It requires the classification of the:

- Magnitude of the potential consequence (severity) of the Risk occurring: and
- Magnitude of the Probability (likelihood) of the Risk occurring.

The classifications are then compared to indicate the risk presented by each pollutant linkage.

Consequence to Receptor Definition Matrix

	Human Health	Controlled Waters	Buildings/Services
Severe Consequence	Acute or chronic permanent impact on human health.	Sensitive controlled water pollution ongoing, or just about to occur.	Catastrophic collapse
Medium Consequence	Chronic permanent impact on human health	Gradual pollution of sensitive controlled water	Degradation of materials
Mild Consequence	Chronic temporary impact on human health	Gradual pollution of non-sensitive controlled water	Damage to building rendering it unsafe.to occupy (eg foundation damage resulting in instability).
Minor Consequence	Non-permanent health effects to human health (easily prevented by means such as personal protective clothing etc).	Slight discoloration of water	Easily repairable effects of damage to buildings, structures and services, i.e discoloration of concrete

Probability Definitions

Probability	Definition in Context
Higher	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. Positive evidence of source, pathway and receptor.
Likely	There is a pollution 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. Suspect source, pathway, and receptor
Low Likelihood	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 such event would take place, and is 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 No evidence of hazard, pathway, and receptor

Standard Risk Matrix

		Consequence/Magnitude of impact			
		Severe	Medium	Mild	Minor
Probability	**High**	Very High	High	Moderate	Moderate/Low
	Likely	High	Moderate	Moderate/low	Low
	Low Likelihood	Moderate	Moderate/low	Low	Very Low
	Unlikely	Moderate/low	Low	Very Low	Very Low

Classified risks and likely action

Significance Level	Definition/Comments
Very High Risk	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. Urgent investigation (if not undertaken already) and remediation are likely to be required. Demonstrable contaminated land situation, highest threat & liability level, urgent action recommended.
High Risk	Harm is likely to arise to a designated receptor from an identified hazard. Realisation of the risk is likely to present a substantial liability. 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. Likely contaminated land situation, risk assessment and action recommended.
Moderate	It is possible that harm could arise to a designated receptor from an identified hazard. However, if is either relatively unlikely that any such harm would be severe, or if any harm were to occur it is more 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. Plausible contaminated land situation, risk assessment and possible action recommended.
Low Risk	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. Unlikely contaminated land situation, possible risk assessment and possible action.
Very Low Risk	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. Negligible risk, no action recommended except vigilance for changes in conditions.

Geotechnical Risk Classification

The geohazards listed in the report within Section 4 follow guidance presented in Clayton, C.R.I. (2001) *Managing Geotechnical Risk*, Thomas Telford and the National Highways document CD622 '*Managing Geotechnical Risk*' (2020) which aims to identify and manage the geotechnical risks associated with a scheme throughout its lifespan, from planning to construction to maintenance.

For each geohazard the probability of the hazard occurring (P) has been considered together with the impact it would have (I) if it were to happen to calculate the risk rating between 1 and 25.

Risks that fall within Moderate, Significant and Severe categories below are considered to be ***substantial*** and are therefore listed within the report.

Probability	**(P)**
Very Likely (VLk)	5
Likely (Lk)	4
Plausible (P)	3
Unlikely (U)	2
Very Unlikely (VU)	1

X

Impact	**(I)**
Very High (VH)	5
High (H)	4
Medium (M)	3
Low (L)	2
Very Low (VL)	1

=

(R)	**Risk**
20 – 25	Severe
15 – 19	Substantial
10 – 14	Moderate
5 – 9	Minor
1 – 4	Negligible

Appendix H – Detailed UXO Risk Assessment Report

Stage 2 Detailed Explosive Ordnance Risk Assessment

Project: Upper Brook Street, Manchester | **Client:** Delta-Simons



The Client

Delta-Simons Limited

Project

Upper Brook Street, Manchester

Site Address

Upper Brook Street
Chorlton-on-Medlock
Manchester
M13 9TX

Report Reference Number

DRA.10140.23

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Author

O. Brown

[redacted]

Review

D. King

[redacted]

Review

G. Storm

[redacted]

Issue authorisation

O. Brown

[redacted]

Impartial Assessments Limited

7 Bell Yard
Holborn
London
WC2A 2JR
United Kingdom

Tel: +44 (0) 207 126 8164

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This report refers to the conditions present on Site at the time of writing. Impartial Assessments will not be held responsible for any subsequent changes to these conditions or any relevant information that may subsequently become available which could render part(s) of this report obsolete.

Reliance must be based on the report as a whole and not on extracts which may lead to incorrect conclusions when taken out of context.

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All reasonable skill, care and diligence has been exercised by Impartial Assessments Ltd in producing this report. However, due to the uncertainty inherent in analysing all risk variables, we cannot/do not guarantee the correctness or accuracy of any interpretation and we shall not, except in the case of gross negligence on our part, be liable for any loss or damages incurred by anyone resulting from any interpretation made within this report.

As detailed a search for pertinent information as possible within the stated timeframe and budget has been conducted. Although unlikely, additional significant information (e.g. local anecdotal accounts) may exist, however future emergence of such evidence would not constitute a failure of this risk assessment.

This report has been prepared for the exclusive use of the Client. Any third party relying on any information, conclusion or recommendation contained within this report, does so at their own risk.

EXECUTIVE SUMMARY

Conclusion	Explosive ordnance (EO) poses a varying risk to the proposed works. Two risk zones have been identified.	
	Low Risk Zone	**Moderate Risk Zone**
Recommendation(s)	► **Explosive Ordnance Disposal (EOD) Engineer** supervision of the SI boreholes and all development phase mechanical excavations within the Moderate Risk Zone only. ► **Intrusive Magnetometer Probe Survey** at each pile position within the Moderate Risk Zone only. Survey only required down to 10.0m bgl. ► **Explosive Ordnance Safety & Awareness Briefing** to all development phase personnel conducting intrusive ground works throughout the Site. ► **Explosive Ordnance Site Safety Instructions** held on Site for the duration of the development phase ground works.	
The Site	The Site is situated in the Chorlton-on-Medlock area of Greater Manchester, ~1km south of Manchester Piccadilly Railway Station. It is bound to the west by Upper Brook Street, to the east by Kincardine Road, to the south by Cottenham Street, and to the north by commercial property. The Site is centred on the approximate National Grid Ref: SJ 84858 96856.	
	The majority of the Site area is currently occupied by Elizabeth Yarwood Court, a two-storey post-WW2 constructed residential apartment building with associated gardens and car park. The Site's west extent is occupied by a disused canopy structure and hardstanding, previously part of a used car sales business. This area is fenced off from the residential development.	
Proposed works	Redevelopment will involve demolition of all existing structures and construction of a six to nine-storeys high building (laboratories and office space). In addition to various shallow mechanical excavations, deep piled foundations will be required. Prior to redevelopment, an SI will be undertaken comprising 3No. boreholes to ~20.0m bgl and 6No. boreholes to ~5.0m bgl.	
Risk Assessment - Key Findings		
Historic Site occupancy	During WW2, the Site boundary encompassed multiple houses with rear yards, a small industrial works, and short sections of two streets.	
Likelihood of EO contamination:	► The Manchester / Salford / Stretford conurbation experienced some 41No. individual air raids during WW2, ranking as the eleventh most heavily bombed British urban area. The Site was located relatively close to the Luftwaffe's primary target areas and therefore experienced a significantly elevated bombing density. Five or six air raids resulted in at least 7No. high explosive (HE) bomb strikes (almost certainly more) and 27No. incendiary bomb (IB) incidents within 400m of the Site boundary. ► Note, the only available bombing incident records appear to be missing local incidents. The low quality of the historic record and potentially significant inconsistencies between records highlight the difficulties associated with accurate wartime record keeping in areas of elevated bombing density. This creates uncertainty with regards to the quantity and locations of local bomb strikes. Therefore, the assessment of UXO contamination risk is accordingly cautious.	

	► It is considered likely that two unrecorded HE bombs struck the southeast corner of the Site and the section of Cottenham Street abutting the south Site boundary, resulting in the immediate destruction (or damage beyond repair) of multiple terraced houses on Site. One original air raid report raises the possibility that this incident occurred on the 11th October 1940. As the wider study area experienced at least three or four subsequent air raids (including two or three major scale attacks), the bombsite ruins on Site would have been vulnerable to UXB strikes on several occasions. Indeed, a nearby (probable) linear HE bomb-stick aligned with the Site during a December 1940 raid, significantly elevating the likelihood that a (unrecorded) unexploded bomb (UXB) was released over the study area and landed in bombsite wreckage on Site. ► As these post-October 1940 air raids occurred during the hours of darkness, the risk that UXBs fell unwitnessed is increased. Note, the ensuing chaos of concentrated bombing would have distracted air raid precautions (ARP) wardens and fire fighters during heavy raids. Furthermore, the bombsite ruins would likely have been abandoned pending clearance and even if they were accessed, the entry hole of any HE UXB (as little as 200 / 300mm in diameter) would have been easily obscured by rubble / debris, and therefore would probably have gone undetected / unrecorded. ► Any such scenario could potentially have resulted in the HE UXB coming to rest under adjacent undamaged buildings or hard surfaced ground on Site, due to the J-Curve (lateral offset) Effect or due to ricochet on contact with sub-surface structures, e.g. concrete foundations. ► Similarly, any small items of aerial UXO, e.g. German 1kg / 2kg IBs and British anti-aircraft (AA) projectiles, landing in bombsite conditions would also likely have gone unobserved and remained undetected, caught up in the wreckage. There would have been no visual and little audible warning of the latter type of UXO strike. Note, these UXO items are less likely to have achieved significant penetration of made ground beneath the rubble (especially the lightweight IBs). ► Any aerial UXO strike to the multiple buildings (terrace houses and industrial works) that survived the war largely intact would have caused incontrovertible evidence of its incidence, as it passed through roofing and struck the floor slab. The same can be said for the residential back yards and the surrounding streets / pavements. Each yard was small and almost certainly sett paved. Evidence of a UXB strike to this hard surfacing would have been persistent and easily recognisable within these frequently accessed yards. ► During WW2, 33No. static heavy AA gun batteries (at least 132No. gun emplacements), six ZAA rocket batteries, and a small number of light AA guns were present within firing range of the Site. The number of AA weapons actually deployed varied throughout the bombing campaign, however a very large quantity of ammunition (chiefly heavy AA shells) was expended, significantly elevating the likelihood of associated UXO strikes on Site. ► Any unexploded 1kg / 2kg IBs or unexploded AA shells occupying the Site's WW2 rubble / debris were probably removed from Site at the time, during bombsite clearance works. It is also conceivable however that any such EO (small, easily overlooked devices) could conceivably have remained on Site, contaminating rubble that may have been used to fill any basement / cellar voids, beneath destroyed dwellings.
Likelihood of EO remaining	► The area of potential concern in the southeast corner (where an elevated likelihood of EO remaining today exists) has only experienced disturbance of very shallow made ground since WW2. Consequently, the potential EO risk (chiefly German HE UXBs at depths >1.5m bgl) remains unmitigated here. ► The larger south-central area of potential concern has been partly redeveloped, experiencing one phase of post-WW2 ground works. However, as this low-rise building is almost certainly founded on traditional shallow footings, the risk associated with deeper buried German HE UXBs (within its footprint) will not have been mitigated to any degree.

Likelihood of EO encounter and initiation	► As several of the proposed SI positions and part the proposed building footprint occupy one of the areas of potential concern (where an elevated likelihood of EO remaining exists) a risk pathway is created, exposing the associated ground works to a potential EO encounter. ► Within this area of potential concern, the zone of potential EO contamination (ZPC) is shallow to deep, extending down from the base of the post-WW2 created made ground. Consequently, all the planned intrusions could potentially encounter EO and it is likely that some of the development phase mechanical excavations (chiefly those within the footprint of the planned buildings) will disturb a significant portion of the ZPC. ► The boreholes planned for the area of potential concern will disturb a small volume of made ground / geology within the ZPC, reducing the likelihood of encountering anything buried (e.g. EO). However, this is offset by the significantly elevated likelihood of EO remaining buried here today and the higher risk associated with 'blind' intrusive methodologies (increasing the likelihood of striking buried EO when compared to 'open' mechanical excavations of the same material). Note, the same can be said for any piling works within areas of potential concern. ► There is a low likelihood of encountering EO within the post-WW2 created made ground on Site.

The executive summary covers the key points only. The main body of this report contains the majority of the Site-specific detail and the limitations of the assessment.

Risk Map



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Glossary

AA	Anti-Aircraft	MU	Maintenance Unit
AAA	Anti-Aircraft Artillery	NEQ	Net Explosive Quantity
ALARP	As Low As Reasonably Practicable	NFF	National Filling Factory
AP	Anti-Personnel	NGR	National Grid Reference
ARP	Air Raid Precautions	OB	Oil Bomb
AT	Anti-Tank	OS	Ordnance Survey
AXO	Abandoned Explosive Ordnance	PAC	Pilotless Aircraft (V1 missile)
BD	Bomb Disposal	PB	Phosphorus Bomb
bgl	below ground level	PM	Parachute Mine (bomb type)
BGS	British Geological Survey	POW	Prisoner of War
BPD	Bomb Penetration Depth	RADAR	Radio Detection And Ranging
CIRIA	Construction Industry Research & Information Association	RAF	Royal Air Force
DA	Delayed Action (bomb type)	RDX	Research Department Explosive
EO	Explosive Ordnance (UXO and AXO)	REF	Royal Explosive Factory
EOC	Explosive Ordnance Clearance	RFC	Royal Flying Corps (1912-1918)
EOD	Explosive Ordnance Disposal	RN	Royal Navy
FAA	Fleet Air Arm (Royal Navy)	RNAD	Royal Naval Armaments Depot
FP	Fire Pot (WW2 German bomb)	RNAS	Royal Naval Air Station
GP	General Purpose (bomb type)	ROF	Royal Ordnance Factory
ha	hectare(s)	SAA	Small Arms Ammunition
HAA	Heavy Anti-Aircraft (gun)	SI	Site Investigation
HC	High Capacity (bomb type)	SIP	Self-Igniting Phosphorus (grenade type)
HE	High Explosive	TA	Territorial Army
HMNB	Her/His Majety's Naval Base	TNT	Trinitrotoluene (explosive)
HMS	Her/His Majesty's Service (shore establishment)	UK	United Kingdom
HO	Home Office	UN	United Nations
HQ	Headquarters	UP	Unrotating Projectile (AA rocket)
HSE	Health & Safety Executive	USAAF	United States Army Air Force (1941-1947)
IB	Incendiary Bomb	USAF	United States Air Force (since 1947)
kg	kilogram(s)	UX	Unexploded
km	kilometre(s)	UX AA	Unexploded Anti-Aircraft (projectile)
LAA	Light Anti-Aircraft (gun)	UXB	Unexploded Bomb
LM	Land Mine	UXO	Unexploded Ordnance
LRRB	Long Range Rocket Bomb (V2 rocket)	V1	Vergeltungswaffe 1 (German cruise missile)
LSA	Land Service Ammunition	V2	Vergeltungswaffe 2 (German ballistic missile)
m	metre(s)	WAAF	Women's Auxiliary Air Force (1939-1949)
MC	Medium Capacity (bomb type)	WO	War Office (1857-1964)
mm	millimetre(s)	WW1	World War One (1914-1918)
MOD	Ministry of Defence	WW2	World War Two (1939-1945)

1 Introduction

1.1 Instruction

Delta-Simons (referred to hereon in as the Client) has commissioned Impartial Assessments Limited (referred to hereon in as IAL) to carry out a Stage 2 Detailed EO Risk Assessment of the proposed works at the Upper Brook Street, Manchester site (referred to hereon in as the Site).

1.2 Objective

The objective of this report is to assess the likelihood of encountering buried explosive ordnance (EO) during intrusive ground works and to assess the consequences of any such encounter. If an intolerable risk level is identified, risk mitigation measures will be recommended.

1.3 Using This Report

In the UK, EO risk is not always considered or fully understood and is often misunderstood. This report aims to provide a comprehensive and coherent account, including introductory text and details on location-specific types of EO. We believe it is important to provide sufficient information to allow the layman to form a good understanding of the potential EO risks.

However, we also appreciate that some readers will not require the full contextual information and therefore the report is structured with this in mind. From **Chapters 3 to 13**, all Site-specific text that affects the outcome of this risk assessment can be found under the highlighted Site-Specific subheadings.

1.4 Explosive Ordnance Risk in the UK

The term EO describes both unexploded ordnance (UXO) and abandoned explosive ordnance (AXO). The former describes devices and projectiles that have been armed (and in some cases fired, dropped, placed, etc) yet failed to function. The latter describes devices and projectiles that have simply been abandoned (discarded or buried).

Fortunately, inadvertent EO initiations (detonations) in the UK are very rare, however, buried EO can cause significant delays to construction projects with associated increases in costs. The origin of UK EO can be broadly categorised as such:

- **Enemy Action (UXO):** the German air force bombed targets throughout the UK during WW1 and WW2. The German Navy bombarded coastal targets in eastern England during WW1 and German long-range artillery bombarded Kent during WW2.
- **Allied Military Activity (UXO and AXO):** several Allied nations used the UK as a staging area for military action in the European theatre of conflict (most notably the US and Canada) during WW1 and WW2.
- **UK Military Activity (UXO and AXO):** domestic British Army, Royal Air Force (RAF) and Royal Navy (RN) training activities as well as anti-aircraft (AA) weapons used during WW1 and WW2.

1.5 Guidelines for Risk Assessment

1.5.1 CIRIA

This assessment has been designed and written in accordance with the relevant Construction Industry Research and Information Association (CIRIA) guidelines: **C681** 'Unexploded Ordnance - A Guide for the Construction Industry' (published 2009) and **C785** 'Unexploded Ordnance Risk Management Guide for Land-Based Projects' (published 2019). C681 and C785 were written (with the support of the UK Health and Safety Executive) to provide the construction industry with accurate and authoritative information regarding matters of onshore EO risk in the UK.

1.5.2 Legislation

There is no specific UK legislation covering the assessment and management of EO risk. However, there is legislation that more broadly covers the consideration of EO hazards:

- Health & Safety at Work Act (1974) and Management of Health & Safety at Work Regulations 1999
- Construction (Design & Management) Regulations (CDM) 2015
- Corporate Manslaughter and Corporate Homicide Act 2007

1.5.3 MOD

EO finds in the UK are handled by the MOD's Joint Service Explosive Ordnance Disposal Operations Centre (JSEODOC). At any site where an identifiable EO risk was not highlighted at project design stage, JSEODOC will not provide EOD services for frequent callouts to EO encounters. Instead, the client will be required to employ the services of a commercial EO risk management contractor to manage the ongoing EO risk.

The delay caused by retrospectively carrying out a risk assessment can have significant cost implications as site works are halted. Therefore, it is essential that EO risk is considered at the earliest possible stage, ideally through the commissioning of a Stage 1 or Stage 2 EO risk assessment.

1.6 Assessment Methodology

1.6.1 Introduction

This report is based on a traditional source-pathway-receptor-consequence (SPRC) assessment methodology and semi-quantitative risk model. The following subheadings describe how this risk assessment structure is applied to buried EO risk (in the UK).

1.6.2 Source

In the UK there are numerous sources of potential EO contamination. Three main factors govern the likelihood of buried EO being present at a given site today:

- **Contamination:** The likelihood that EO came to be buried at a site.
- **Subsequent Detection:** The likelihood that EO (chiefly UXO) contamination went unobserved and reported.
- **Degree of (any) Risk Mitigation:** Could subsequent earthworks or Explosive Ordnance Clearance (EOC) activities have mitigated the buried EO risk?

1.6.3 Pathway

The activities that could result in the EO hazard reaching sensitive receptors and the specific type of EO hazard.

- **Encounter:** The likelihood of buried EO being encountered during the proposed works depends on the total volume of soil disturbed and the type(s) of intrusion methodology. Note, site-specific bomb penetration depth (BPD) calculations must be conducted where appropriate.
- **Initiation:** The likelihood that an encounter results in the EO initiating.

1.6.4 Receptor

The number and sensitivity of receptors will vary from site to site. In the context of an EO initiation, the receptors present at the time of the event will almost always include the most sensitive category; human health.

1.6.5 Consequence

The consequences of an inadvertent EO initiation event vary from none to catastrophic. However, the likelihood of initiating EO is far lower than that of encountering EO. The negative consequences of an EO encounter are much more likely to be financial, resulting from project delays.

1.6.6 Semi-Quantitative Risk Calculation

Once all project-specific factors have been assessed, a semi-quantitative risk assessment (likelihood versus consequence risk matrix) will be carried out or multiple calculations will be carried out if the factors described above vary considerably across the site. In the latter scenario, a risk map will be drawn to illustrate the differing risk zones.

1.6.7 Recommendations

If a significantly elevated risk level(s) is concluded, industry standard risk mitigation measures (appropriate to the project specific intrusive methodologies) will be recommended to reduce the elevated risk level(s) to as low as reasonably practicable (ALARP) level.

1.7 Information Sources

To guarantee a robust assessment of risk, primary source records form the basis of this report. The following information types and information sources were accessed / contacted during the research process:

- The National Archives, Manchester Archives & Local Studies, Historic England, Council for British Archaeology, Greater Manchester HER, British Geological Society, the MoD, the local authority, the Client.
- Historic OS mapping, historic aerial photography and various web resources.
- Our PIEO (potential indicators of explosive ordnance) GIS map and our physical library. Note, PIEO is the result of over 13 years of research and is constantly growing.

1.8 Reporting Conditions

The accuracy of original records relating to bombing is difficult to verify. Wartime bombing records were only as detailed and accurate as the availability of time, personnel, and ease of access to information would allow. The conditions under which information was gathered in many urban locations, i.e. intense aerial bombardment, will not have been conducive to accurate record keeping. Air raids within sparsely populated locations are less likely to have been witnessed, limiting the accuracy of any corresponding records. Furthermore, such records were often based on unverifiable second-hand eyewitness accounts.

Many records of historic military activity have not survived and some of those that have are only declassified and released into the public domain decades after their creation. Consequently, pertinent records can be inaccessible at the time of requirement. Impartial Assessments cannot accept liability for any missing historic records, inaccuracies or omissions within the available historic records.

It is never possible to accurately determine, through desktop study alone, the precise location, type and condition of buried EO at a given site. Furthermore, some factors (human behavioural) make assessment of EO risk partly subjective.

2 The Site

2.1 Location

The Site is situated in the Chorlton-on-Medlock area of Greater Manchester, ~1km south of Manchester Piccadilly Railway Station. It is bound to the west by Upper Brook Street, to the east by Kincardine Road, to the south by Cottenham Street, and to the north by commercial property.

The Site is centred on the approximate National Grid Ref: SJ 84858 96856.

Site location maps and recent aerial photography are displayed at **FIGURE 1**.

2.2 Description

The majority of the Site area is currently occupied by Elizabeth Yarwood Court, a two-storey post-WW2 constructed residential apartment building with associated gardens and car park. The Site's west extent is occupied by a disused canopy structure and hardstanding, previously part of a used car sales business. This area is fenced off from the residential development.

2.2.1 Proposed Works

Redevelopment will involve demolition of all existing structures and construction of a six to nine-storeys high building (laboratories and office space). In addition to various shallow mechanical excavations, deep piled foundations will be required.

Prior to redevelopment, an SI will be undertaken comprising 3No. boreholes to ~20.0m bgl and 6No. boreholes to ~5.0m bgl.

A proposed SI positions plan is displayed at **FIGURE 2**.

3 Site History Assessment

3.1 OS Mapping

3.1.1 Introduction

Bomb damage resulting from German air raids can be identified by comparing historic OS maps. These maps can also help identify examples of historic military activity. Note, 19th / 20th Century military structures had a typical shape and were distributed in typical patterns.

The table below includes a review of the relevant OS maps. Note, the process adopted in generating these maps (mapping intervals, scale, exclusion of some features in the interests of national security, etc), may result in an incomplete account of a site's history.

Latest pre-WW2 and earliest post-WW2 large scale OS maps are displayed at **FIGURE 3**.

3.1.2 Site-Specific

	Date	Scale	Observations	
Pre-WW1	1893	1:2,500	Site occupancy?	Dwellings with back yards / gardens. Possible commercial use building with unbuilt ground (yard area) in the northeast.
			Evidence of local military activity?	No.

	1908	1:2,500	Site occupancy?	Much of the northeast unbuilt ground (yard) has been developed. Probably commercial use buildings.
			Evidence of local military activity?	No.
Pre-WW2	1932	1:2,500	Site occupancy?	Further development in the northeast. One large and one small building now occupy this area. The northernmost dwelling has been extended east or redeveloped.
			Evidence of local military activity?	No.
	1938	1:10,560	Site occupancy?	Unchanged. Note, this small-scale map lacks detail.
			Evidence of local military activity?	No.
Post-WW2	1951	1:2,500	Site occupancy?	Unchanged. The large northeastern building is identified as a Works.
			Site ground cover type(s)?	Not recorded.
			Evidence of WW2 bombing? ('Ruins', clearance, redevelopment)	Probably. The row of south-facing dwellings and two houses in the southeast corner have been demolished. Several more clearance areas are visible in the immediate surrounding area.
			Evidence of local military activity?	No.
	1961	1:1,250	Site occupancy?	Three west-facing dwellings have been demolished.
			Evidence of local military activity?	No.
	1969	1:1,250	Site occupancy?	All Site buildings except the two dwellings in the northwest corner have been cleared.
			Evidence of local military activity?	No.
	1978	1:1,250	Site occupancy?	The remaining two houses have been demolished. The existing residential development has been built and the west extent has been demarcated (possibly developed). The Site is likely in its present-day configuration.
			Evidence of local military activity?	No.
	Other significant observations		None.	

TABLE 1: Historical OS Mapping Review

3.2 Aerial Photography

3.2.1 Introduction

Historical aerial photography is often key in identifying temporary wartime activity. As well as clarifying historic site occupancy, aerial photographs can elucidate the degree of bomb damage to structures and show the locations of German high explosive (HE) bomb craters. Note, the latter usually only persisted for a short time.

WW2-era aerial photography is displayed at **FIGURE 4**.

3.2.2 Site-Specific

	Date	Type	Observations	
Pre-WW2	1st Aug 1937	Oblique Low resolution	Timing?	~3No. years before the first local WW2 air raid.
			Site occupancy?	As per the period OS mapping. All buildings on Site are two-storeys in height.
			Site ground cover type(s)?	Unidentifiable due to image angle and quality.
			Evidence of local military activity?	None.
			Other significant observations?	The poor quality of this image prevents detailed analysis.
WW2	30th May 1944	Vertical Low resolution	Timing?	~21No. months after the final local WW2 air raid.
			Site occupancy?	Probably as per the period OS mapping.
			Site ground cover type(s)?	Unidentifiable due to image quality.
			Evidence of WW2 bombing? (ruins, clearance, craters)	Probably. The OS mapped clearance area in the south is visible.
			Evidence of local military activity?	None.
			Other significant observations?	The poor quality of this image prevents detailed analysis.
Post-WW2	7th May 1946	Vertical High resolution	Site occupancy?	As per the 1951 OS map.
			Site ground cover type(s)?	Ambiguous in the west. The residential back yards are probably either paved or bare earth. Two small shrubs / trees are visible, however no areas of dense vegetation are visible. The probable bombsite in the south has been cleared of rubble / debris.
			Evidence of WW2 bombing? (ruins, clearance, craters)	The two small dwellings in the southeast corner have been cleared. The rooves of the remaining buildings on Site appear to be undamaged and show no signs of large-scale replacement. Note, some minor repairs (replacement of individual panels) may have occurred in the northeast.
			Evidence of local military activity?	None.
			Other significant observations?	None.

TABLE 2: Historical Aerial Photography Review

3.3 Additional Historical Information

If a site encompasses a historic landmark, significant building etc, further research might locate a written account providing details on the site's historic occupancy. Such details could prove significant when assessing the various variables relating to, for example, the likelihood of a German UXB strike going unnoticed and unreported.

No such information was located.

4 WW2 Enemy Action Assessment: Aerial Bombing

4.1 German bombing during WW2

Between 1939 and 1945, the German air force (the Luftwaffe) dropped approximately 75,000 tonnes of HE bombs and over two million incendiary bombs (IBs) on the four nations of the UK. Almost all counties were affected to some degree.

At the time, bombing was still in its infancy. Testing showed that the accuracy of daylight, level flight bombardment would put 50% of the bombload within 91m of the centre of the target from an altitude of 3,000m. At double this altitude the error exceeded 400m. In poor visibility and at night, the error could increase by >250%.

Furthermore, these tests were conducted within an uncontested environment. The various British AA defences and navigational countermeasures greatly hindered bombing. Luftwaffe aircraft frequently abandoned their intended target and jettisoned their bombloads indiscriminately. Consequently, numerous bombing incidents occurred in open countryside throughout the UK, many miles from intended targets.

Bombs were only rarely dropped individually. The normal procedure was to drop an internally carried bombload in a single sequence, with release spacings pre-set from 10m to 100m. 20No. 50kg bombs (the most numerous HE bombload) could thus extend in a line (called a bomb-stick) varying between 200m and 2km in length. These patterns (when accurately plotted) can aid in locating unreported UXBs. It should be noted however that externally carried bombs could be released individually, creating uneven bomb-stick patterns or solitary bomb strikes.

For other types of commonly deployed ordnance, inaccuracy was inherent. 1kg / 2kg IBs and parachute retarded mines (high-capacity blast bombs) were easily blown off course by the wind.

4.2 Explosive Ordnance Hazards Overview

4.2.1 Introduction

During WW2 the Luftwaffe deployed a variety of ordnance against the UK. The most frequently deployed large bombs achieved significant ground penetration due to their 'thick-skinned' steel construction and are therefore more likely to remain buried in the ground today. These HE (and some incendiary type) bombs are termed 'iron' bombs. The 50kg and 250kg 'iron' bombs accounted for approximately 93% of 'iron' bombs dropped on the UK.

Descriptions of these different bomb types are presented below. Data sheets detailing those bombs most likely to be encountered today are displayed at **APPENDIX 1**.

Note, the Italian Air Force participated in a small number of air raids in Essex and Kent during 1940. The Italian bombs were comparable to German general purpose 'iron' bombs, however any UXB find would be extremely rare.

4.2.2 More Likely to be Unearthed in the UK Today

- **High Explosive 'iron' bombs - General Purpose:** The SC series accounted for the majority of HE bombs dropped on the UK. This design had a moderate charge to weight ratio, approximately 50% charge. The most common weights were 50kg (SC50), 250kg (SC250) and 500kg (SC500). 6No. additional models (1,000kg, 1,200kg, 1,400kg, 1,800kg, 2,000kg and 2,500kg) were deployed in much smaller numbers.

- **High Explosive 'iron' bombs - Semi Armour Piercing:** The SD series were very similar in appearance to the SC bombs but had lower charge to weight ratios, approximately 30% charge. The casing was thicker, allowing for greater penetration through structures. There were six 'iron' bombs models ranging from 50kg to 1,700kg.
- **Incendiary 'iron' bombs:** The Brand C50A used a SC50 type casing but contained a mixture of incendiary liquids (including phosphorus) that ignited on contact with the air. The C50B was the same size but mostly phosphorus filled. The Sprengbrand C50 (Firepot) also utilised a thick 'iron' bomb casing, however contained both Thermite incendiary containers and a 7kg HE charge. These bombs weighed approximately 41kg and 50kg respectively and were introduced later in the war.
- **Incendiary Sub-Munitions:** The 1kg B1E IB was the most frequently dropped German bomb. Up to 620No. B1Es could be packed into a sub-munition canister, which opened at a pre-determined height, scattering the IBs over a wide area. The Thermite fill burns at extremely high temperature. The longer 2kg B2E model incorporated a small HE charge with delay fuze. The B2E is therefore more hazardous than the B1E, however was dropped in smaller numbers. Although light weight, both had the potential to fully penetrate soft ground.

4.2.3 Less Likely to be Unearthed in the UK Today

- **High Explosive 'iron' bombs - Armour Piercing:** The PC series (four models between 500kg and 1,600kg) were used against reinforced military structures and warships. Consequently, they were not commonly used against the UK mainland. Charge to weight ratios were low, approximately 15% charge.
- **High Explosive Blast Bombs - Parachute Mines:** Converted naval influence mines were dropped on urban targets. Their thin steel bodies allowed for very high charge to weight ratios, approximately 73% charge. Luftmine A (LMA) and Luftmine B (LMB) weighed 500kg and 1,000kg respectively. Each was parachute retarded, enabling detonation at ground level and therefore no ground penetration. Consequently, the only unexploded parachute mines found today, wash up along the coastline or remain on river or lake beds.
- **Oil Incendiary Bombs:** The Flam 250 and Flam 500 bombs contained a mixture of benzine and petroleum, ignited by a small HE charge. They were constructed of thin metal which broke up on impact, spreading the incendiary mixture across an area. As such they are unlikely to remain buried in the UK today. The bombs proved unreliable, often failing to ignite, and consequently were withdrawn from service in 1941.
- **Anti-Personnel (AP) Sub-Munitions:** The 2kg SD2 'Butterfly' bomb was dropped on several British cities and towns. It was a nuisance weapon incorporating both time-delay and anti-handling fuzes. It contained a small 225g HE charge, however had no ground penetration ability. A sub-munition canister could hold up to 108No. SD2s. The SD10 was a larger (10kg) AP bomb. It could achieve full penetration, however this model was dropped in very small numbers on the UK. A sub-munition canister could hold 17No. SD10s.
- **Miscellaneous:** The Luftwaffe dropped various other devices on the UK. Flares (for target illumination) were by far the most numerous, however had no ground penetration potential. Photoflash bombs (to aid reconnaissance photography) are similar in appearance to 50kg bombs. Inert concrete-filled bombs were dropped to cause disruption and unnecessarily tie up bomb disposal (BD) resources.

4.2.4 'Iron' Bomb Penetration Depths

The Research & Experiments Department of the Ministry of Home Security used BD records to study German HE UXB penetration depths, publishing their findings in 1949. The British Army's BD headquarters provided details of 1,304 UXB recoveries. In addition, the ministry carried out their own tests, involving 24No. bombs dropped into Chalk under controlled conditions.

The average penetration depth of 430No. 50kg bombs (the most commonly dropped HE bomb) in London Clay was 4.6m and 6.1m for the 250kg model. Note, these bombs landed in open ground and were therefore unaffected by structures or hardstanding. Once the distribution of bomb weights against penetration depths was plotted, the mean line was extrapolated for each bomb weight to produce probable maximum depth figures.

For each bomb weight, the mean average of all observed penetration depths was calculated for each geology. The resulting figures, plus the observed minimum penetration depths, are presented in the table below. Note, bombs weighing >1,000kg have been omitted from the table as only several such UXBs were recovered during WW2.

	Clay			Chalk			Gravel			Sand			Sandstone		
Bomb (Kg)	Min (m)	Average (m)	Max (m)	Min (m)	Average (m)	Max (m)	Min (m)	Average (m)	Max (m)	Min (m)	Average (m)	Max (m)	Min (m)	Average (m)	Max (m)
50	0.7	4.0	9.1	1.0	3.5	7.7	1.0	2.8	7.8	1.0	2.8	7.8	1.8	2.7	6.0
250	1.5	6.8	15.8	1.0	6.0	13.1	0.7	4.8	13.7	1.8	4.8	13.7	2.5	4.6	10.3
500	3.8	8.7	19.8	4.0	7.6	16.4	2.5	6.0	17.3	3.0	6.0	17.3	-	5.8	13.1
1,000	4.8	10.9	24.9	4.2	9.6	20.7	2.0	7.6	21.9	6.8	7.6	21.9	-	7.3	16.4

TABLE 3: WW2 German UXB Penetration Depths Data

Although most German HE UXBs came to rest after several metres travel through the ground, these weapons can be encountered at any depth between just below WW2 ground level and the maximum BPD. There are three reasons why heavy bombs might be found at surprisingly shallow depths:

- **Low Altitude Release:** Some Luftwaffe raids (particularly those involving fast fighter-bombers) were executed at very low altitudes, to avoid RADAR detection. Bombs released over soft ground from very low altitude would impact at a shallower angle, resulting in extreme J-Curve Effect (see **Heading 4.2.5**).
- **Deflection:** 'iron' bombs had conical nosecones and were therefore susceptible to deflection. A bomb striking a structure (above or below ground), could deflect and come to rest at a shallower depth.
- **Aircraft Crash Site:** For several reasons, a pilot may not have been able to dump his bombload before impacting the ground. Any internally or externally fitted bombs could have become shallow buried on impact.

4.2.5 'Iron' Bomb J-Curve Effect

WW2 BD units reported that most deep buried German HE UXBs were observed in a horizontal or up-turned orientation. As a HE UXB penetrates the ground at an angle slightly offset from the vertical, it begins to turn, creating a curved passage through the soil.

This phenomenon can be significant when assessing the risk of UXO as the J-Curve Effect results in a horizontal offset from the point of UXB entry. A HE UXB could impact soft ground adjacent to a building and then come to rest beneath that building. The degree of lateral offset is typically one third (approximately) of the bomb's ultimate penetration depth. Therefore, for locations which experienced high-altitude bombing raids, J-Curve offsets will typically be between 2.0m and 4.0m. In extreme conditions, a low altitude attack resulting in a low angle UXB strike could produce even greater horizontal offset, up to 15.0m.

4.3 British Records of Bombing

4.3.1 Official Records

The Bomb Census was undertaken by the Ministry of Home Security. The Bomb Census was compiled using information primarily gathered by ARP (Air Raid Precautions) wardens. Standardised forms were used to keep a written record of each incident. In many areas, these reports were used to create bomb plot maps. The Ministry also calculated bombing density statistics for every administrative area and created Daily Intelligence Reports, recording the date and location of every single air raid.

The Bomb Census commenced in September 1940, more than three months after the German bombing campaign commenced. Initially, only information relating to London, Birmingham and Liverpool was collated. It was not until

September 1941 that the Bomb Census was extended to cover the entire UK. Consequently, many pre-September 1941 records were not standardised and, in some cases, were poor quality.

The level of detail varied greatly with location. Furthermore, the Bomb Census did not cover air raids on military property. The armed forces had no formal process for recording air raids and processing associated records.

As well as bombing incident records, some local authorities produced war damage maps. Council engineers carried out street by street surveys to create a record of the varying degrees of damage sustained by buildings.

Today, many original (archived) bombing records are incomplete, some collections are missing altogether and in some cases, entire records were destroyed at the time by German bombs.

4.3.2 Unofficial Records

In some parts of the UK where official bombing records are incomplete or missing, historic eyewitness accounts, newspaper articles, aerial photographs, etc can be used to build up a picture of WW2 air raids. The credibility of any such information, however, must be addressed and assessed.

4.4 Luftwaffe Targets

4.4.1 Brief Overview

The Luftwaffe carried out reconnaissance flights over the UK. Numerous aerial photographs were taken with subsequent German annotations earmarking various facilities for attack. Luftwaffe crews were also given British OS maps with German annotations highlighting their target area. In the absence of detailed bombing records, the presence of a known target increases the likelihood that bombs fell locally.

Although official German doctrine did not specifically target civilian residential areas, the Blitz raids on individual targets were gradually replaced by what was, for all intents and purposes, unrestricted indiscriminate bombing. This was due to the effectiveness of British countermeasures. The Luftwaffe identified city centre aiming points for some attacks, as well as identifying individual targets. Typical types of target:

- **Common Primary (strategic) Targets:** RAF airfields, Royal Navy bases, commercial docks, weapons (chiefly aircraft) factories and RADAR installations.
- **Common Secondary Targets:** engineering works, steel works, factories, depots, railway marshalling yards, gasworks, power stations, army camps / barracks, AA artillery batteries, coastal gun batteries etc.

Note, the inherent inaccuracies in WW2-era aerial bombardment resulted in many wayward bomb strikes in areas surrounding targeted facilities.

4.4.2 Site-Specific

Original Luftwaffe target mapping and target reconnaissance photography of Greater Manchester was accessed.

Target Category	Relevance and Proximity to the Site
Confirmed primary aiming point (indiscriminate bombing)	Manchester City Centre (~1.5km northwest)
Confirmed closest primary individual target(s)	Bus Depot & Car Works (~860m east) Mayfield Railway Station (~860m north)
Confirmed secondary individual target(s)	-
Unconfirmed but potential secondary target(s)	-

TABLE 4: WW2 Bombing Targets

4.5 Bombing Decoy Installations

4.5.1 Brief Overview

British decoys were intended to draw enemy bombers away from the true targets. 839No. decoys were built at 602No. sites in England, with approximately 200No. more established in Wales, Scotland and Northern Ireland. Although success rates varied greatly, the confirmed presence of a bombing decoy significantly increases the likelihood that bombs fell near or on that location. 5No. types were fielded:

- **'K' and 'Q' Sites - Dummy Aerodromes**. 230No. were established. 'K' decoys (landing field, mock-up buildings, and inflatable aircraft) were for daylight use. 'Q' decoys used lights to create a flarepath simulating a runway at night.
- **'QL' Sites - Urban Lighting**. Electric lights were used to simulate poorly implemented blackout procedures. As a bomber force approached, the lights would be extinguished erratically.
- **'SF' and 'QF' Sites - Diversionary Fires**. The largest and most sophisticated decoys. When lit, 'Starfish' sites gave the impression of an urban area set alight by incendiary bombing. They were installed near cities. Similar to, however smaller than 'SF' decoys, 'QF's were installed near and for the protection of specific vulnerable points (VPs) such as factories, military sites, oil storage tank farms, etc. Some 100No. 'QF' sites were established in England.
- **'M' and 'C' Sites - Dummy Factories and AA Batteries**. The former comprised a scale model of a specific factory, vital to the war effort. They were made from wood and canvas and had other features, such as access roads and equipment.
- **ASQL - Assault.** During August and September 1943, 18No 'QL' sites were installed along the south coast of England during a deception operation. These temporary decoys received very little attention.

Between 1942 and 1943, most 'K' sites were dismantled, however many of the other decoys were used up until late 1944 when Luftwaffe activity over the UK had all but ceased. By the end of 1941, the airfield decoys had received 359No. attacks compared with 358No. raids carried out against the real airfields. By June 1944, approximately 730No. attacks had been recorded on all decoy types. At least 5% of the total weight of German bombs dropped are estimated to have been aimed at Britain's decoy sites.

4.5.2 Site-Specific

As the study area was urban, no bombing decoys were installed locally. The closest was ~7km to the southeast.

4.6 Local Air Raids Information

4.6.1 Brief Summary

Between 29th July 1940 and 30th July 1942, Manchester County Borough experienced 41No. individual air raids during 31No. days of Luftwaffe activity. Most were small in scale, often executed by a solitary bomber. Several medium scale attacks and four major scale raids were also mounted. Note, 'major' was a Luftwaffe designation that described a raid delivering >100No. tonnes of HE (in addition to incendiaries) onto a target area.

The first significant raids (medium-scale) affecting the borough, occurred on the 28th August and 1st October 1940. Then two consecutive major attacks on the nights of the 22nd / 23rd and 23rd / 24th December 1940 (the 'Christmas Blitz') devastated parts of Manchester, Salford and Stretford. These two attacks saw 441No. German bombers drop 272No. tonnes of HE on the first night and 195No. tonnes of HE on the second night. Seven conflagrations and 600No. smaller fires were reported, the result of tens of thousands of small (1kg / 2kg) incendiary bombs (IBs).

During 1941, the wider Manchester conurbation experienced two additional major* raids, on the 9th January and 1st June. Although each involved half as many aircraft as the 22nd December 1940 raid, they still delivered a further 208No. tonnes of HE bombs and thousands of IBs. Three medium-scale raids were mounted in the spring of 1941.

The Christmas Blitz alone caused the total destruction of >4,000No. houses with a further 12,000No. sustaining serious damage. Manchester County Borough suffered 1,546No. casualties during these two raids.

*The fourth and final major raid actually only delivered 97No. tonnes of HE, however is close enough to 100No. tonnes to be considered 'major'.

4.6.2 Bombing Density

The table below records the Ministry of Home Security's bombing density calculation for the former Manchester County Borough. It gives a breakdown of the number of large Luftwaffe bombs reported within the administrative area. The adjacent table displays IAL's bombing density parameters.

Administrative Area Size (Acres)	27,255
HE 'iron' bombs (all types)	712
HE Parachute Mines	18
'Flam' Oil IBs	17
Phosphorus IBs	0
'Fire Pot' Phosphorus IBs	0
V1 Flying Bomb	1
V2 Long Range Rocket	0
Total (excluding V Weapons)	737
Bombs Per 1,000 Acres (405ha)	**27**

Qualitative	Quantitative
Very Low	<5 bombs per 1,000 acres (405ha)
Low	5 to 15 bombs per 405ha
Low to Moderate	15 to 30 bombs per 405ha
Moderate	30 to 75 bombs per 405ha
Moderate to High	75 to 150 bombs per 405ha
High	150 to 300 bombs per 405ha
Very High	>300 bombs per 405ha

TABLE 5: Bombing Statistics and Parameters - National Source

These figures do not include UXBs, 1kg / 2kg IBs, or 2kg AP bombs. Secondary source data (Cooper G. 2018) states that during the first major air raid alone, some 37,000No. 1kg / 2kg IBs were dropped. Luftwaffe records list 1,925No. 1kg / 2kg IB canisters dropped during the four heaviest raids on the conurbation. The smallest Luftwaffe canister held just 36No. 1kg IBs and therefore it can be said that at least 70,000No. 1kg / 2kg IBs were dropped. Note, this number is likely far greater, as larger models of IB canister (containing hundreds of IBs) were almost certainly used and small IBs would have also been dropped during the many small and medium-scale raids.

4.6.3 Site-Specific

Note, the bombing density figure for a whole administrative area is not always a good indication of the bombing density over a specific site. Within larger districts, particularly rural districts, bombing density figures may be skewered by the presence of a heavily bombed target.

Despite the major-scale air raids, the overall bombing density figure for Manchester Borough is not high because the Luftwaffe's primary target area incorporated parts of Manchester County Borough, Salford County Borough and Stretford Municipal Borough. Consequently, the weight of Luftwaffe ordnance dropped was divided between these three administrative areas. Furthermore, Manchester County Borough was a very large administrative area, most of which did not contain any Luftwaffe bombing targets and was situated several kilometres from the Luftwaffe's primary target area. This "diluted" the bombing density further.

According to the bombing density calculation above, the Site occupied an administrative area that experienced a low-to-moderate bombing density. However, further analysis indicates that **the study area experienced a moderate or high bombing density**.

4.7 Bomb Failure Rate

4.7.1 Brief Overview

There are three reasons why German 'iron' bombs dropped during WW2 failed to function as designed:

- **Human Error:** failure of the aircraft's crew to charge the electrical condenser in the fuze.
- **Very Low Altitude Release:** the fuze would not have enough time to arm itself before impact.
- **Faulty Fuze:** inadvertently during manufacture or sabotage by POWs working in German factories.

The Bomb Census recorded a daily average of 84No. German 'iron' bomb UXBs dropped on civilian targets throughout Britain, between 21st September 1940 and 5th July 1941. 8.5% of these were Delayed Action (DA) bombs (time bombs) which exploded sometime later. The remainder were unintentional 'duds' (UXBs).

By the end of WW2, the Ministry of Home Security calculated a total figure of 200,195No. HE bombs recorded as exploded in Britain. An additional 25,195No. HE UXBs were recorded, giving a HE bomb failure rate of 12.6%.

The Luftwaffe figure for the total number of bombs dropped on the UK was approximately 11% higher than the number observed and reported by UK authorities. This suggests that the total number of UXBs remaining buried in the UK today is greater. However, anecdotal evidence suggests that German sources overstated their bombing statistics for propaganda reasons.

The average HE bomb failure rate of all boroughs and districts making up the London Civil Defence Region (the most heavily bombed part of the UK) was calculated as 10%, with rates ranging from 6% to 15%. Note, those areas of the capital that suffered the most damage, had the most ruins into which subsequent UXBs could fall unnoticed / go unrecorded. This limits the accuracy of the observed failure rates in those areas.

The discrepancy between the British and German records combined with the fact that HE UXBs are still consistently being discovered in the UK today (averaging five per year), confirms that the UK's 12.6% rate is inaccurate and is in fact higher. As rates of 15% were observed in some areas, this is considered to be a more accurate estimate of the true failure rate.

4.7.2 Site-Specific

No evidence has been found to suggest that the local HE bomb failure rate differs significantly from the national average.

Note, records of exploded and unexploded HE bombs dropped on Manchester, Salford and Stretford during the Christmas Blitz produce a failure rate of 16.6% (Smith P J C. 2003). A bomb census report relating to the 9th January 1941 raid describes 46No. HE bombs (including seven UXBs) and approximately 50No. IBs reported in Manchester County Borough. This gives a HE bomb failure rate of 15.2%.

4.8 Site-Specific Bombing Incident Records

4.8.1 Manchester ARP Message Forms

The collection of original ARP message forms describing every bombing incident throughout the borough is not held by the relevant archives. This collection of numerous reports has either not survived to the present day or is held in a private collection.

4.8.2 Manchester Bomb and Damage Plot Map

A series of original maps, produced by Manchester City Council's Architect's Department (Building Surveyor's Division) during the war, was accessed. These maps were updated throughout the conflict to record all air raid incidents on the county borough.

No original legend / key accompanies the maps, however contemporary descriptions confirm most of the plot symbols. No symbol for UXBs was identified and the degrees of damage sustained are unidentified. Any IB strike symbol with a number written within it represents the number of individual 1kg / 2kg IBs falling at that location.

A composite map (several maps stitched together) of the study area is displayed at **FIGURE 5**.

- Four or five air raids affected the wider study area (~400m radius from the Site centre point).
- Five HE bomb strikes and 27No. 1kg / 2kg IB strikes are plotted within the wider study area.
- No incidents are plotted within or adjacent to the Site boundary. The closest strike (HE bomb) is plotted ~50m to the north.
- No buildings are recorded as having sustained bomb damage within 250m of the Site.

4.8.3 Manchester Damage to Property Report Cards

Two collections of original cards detailing bomb and anti-aircraft (AA) shell damage to buildings throughout Manchester County Borough, was accessed. This record, produced by the council's Building Surveyor's Division, is understood to cover the entire bombing campaign. Some cards include the address of the property and the date of damage.

These collections were searched for references to the street / road names bounding the Site. One card for Cottenham Street was available, however this only relates to three neighbouring terrace houses ~80m east northeast of the Site. No. 73, 75, and 77 Cottenham Street sustained category 'A' and 'B' (severe) damage, inspection date 10th April 1942. The date of occurrence was not reported.

Note, no bomb strike(s) are recorded at or near this location on the bomb and damage plot map and these houses were demolished by the late 1940s. It is considered likely that a HE bomb was responsible for this damage.

4.8.4 Bomb Census - Incident Reports

Two collections of written reports, produced by the Ministry of Home Security (MoHS), were accessed. One covers the entire local bombing campaign however lacks detail and the other includes more detail however is an incomplete record of local incidents. Excerpts from relevant reports are displayed below:

- **11th October 1940 -** air raid commenced at 22:00hrs. Most bombs fell in the south-central part of the city, which is largely residential. 28No. HE bombs, 67No. IBs, and 2No. oil IBs caused widespread damage to dwelling houses. A considerable number of fires were caused, all of which have been dealt with. Amongst the more serious incidents was the demolition of four houses at Chorlton-on-Medlock.

  This vague report could relate to bombing incidents in the immediate vicinity of the Site.

- **22nd / 23rd December 1940 -** 300No. evacuated due to a UXB at Temple Street and Rushholme Road (~300m northeast of the Site). Incident at the corner of Ducie Street and Oxford Road (~480m southwest of the Site), many trapped.

  There are no bomb strikes (that correspond to these descriptions) recorded at these locations on the bomb and damage plot map.

There were several additional reports that could conceivably relate to bombing in the wider study area, however the descriptions are too vague to confirm either way.

4.8.5 Bomb Census - Bomb Plot Trace Maps

A collection of bomb plot maps (created by the MoHS) covering Manchester Borough was accessed. This collection comprises maps that plot bombing incidents during 14No. air raids, however each map is specific to a part of the borough and does not necessarily plot all bombs dropped during that raid.

Even though this collection includes maps that record some of the air raids known to have affected the wider study area, no maps recording bomb strikes on the wider study area were available.

4.8.6 Manchester Air Raid Fatalities Map - 22nd to 24th December 1940

A contemporary digital map of Greater Manchester recording the locations of every Christmas Blitz bombing incident that resulted in at least one fatality, was accessed. This map (published by the Manchester Evening News) was compiled using data from the Commonwealth War Graves Commission, however only covers the two heaviest air raids on the city. Note, as many bomb strikes did not cause fatalities, this is an incomplete record of local bombing incidents.

No fatalities are recorded in the wider study area. The closest being ~430m northwest of the Site, at 101 York Street.

4.8.7 Anecdotal and Secondary Source Evidence

A search of online resources and local history publications was carried out with the intention of locating any relevant anecdotal / eyewitness accounts or secondary source information relating to local bombing incidents. Local history publications detailing the air raids against Greater Manchester were accessed, however no relevant information relating to the study area was included.

4.9 Abandoned Bombs

4.9.1 Brief Overview

When a WW2 BD team arrived at the scene of a confirmed UXO strike, they would classify the incident by its potential hazard, Categories A, B, C and D, with A the highest priority for immediate removal and disposal. Occasionally, BD engineers could not find or recover the UXO and its location was simply recorded as an 'abandoned bomb'. The reasons for abandonment could be inaccessibility, extremely soft ground (extreme burial depth) or simply a harmless location (e.g. an isolated field). Note, BD teams in heavily bombed areas were constantly overstretched due to the sheer number of UXBs reported.

The archive office of the British Army's 29 EOD&S Group holds an Abandoned Bomb Register for Britain, as does the Ministry of Housing, Communities & Local Government. The registers lack detail, particularly with regards to locations. A general address rather than a precise position (grid refence) is usually given. Some of the abandoned bombs are likely to have been subsequently recovered or discredited, however remain on the register.

4.9.2 Site-Specific

No abandoned bombs are listed within 1km of the Site.

4.9.3 WW2 Bombing Incident Records Conclusion

- **Number and intensity of local air raids**: Five or six air raids confirmed to have affected the wider study area. One or two were major attacks.
- **Number of local bombing incidents**: At least seven HE bomb strikes and 27No. 1kg / 2kg IB strikes have been identified within 400m of the Site. However, the 1951 OS map highlights four plots of WW2-era buildings clearance on and close to the Site that do not correspond to any recorded bombing incidents. As the buildings occupying these plots existed just three years before WW2, their clearance is less likely the result of any local council led slum clearance policy and no such evidence has been found. Therefore, there could be multiple additional local bomb strikes missing from the available historic record.
- **Local bomb-stick orientations**: The types of bombing incident record available lack the detail required to confirm beyond doubt individual aircraft HE bombloads (linear bomb-sticks).

  A pair of HE bomb strikes (dated 22nd / 23rd or 23rd / 24th December 1940) align with the Site. If these were indeed dropped by the same aircraft, this incident is significant as it raises the possibility that this aircraft released a third HE bomb (unrecorded) which struck the Site and failed to explode.

Assuming HE bomb strikes (missing from historic record) accounted for some or all of the several examples of WW2-era housing clearance in the local area, their close proximity suggests that additional aircraft flew over the immediate study area, whilst releasing their bombloads. Any unrecorded UXBs could conceivably have struck the Site.

Regarding the multiple 1kg / 2kg IB strikes affecting the wider study area, these lightweight IBs were significantly affected by the wind, especially when dropped during high altitude raids (the likes of which occurred locally). As such, the aircraft that dropped these bombs may not have flown as close to the Site as these strike locations suggest. Any HE UXB(s) dropped by the same aircraft would not necessarily have fallen as close to the Site as the IBs. Inversely, those lightweight IB incidents that occurred further away from the Site could conceivably be significant, with regards to associated HE UXB contamination.

Note, bomb-stick orientation analysis requires some assumptions to be made and there are factors that inhibit the accuracy of such analysis. Such analysis can therefore not always be relied upon as completely accurate.

4.10 Aircraft Crash Sites

4.10.1 Brief Overview

Numerous German aircraft came down over the UK during WW2. In most cases, the pilot was able to jettison any remaining bombload prior to impact or the aircraft belly-landed resulting in only superficial damage to the fuselage. However, in some cases, mechanical malfunction and / or crew injury meant bombs were not released. If the aircraft struck the ground at a steep angle and at high velocity, high density objects (engines and bombs) became buried, sometimes to significant depths.

4.10.2 Site-Specific

No Luftwaffe aircraft crashed within the Site boundary.

5 WW2 Enemy Action Assessment: Other

5.1 V Weapons

5.1.1 Brief Overview

In mid-1944 Germany launched the V1 Flying Bomb campaign. The V1 was a primitive cruise missile carrying an 848kg HE warhead. Between 13th June 1944 and 29th March 1945, V1s were launched from static sites in France and Belgium. 5,823No. missiles landed in England, 2,419No. of which reached London, their intended target.

Not long after, Germany launched the V2 Rocket campaign. The V2 was a primitive ballistic missile carrying a slightly smaller HE warhead (735kg). Between 8th September 1944 and 27th March 1945, V2s were launched from static and mobile sites in Holland. 1,102No. rockets landed in England, 516No. of which hit London, the initial target area. Later on, Norwich was targeted, sustaining 43No. strikes.

Both weapons were constructed of thin sheet steel and consequently had very limited ground penetration ability, if they failed to function. Therefore, V Weapons do not themselves pose a UXO risk, however the damage they caused can hamper the accurate assessment of Luftwaffe UXB risk.

5.1.2 Site-Specific

There were multiple V1 Bomb strikes in the wider region, however none occurred within 1km of the Site. V Weapons can be disregarded as a direct UXO risk and as an indirect EO risk factor.

5.2 Artillery Bombardment

5.2.1 Brief Overview

Six German Navy artillery batteries (comprising 20No. guns of between 21cm and 40.6cm calibre) were established in the German occupied Pas-de-Calais area from July 1940. In addition, the German army brought railway-mounted guns to this area of France, seven of which (six 28.0cm calibre guns and one 21.0cm gun) were capable of striking inland targets in Kent.

The first shells were fired at Kent on the 12th August 1940 with frequent attacks occurring during each of the next four years until the final bombardment on the 26th September 1944. In all, at least 1,000No. attacks (each involving multiple projectiles fired) were recorded, an average of one every two days. The towns of Folkestone, Deal and Dover were targeted, however many shells landed in the surrounding countryside. UXO finds of this type are rare.

5.2.2 Site-Specific

Lancashire was located well beyond the range of the German cross-channel artillery batteries.

6 WW1 Enemy Action Assessment

6.1 Aerial Bombing

6.1.1 Brief Overview

Between December 1914 and August 1918, the German navy air wing and army air wing carried out 51No. Zeppelin airship raids and 52No. fixed-wing aircraft raids (involving multiple aircraft) against England and south-east Scotland. Note, many more attacks involving solitary fixed-wing aircraft occurred. An estimated total of 9,000No. HE bombs and IBs were dropped, with London and the east Kent towns experiencing the most raids. During the four years long campaign, Britain suffered 4,820No. casualties.

The German bombing campaign of WW1 was significantly smaller in scale than the WW2 campaign, in terms of the number of raids, number of aircraft per raid, and size of bombloads (for fixed-wing aircraft). As it was the first time Britain had experienced aerial bombardment, the small-scale daytime attacks often attracted spectators, which increased the chance of any UXB being observed and reported. When combined with the fact that most WW1 bombsites have been redeveloped, German WW1 UXB finds are rare.

6.1.2 Site-Specific

Manchester County Borough was not bombed during WW1.

6.2 Naval Bombardment

6.2.1 Brief Overview

Several coastal towns in Yorkshire, Norfolk, Suffolk, and Kent were subjected to naval bombardment from German warships during seven raids in 1914, 1916 and 1917. These raids varied in intensity, both in terms of duration (number of shells expended) and calibre of artillery employed. The heaviest attack resulted in >1,000No. shells fired, with the lightest raid expending only several rounds.

The relatively short firing distances during these bombardments resulted in many shells failing to explode, as there was not enough time for some shells to arm themselves before striking the coast. German WW1 UX naval shell finds are extremely rare.

6.2.2 Site-Specific

Manchester County Borough was not subjected to naval bombardment during WW1.

7 Domestic Military Activity Assessment

7.1 Sources of Potential Explosive Ordnance Contamination

The table below lists all the modern and historical sites and activities that could have potentially resulted in British / Allied UXO and AXO contamination in the UK.

Source of EO	Examples	Associated EO Hazard Items	Relevance
Military Bases and Installations	Army camps, RAF, RN or USAAF airfields, RN shore establishments, signals or communications installations, military training centres, etc.	Various conventional and chemical EO. The types of EO will depend on the type of site and branch of the military utilising it. Plus AXO (SAA, LSA and AA ammunition) for WW2 site defence, if applicable.	INSIGNIFICANT
Military Training Areas and Weapons Ranges	Inland and costal RAF and USAAF bombing ranges. Army / Royal Marines / RAF Regiment etc weapons ranges.	Various conventional and chemical EO. The types of EO will depend on the type of range / training area and branch of the military utilising it.	INSIGNIFICANT
Munitions and Explosives Factories	Royal Ordnance Factories, National Filling Factories, National Explosives Factories, Royal Naval Cordite Factories, etc.	Various conventional and chemical EO. The types of EO and explosives contamination will depend on the type of factory. Potentially plus AXO (SAA, LSA and AA ammunition) for WW2 defence.	INSIGNIFICANT
Munitions Storage Depots	Royal Naval Armaments Depot, Royal Naval Ordnance Depots, RAF Ammunition Depots, Air Ammunition Parks, Reserve / Forward Ammunition Depots, Central Ammunition Depots, etc	Various conventional and chemical EO. The types of EO potentially present will depend on the branch of the military utilising it. Potentially plus AXO (SAA, LSA and AA ammunition) for WW2 defence.	INSIGNIFICANT
Fortifications and Defence Measures	Pillboxes, fortified houses, various earthworks (e.g. trenches) etc at: Nodal Points, Stop-Lines, VPs, etc.	SAA, regular army LSA, AA ammunition, Flame Fougasse, and Home Guard-specific weapons / ammunition.	INSIGNIFICANT
Military Requisitioned Sites: WW1 and WW2	During WW1 and WW2 many private properties were requisitioned by the War Office for military use, including training.	SAA, regular army LSA and Home Guard specific weapons / ammunition.	INSIGNIFICANT
Pipe Mines and Conventional Minefields: WW2	Pipe mines and improvised mines at military bases. Conventional minefields at beaches and some Nodal Points.	Canadian pipe mines, various British landmines (AT and AP) and IEDs.	INSIGNIFICANT
RAF and USAAF Crash Sites	Numerous British and American aircraft crashed in the UK, chiefly during WW2. Munitions and ammunition not always fully recovered.	Various conventional air-delivered ordnance (bombs and rockets) and machine gun / autocannon ammunition.	INSIGNIFICANT
Home Guard Activity: WW2	Volunteer army tasked with home defence during WW2. An armed branch of the British Army. Battalions were active in all British counties.	SAA, regular army LSA, Home Guard specific ammunition e.g. 29mm Spigot Mortar, 3-inch Smith Gun, No.73, No.74, No.75 and No.76 grenades, etc.	**UNLIKELY**
Anti-Aircraft Weaponry: WW1 and WW2	Light AA (machine gun and autocannon), Heavy AA (QF guns), and ZAA (rocket projectors).	SAA, autocannon shells (20mm, 37mm, 40mm), QF shells (3, 3.7, 4.5-inch), UP rockets (2 and 3-inch).	**POTENTIALLY SIGNIFICANT**

TABLE 6: Sources of Potential Domestic Explosive Ordnance

Soldiers of the 48th Lancashire (Ardwick) HG battalion would have been active locally during WW2, however armed soldiers are highly unlikely to have utilised (or even accessed) the Site whilst on duty. No evidence of historic domestic military activity affecting the Site has been identified and the Site's historic occupancy and location indicates a very low likelihood that any such activity did occur.

Every year, a small number of items of wartime LSA (e.g. grenades, artillery projectiles, etc) are unearthed in the back gardens of residential properties all over the UK. Some of these finds are likely the result of previous occupants burying inherited (unwanted) war souvenirs. The possibility of such EO contamination of the Site during its historic residential use cannot be ruled out entirely, although is considered highly unlikely.

7.2 British Anti-Aircraft Weaponry

7.2.1 WW1

AA artillery was in its infancy during WW1 and therefore British AA gun deployments were on a far smaller scale than during WW2. Initial activity saw guns installed on top of some buildings and at other key facilities in London and Kent during 1914. By the end of WW1, the London Air Defence Area comprised 286No. guns.

London was the most heavily defended region. Some other cities were defended, however Kent had the most AA batteries outside of the capital. Note, many of Britain's AA guns were not static. Single guns were mounted on trucks and moved around. RN installations also received protection. At the beginning of the conflict, 58No. guns were distributed between naval facilities at Dover, Harwich, Liverpool, the Tyne and the Humber.

The 3-inch QF gun was the mainstay of British AA artillery. UX 3-inch shells typically landed between 8km and 10km away. The smaller calibre 1-Pounder QF autocannon was also used in the LAA role.

7.2.2 WW2

During WW2, the British Army's AA Command utilised three types of AA weapon for home defence: heavy AA (HAA) guns, light AA (LAA) guns, and Unrotated Projectile (UP) rocket projectors. From 1940 to 1945, BD units dealt with approximately 7,000No. UX AA projectiles in the UK, however such UXO is still unearthed today.

- **HAA Guns:** The vast majority of HAA guns (3.7 and 4.5-inch calibre) were deployed in static batteries of between four and eight guns. HAA batteries were used to engage bombers at high altitudes and were the main constituent of most city's (and some town's) Gun Defence Area (GDA). Mobile gun mounts were also available for temporary deployments to key military and civilian targets. Note, a very small number of British 5.25-inch guns were deployed from 1942 onwards, as well as batteries of US Army 90mm guns during 1944.

  Some 2,000No. of these guns were available during the 1940 / 1941 Blitz. GDAs could expend vast quantities of ammunition during each engagement. The most numerous 3.7-inch gun variant had a firing ceiling of approximately 9km. Although a number of factors will have affected the range of falling UX shells, most typically landed 10km to 15km away. Note, greater distances were achievable.

- **LAA Guns:** Smaller calibre guns (machine guns, 20mm and 40mm autocannon) were used for point (individual target) defence of strategic targets / vulnerable points (VPs). At the time, government policy mandated that (where possible) every VP should be protected, however in reality, a chronic shortage of effective LAA guns (autocannon) during the early years meant that only priority VPs received adequate protection. These smaller guns were easily transportable, and LAA regiment deployments were often temporary. British WW2 40mm guns had a firing ceiling of approximately 7.1km. Although a number of factors will have affected the range of falling UX shells, most typically landed <10km away.

- **ZAA Rockets:** A ZAA battery comprised a grid of typically 64No. UP rocket projectors firing single and (later) multiple 2-inch (UP-2) and 3-inch (UP-3) rockets in a volley, creating a 'box of effect' at preselected altitudes. Although a number of factors will have affected the range of falling UX rockets, they typically landed within 10km of the battery.

  Prototype ZAA weapons were fielded in late 1940 and deployed in cities around Britain from 1941. However, they were only deployed in significant numbers after the initial nine-month Blitz campaign had ended. Consequently, ZAA batteries saw far less action than AA guns. By the end of the war, >50No. ZAA batteries were operational across Britain.

7.2.3 Site-Specific

- Five AA batteries were active within firing range of the Site during WW1. However, the lack of air raids in the region suggests they would not have expended ammunition. There is a very low likelihood that a UX AA shell struck the Site during WW1.
- 33No. static HAA batteries (totalling at least 132No. gun emplacements) were built within firing range of the Site during WW2. Firing between 10No. and 20No. rounds per minute over a frequently and heavily bombed British city, these guns would have expended a very large quantity of ammunition. Consequently, there is an elevated likelihood of UX HAA shells striking the Site.
- The 81st AA Regiment deployed LAA guns to at least one confirmed VP within firing range of the Site, the Metropolitan-Vickers factory at Trafford Park. LAA gun deployments do not however appear to have been frequent in the wider area and consequently there is a low likelihood of UX LAA shells striking the Site.
- Six ZAA rocket projector sites (operated by the No.135 'Z' Battery, 44th AA Brigade) were active within firing range of the Site during WW2. Formed in September 1940, this ZAA unit would have seen some action, however it is understood that most of the six projector sites were not active until after the vast majority of Manchester's air raids had occurred, for example a HG manned battery established in Alexandra Park in July 1942. Therefore, it is considered highly unlikely that a UX AA rocket struck the Site.

7.3 Explosive Ordnance Hazards Overview

7.3.1 HAA Artillery Shells

Of all types of AA projectile, HAA shells are the most likely to be encountered on Site today.

HAA shells were of the bursting (as opposed to shot) type of artillery projectile. That is, the filling caused the shell casing to burst. Each shell was filled with HE which caused a blast effect and fragmented the casing producing shrapnel. As well as standard HE ammunition, shrapnel rounds (containing numerous ball bearings) were used during WW1 and the early stages of WW2. HAA shells have a larger net explosive quantity (NEQ) than most commonly encountered items of British land service ammunition (LSA), e.g. grenades, but contain far less HE than the SC50 (the smallest German HE 'iron' bombs).

British mechanical time-delay and barometric pressure fuzes of WW2 were poorly designed, resulting in high HAA ammunition failure rates (around 30%) during 1940 and 1941. By 1944 however, new fuzes had reduced the rate to approximately 2%.

Unlike bombs, AA shells were not designed to strike the ground nose first and therefore UX AA shell strikes on soft ground did not always create recognisable circular entry holes. This, combined with their lower mass (compared to a UXB) resulted in shallower ground penetration depths, typically <1.0m bgl in soil. Although, in very soft / saturated ground, UX HAA shells were observed to penetrate to >1.5m bgl.

A data sheet detailing those AA projectiles most likely to be encountered in the UK is displayed at **APPENDIX 2**.

8 Explosive Ordnance Migration

8.1 Introduction

Any fill material deposited on a site is unlikely to be contaminated with EO, as the material will have experienced excavation, transport, and processing during which any large objects are likely to have been observed and removed. However, EO encounters within such material do occur, confirming that items can be missed.

One known reason is WW2 Blitz rubble. The Blitz resulted in vast quantities of bombsite rubble. This material was put to use in a variety of ways. >750,000No. tonnes of London's rubble were used to build runways for new military airfields and Liverpool's rubble was used to create and maintain flood defences throughout Merseyside. Blitz rubble was also commonly used for smaller scale construction works, immediately following WW2.

In 2010, two German HE UXBs were encountered in, what was later identified as, Blitz rubble at a Plymouth building site. Such incidents are rare however, and such contamination is much more likely to take the form of smaller items e.g. UX AA projectiles or UX 1kg / 2kg German IBs.

8.2 Site-Specific

Following the mid and post-war demolition / clearance of bombsite ruins within the Site boundary, it is possible that quantities of Blitz rubble already on Site were then used to fill any cellar / basement voids, in order to create street level redevelopment plots. Any small items of UXO (chiefly 1kg / 2kg IBs and AA shells) occupying such rubble could conceivably have remained / been redeposited on Site.

9 Local Explosive Ordnance Encounters

9.1 Introduction

Even if research does not identify potential sources of EO contamination at a given site, knowledge of a recent EO encounter in the vicinity could indicate an elevated risk at that site. EO encounters on civilian land are often reported in the media and therefore a web search of media outlets was carried out.

9.2 Site-Specific

No evidence of an EO incident on or adjacent to the Site identified.

10 Site-Specific Risk Assessment

10.1 Introduction

Two key Site-specific considerations must be assessed, the likelihood of an EO linkage (source-pathway-receptor) becoming complete and the severity of the resulting consequences. The 'likelihood' consideration itself is a function of the likelihood of contamination, the degree of subsequent risk mitigation (if any), the likelihood of encounter and the likelihood of initiation. These factors (in relation to the Site) are assessed at **Headings 10.2 to 10.5**.

10.2 The Likelihood of Contamination

10.2.1 Hazard Items

The table below details the most common EO types encountered in the UK today. The / those EO type(s) relevant to the Site (the Site-specific hazard item / items) are:

- WW2 German UXBs (HE and incendiary)
- British AA shells

EO Type	NEQ or Incendiary Hazard	Likely Contamination Depth	Hazard Class
German HE 'iron' bombs	25kg to 220kg HE (most common) 530kg to 990kg HE (least common)	Deep (3.0m to 10.0m+)	**Very High**
German 41kg and 50kg Incendiary 'iron' bombs	13kg incendiary composition or 7kg HE	Shallow / Deep (2.0m to 6.0m)	**High**
British HE HAA Shells and Rockets	1.1kg - 2.2kg HE	Shallow (0.5m to 2.0m)	
Some British HE Land Service Ammunition	1 - 2kg HE	Very Shallow (<1.0m)	

Some British HE Land Service Ammunition	<1kg HE	Very Shallow (<1.0m)	**Moderate**
German 2kg Incendiary + HE Bombs	680g thermite (incendiary) + 100g HE	Very Shallow (<1.0m)	
German 1kg Incendiary Bombs	680g thermite	Very Shallow (<1.0m)	**Low to Moderate**
British HE LAA Autocannon Shells	4g to 70g HE and / or incendiary composition	Very Shallow (<0.5m)	
British Small Arms Ammunition	Small quantity of black powder. Inert projectile or <1g incendiary composition	Very Shallow (<0.5m)	**Low**

TABLE 7: Most Common Hazard Items

10.2.2 Subsequent Detection

There are many variables that affect the likelihood that a German UXB or British UX AA projectile strike was detected and reported, either as it fell to the ground or subsequently. Accurately assessing the precise conditions that existed at a given site >75 years ago is problematic. The most pertinent variables are addressed below.

Historic Ground Cover	
Risk Elevating Ground Cover	Site-Specific Comment
Bombsite: a UXO strike to a building in ruin will likely have remained undetected. The entry hole of a UXB will have been easily obscured under the rubble / debris. However, a small UX AA projectile or UX 1kg / 2kg IB may not have achieved ground penetration, instead coming to rest within the rubble.	Multiple buildings on Site sustained significant bomb damage, either serious damage, damage beyond repair or total destruction.
Water: UXO landing in a stream, canal, river, pond, lake or the sea would have been immediately lost beneath the waterline and would not have resulted in any persistent evidence of its incidence.	n/a
Soft / Waterlogged / Unconsolidated Ground: a UXO entry hole within marshland, tidal riverbank sediment, tidal coastal sediment / sand dunes, etc will have closed up / collapsed relatively soon after it occurred.	n/a
Dense Vegetation: Peripheral unmaintained vegetation or woodland in an urban location. Or rural forest, heathland, etc. A UXO entry hole within inaccessible vegetation could have been overlooked. Note, WW2-era woodland obscures the view of the ground cover beneath and therefore it must be assumed that vegetation exists beneath the canopy.	No evidence found. Note, the residential back yards / gardens on Site were very small and highly likely to have been sett-paved.
Arable Land: a field under dense crop growth or ploughed soil. A UXO entry hole within this dense foliage or broken soil could have been overlooked.	n/a
Risk Reducing Ground Cover	Site-Specific Comment
Undamaged Building / Structures: any UXO strike would have caused substantial damage and incontrovertible evidence of the incident.	Multiple buildings appear to have survived the bombing campaign intact.
Undamaged Hardstanding: A UXO strike on historic hard surfacing (roads, pavements, commercial yards, etc) would have created an easily recognisable entry hole.	All unbuilt ground on and adjacent to the Site was almost hard surfaced.

Maintained Grass Lawns: a grass lawn known to have been in use throughout WW2 and therefore subject to regular grounds maintenance, e.g playing fields, parkland, sports pitches, golf course fairways. A UXO strike would have created an easily recognisable entry hole.	n/a
Less Easily Assessed Ground Cover Types	Site-Specific Comment
Waste / scrap / aggregate etc storage area: a UXO strike to a heap of unconsolidated material could have collapsed / become obscured. However, if the ground cover beneath was hard surfaced, a large UXB entry hole could have been subsequently observed and reported.	No evidence found.
Wasteland: the ground cover on such land may not be easily identifiable. Weed-covered bare earth or broken up made ground could conceivably obscure a UXO entry hole. Alternatively, a UXO strike to hard unvegetated earth ground could have been recognisable.	n/a
Railway Tracks: a small UXO entry hole within material in between tracks could conceivably have collapsed. Alternatively, a large UXB strike to rail track would have caused obvious damage.	n/a
Quarry: clay pit, gravel pit, etc. The type and condition of the ground cover might not be easily identifiable. Note, disused quarries could easily become flooded.	n/a

TABLE 8: Historic Ground Cover

Historic Site Occupancy and Access	
UXO Observed as it Occurred	Site-Specific Comment
Air Raid Timing: If most local air raids occurred during the hours of darkness, there is a greater chance that any UXO fall occurred unobserved. If the study area only experienced daylight attacks, there is a greater chance that any UXO strike was witnessed as it occurred.	All local air raids occurred during the hours of darkness.
Population Density: If the study area was sparsely populated, there is a greater chance that any UXO strike could occur unobserved. Within a densely populated built up area, the opposite is true. Note however, most people would have been sheltering during large scale night raids.	The study area was densely populated and the Site was developed. The works in the northeast may have been inactive (deserted) at night.
Civil Defence and Military Defence: Many vital facilities (factories, dockyards, etc) had their own teams of Fire Watchers tasked with extinguishing small IBs. These observers would have also reported any UXB strikes. AA batteries, searchlight batteries, barrage balloon sites, and Royal Observer Corps posts. Associated personnel would have reported any UXB strikes.	Volunteer fire watchers (employees) may have guarded the northeast works during night raids. No specific evidence found. Note, many businesses did not protect their premises from small IBs during every single night raid and anecdotal accounts state that the voluntary nature of such activity saw many not turning up for their shifts.
Civil Defence Requisition: many schools, churches and other public buildings in frequently bombed areas were requisitioned by Civil Defence for use as first aid posts, reception centres and canteens for bombed out civilians. Such buildings were therefore in use during night raids.	No evidence found.
UXO Subsequently Observed	Site-Specific Comment
Bomb Damage: If substantial bomb damage occurred, parts or all of a site would have been abandoned for the remainder of the war. Any subsequent	The two bombsites on Site were likely cordoned off for the remainder of the war. It is possible that some other lightly /

evidence of a UXO strike is more likely to have remained unobserved for a significant period.	moderately damaged properties were temporarily abandoned pending repairs.
Site Occupancy: If a site was occupied by buildings that survived the war intact, it likely remained inhabited or in use during the bombing campaign. Probably accessed on a daily basis, evidence of a UXO strike is highly unlikely to have gone unreported. Undeveloped sites could have been neglected for significant periods. Any UXO is more likely to have remained unobserved and gone unreported.	Those houses that survived the war (no damage or minor, repairable damage) were probably inhabited during the latter war years, if not throughout the conflict.
UXB Searches: the Luftwaffe used delayed-action (DA) bombs, designed to detonate up to 72hrs after impact. As a result, ARP wardens, residents and workers often carried out specific searches for DA / UXB entry holes within the environs of their buildings, following local raids. Undeveloped isolated land is unlikely to have been searched.	Residents may have been encouraged, by ARP wardens, to search their back yards for DA bomb / UXB entry holes, following each local raid.

TABLE 9: Historic Site Occupancy and Access

10.2.3 Site-Specific Conclusion

It is considered likely that two unrecorded HE bombs struck the southeast corner of the Site and the section of Cottenham Street abutting the south Site boundary, resulting in the immediate destruction (or damage beyond repair) of multiple terraced houses. An air raid record raises the possibility that this incident occurred on the 11th October 1940. As the wider study area experienced at least three or four subsequent air raids (including two or three major scale attacks), the bombsite ruins on Site would have been vulnerable to UXB strikes on several occasions. Indeed, a local (probable) HE bomb-stick aligned with the Site during a December 1940 raid, significantly elevating the likelihood that a UXB (unrecorded) was released over the study area and landed in bombsite wreckage on Site.

As these post-October 1940 air raids occurred during the hours of darkness, the risk that UXBs fell unwitnessed is increased. Note, the ensuing chaos of concentrated bombing would have distracted ARP wardens and fire fighters during heavy raids. Furthermore, the bombsite ruins would likely have been abandoned pending clearance and even if they were accessed, the entry hole of any HE UXB (as little as 200 / 300mm in diameter) would have been easily obscured by rubble / debris, and therefore would probably have gone undetected / unrecorded.

Any such scenario could potentially have resulted in the HE UXB coming to rest under adjacent undamaged buildings or hard surfaced ground on Site, due to the J-Curve (lateral offset) Effect or due to ricochet on contact with sub-surface structures, e.g. concrete foundations.

Similarly, any small items of aerial UXO (German 1kg / 2kg IBs and British AA projectiles) landing in bombsite conditions would also likely have gone unobserved and remained undetected, caught up in the wreckage. There would have been no visual and little audible warning of the latter type of UXO strike. Note, these UXO items are less likely to have achieved significant penetration of made ground beneath the rubble (especially the lightweight IBs).

Any aerial UXO strike to the multiple buildings (terrace houses and industrial works) that survived the war largely intact would have caused incontrovertible evidence of its incidence, as it passed through roofing and struck the floor slab. The same can be said for the residential back yards and the surrounding streets / pavements. Each yard was small and almost certainly sett paved. Evidence of a UXB strike to this hard surfacing would have been persistent and easily recognisable within these frequently accessed yards.

There is a very low likelihood of historic British LSA or SAA contamination of soil within the Site boundary.

10.3 Degree of Risk Mitigation

10.3.1 Ground Works

Ground works on an EO contaminated site could have resulted in the partial or complete removal of the buried EO threat. If EO was uncovered during intrusive ground works, the incident would have been reported and dealt with by the armed forces. Note, it is usually not possible to accurately determine the volume of soil disturbance associated with historic or even recent ground works at a given site.

10.3.2 Explosive Ordnance Clearance

EOC was not as effective historically as it is today. Surveys were not always undertaken to set parameters and degrees of certainty. Recent EO finds on land known to have been previously surveyed for EO confirm that older detection equipment was ineffective. Furthermore, some EOC tasks did not result in 100% clearance of all EO, by design. Magnetometer surveys can be calibrated to ignore magnetic anomalies that model under a certain mass.

A standard notice accompanying British Army EOC documentation states that 'the presence of EO can never be completely discounted. Although considered unlikely, there still remains the possibility of buried or stray [EO] items.' EOC tasks are not conducted on all MOD land prior to disposal / sale. An EOC task will only be carried out on land where there is a known risk of EO contamination, e.g. a former firing range.

IAL has access to a database of historic EOC tasks carried out by the British Army's 33 Engineer Regiment EOD (now part of 29 EOD&S Group). However, this database is only complete up until the early 2000s and only provides basic details on each task. Freedom of Information requests lodged by IAL confirm that the MOD will almost always withhold any historic EOC task documentation for civilian sites in the UK.

10.3.3 Site-Specific Conclusion

Ground Works: Post-WW2 / Post Military Use	Site-Specific Comment
EOC Activity: evidence of EOC task(s) affecting the Site. Or, is there an increased chance that the Site has experienced partial or complete EOC?	Highly unlikely to have occurred on Site.
Phases of Development / Redevelopment: How many phases of ground work have affected the Site?	Each existing developed portion of the Site represents one phase of post-WW2 redevelopment.
Greenfield Land: Does the Site contain any significant areas of undisturbed greenfield land?	No.
Very Shallow Buried EO: Have any parts of the Site experienced very shallow level soil / made ground disturbance? e.g. demolition, soil stripping, site enabling works, minor grading works, agricultural ploughing, etc.	The whole Site area will have experienced disturbance of very shallow made ground (grubbing out of historic foundations, levelling, resurfacing, soft landscaping, etc).
Shallow Buried EO: Have any parts of the Site experienced shallow level soil disturbance? e.g. grading works, strip / pad foundations, buried services installation (drainage), etc.	Post-WW2 structural foundations almost certainly required shallow level excavations only.
Deep Buried German 'Iron' UXBs: Have any parts of the Site experienced deep level soil disturbance? e.g. bulk excavations (basement levels), dense pile layout, installation of large subsurface tanks, cut and fill, etc.	Unlikely to have occurred on Site.

Conclusion
The southeastern corner (an area of potential concern) has only experienced disturbance of very shallow made ground since WW2. Consequently, the potential EO risk (chiefly German HE UXBs at depths >1.5m bgl) remains unmitigated here. The larger south-central area of potential concern has been partly redeveloped, experiencing one phase of post-WW2 ground works. However, as this low-rise building is almost certainly founded on traditional shallow footings, the risk associated with deeper buried German HE UXBs (within its footprint) will not have been mitigated to any degree.

TABLE 10: The Degree of Risk Mitigation: Site-Specific Comments

10.4 The Likelihood of Encounter

10.4.1 Introduction

The likelihood of an EO encounter at a given site will vary depending on the hazard items, the EO burial depth and the type(s) of intrusive methodology employed. The greater the volume of soil disturbed within the Zone of Potential EO Contamination (ZPC), the greater the likelihood of an EO encounter.

Most domestic AXO and UXO (LSA and SAA), British UXAA projectiles and small (1kg and 2kg) German IBs will typically be encountered at very shallow or shallow burial levels (<1.0m and <2.0m). Whereas heavy German 'iron' bombs will typically be encountered at deeper levels.

The ZPC is defined as the site-specific volume of soil which could contain EO. The size of a ZPC will depend on the history of the site. At a site where the hazard items are German UXBs only, the ZPC will exist between just below WW2 ground level and the maximum BPD. Alternatively, at an active military site where the threat items are known to be British AXO only, the ZPC will exist between just below present-day ground level and approx. 1.0m bgl.

The smaller the mass of the individual EO threat item, the shallower the likely 'as found' depth, generally speaking. There are however some noteworthy exceptions regarding German 'iron' UXBs. In extreme cases, heavy UXBs can be encountered at shallow depths (see **Heading 4.2.5**).

10.4.2 Bomb Penetration Depth Calculations

To calculate BPDs for a given site, one must make assumptions based on the most likely bomb impact scenario:

- **Impact Velocity:** The majority of German HE bombs dropped on the UK resulted from large-scale carpet-bombing raids. These attacks were carried out at altitudes exceeding 5,000m which would have resulted in a 500kg HE UXB impacting the ground at approximately 260m/s.
- **Impact Angle:** Luftwaffe high altitude bombing resulted in bomb impact angles of 10 to 15 degrees from the vertical. Note, it will be assumed that the bomb was stable at the point of impact.
- **Bomb Design:** Some larger German bombs had metal 'Kopfrings' fitted around the nose of the bomb to limit ground penetration. It must be assumed that no such retarder units were fitted.

10.4.3 Site-Specific Ground Conditions

BGS Geological Mapping	Superficial / Drift	Bedrock
	Till (diamicton - clay soil entrained with sand, gravel, and boulders)	Chester Formation (sandstone)
BGS SI Data	Borehole logs for the SI (dated 1970) record the following ground conditions: ► 1.5m of Made Ground - clay, brick, stones, ash, and concrete ► 1.5m to ~3.5m - Gravel and Sand ► ~3.5m to 4.0m - horizontally discontinuous dark brown boulder Clay ► 4.0m to >5.8m - weakly cemented Sandstone with occasional marl lenses and small pebbles	
Site-specific factors	Buildings in a state of ruin during WW2 (above ground structures). Building foundations (sub-surface structures). Potential for basement / cellar voids.	

TABLE 11: Site-Specific Ground Conditions

10.4.4 Site-Specific Maximum Bomb Penetration Depth

During WW2 the Luftwaffe dropped different types of HE bomb on the UK. The SC series accounted for the vast majority, and of this series, the SC 500 variant (weighing 500kg) was the heaviest of the three most deployed types. Therefore, a 500kg bomb will be used as the benchmark weapon for the BPD calculations.

During WW2, the Site was underlain by made ground and geology (both superficial and bedrock) that varied significantly in composition within 15.0m of the surface. Note, the empirical BPD evidence records UXBs travelling through topsoil and geology (of one uniform composition). Each lithology will have had a differing effect on a UXB, both individually and in combination, thereby complicating the estimation of burial depth. In addition, man-made features (rubble / debris, floor slabs, foundations) will have had an unquantifiable decelerating effect. Consequently, an accurate calculation of the maximum BPD cannot be performed.

Based on the data in **TABLE 3**, a 500kg UXB is unlikely to have penetrated a significant distance into the sandstone bedrock (having passed through up to ~9.0m of other geology). Therefore, an approximate average maximum BPD of **~10.0m** is considered appropriate.

Note, theoretically a UXB could remain on Site at a greater depth, however Ministry of Home Security data indicates that only 3% (approximately) of the bombs dropped on the UK weighed over 500kg.

10.4.5 Site-Specific Average Bomb Penetration Depth

Original records allow for a calculation of the percentage of each German HE bomb type (weight / model) dropped on London. The 50kg bomb was the most frequently deployed, accounting for 52% of all HE bombs. Note, estimating the size of a bomb after it exploded was not always straight forward and therefore, these percentages are likely imprecise.

The weight of the average 'fictional' HE bomb type landing on Manchester (the average benchmark weapon) can be calculated as 192kg. This average UXB type would have had an **average BPD of approximately 4.0m below WW2 ground level**.

10.4.6 Other UXO

Similar studies of penetration depth were not carried out for other types of aerial UXO falling on the UK historically. However, historic records do give an indication of likely penetration depths. The most numerous German bomb dropped on the UK, the 1kg IB, was observed to achieve full penetration into soft soils, i.e. >350mm bgl. British UX

HAA and UX UP rocket projectiles were found at depths up to 2.0m bgl in very soft soil. Lightweight UX LAA projectiles could have achieved full penetration within soft soils, however may have also been found on the surface or in a state of partial burial.

Any relatively lightweight items of UXO (German 1kg / 2kg IBs and British AA shells) are unlikely to have penetrated more than 1.0m of hard surfacing and made ground at any location on Site.

10.4.7 Site-Specific Conclusion

- As several of the proposed SI positions and part the proposed building footprint occupy one of the areas of potential concern (where an elevated likelihood of EO remaining exists) a risk pathway is created, exposing the associated ground works to a potential EO encounter.
- Within this area of potential concern, the ZPC is shallow to deep, extending down from the base of the post-WW2 created made ground. Consequently, all the planned intrusions could potentially encounter EO and it is likely that some of the development phase mechanical excavations (chiefly those within the footprint of the planned buildings) will disturb a significant portion of the ZPC.
- The boreholes planned for the area of potential concern will disturb a small volume of made ground / geology within the ZPC, reducing the likelihood of encountering anything buried (e.g. EO). However, this is offset by the significantly elevated likelihood of EO remaining buried here today and the higher risk associated with 'blind' intrusive methodologies (increasing the likelihood of striking buried EO when compared to 'open' mechanical excavations of the same material). Note, the same can be said for any piling works within areas of potential concern.
- There is a low likelihood of encountering EO within the post-WW2 created made ground on Site.

10.5 The Likelihood of Initiation

10.5.1 Introduction

The likelihood of initiating EO depends on the type of EO and how aggressively it is encountered. Various types of EO buried in the UK require an impact, vibration or heat to initiate. Most EO contains a fuze and most fuzes contain a small quantity of shock-sensitive primary explosive. An impact to a fuze can therefore cause it to initiate, in turn detonating the main explosive charge.

German UXBs buried in the UK do not spontaneously self-detonate. The vast majority of German WW2 'iron' bombs contained an electrical fuze. Decades of burial (exposure to environmental conditions) will have caused these fuzes to corrode and lose their electrical charge. Consequently, during any such UXO encounter, it would be almost impossible for the fuze to initiate via its original (electrical) explosive train.

In theory, German UXBs could still initiate if the bomb were impacted with enough force. Percussive piling and bore-holing are engineering works that could impart enough force to detonate the main explosive charge of an EO, without requiring the fuze to function. Furthermore, the 'blind' nature of these intrusions elevates the likelihood of an EO impact.

Excavators and loaders impart less energy via their buckets and site workers might be able to notice a partially unearthed EO and halt works prior to an impact. For these reasons, IAL conducts separate risk rating calculations for different intrusive methodologies.

During WW2, the Allied air forces used mechanical (not electrical) fuzes, which pose a greater long-term UXB hazard on the continent. Furthermore, in Germany, 1No. buried Allied WW2 HE bomb per year (on average) self-detonates due to degradation of the chemical detonator in its time-delay fuze.

Sensitive types of EO include German 2kg (mechanically fuzed) 'Butterfly' bombs, types of British (mechanically fuzed) unexploded LSA ('blind' / 'dud' items), and bombs with chemical time-delay fuzes.

10.5.2 Site-Specific Conclusion

- There is no reason to believe that the Site-specific hazard items are more sensitive to an initiation when compared to similar EO contamination elsewhere in the UK.
- As 'blind' and percussive intrusive methodologies (boreholes and piling) are proposed, the likelihood of an EO initiation / detonation during the project is significantly increased.

11 The Historical Record: Extent and Accuracy

11.1 Introduction

The availability of key documents and data will affect the completeness and accuracy of the Site-specific risk assessment. Furthermore, historical records can sometimes be proven inaccurate, when compared with other records. Some inaccuracies could significantly affect the outcome of a risk assessment and therefore a Site-specific review must be conducted.

11.2 Site-Specific

Original written incident reports confirm that the separate Manchester bomb and damage plot map (purporting to record the entire bombing campaign) is in fact missing at least three bombing incidents (probably all HE) within 500m of the Site. And historic OS mapping and aerial photography almost certainly highlight additional missing bomb strikes within 200m of the Site.

The low quality of the historic record and potentially significant inconsistencies between records highlight the difficulties associated with accurate wartime record keeping in areas of elevated bombing density. This creates uncertainty with regards to the picture of local bomb strikes and raises the possibility of additional bomb strikes missing from the historic record. Therefore, IAL's assessment of UXO contamination risk on Site is accordingly cautious.

12 Site-Specific Risk Calculation

12.1 Introduction

The first stage of the semi-quantitative risk model considers potential sources of buried EO on Site. The next stage evaluates the possible linkages, identifying whether significant harm could occur (as a result of the proposed Site works) and the impact of such harm. To provide a numerical evaluation of risk, the two key considerations must be assigned a score and then multiplied together to provide a final risk rating / risk level:

- The likelihood of an EO linkage becoming complete: **FACTOR 3** (= Factors 1 x 2)
- The severity of the consequence(s) resulting from this linkage completion: **FACTOR 6** (= Factors 4 x 5)

12.2 Factor 1 (F1): Explosive Ordnance Presence

The Likelihood of EO contamination of the Site combined with the degree of subsequent risk mitigation. This factor is described and scored in the table below.

Classification	Example Descriptions	F1 Rating
Impossible	No EO contamination due to complete subsequent excavation / removal of the ZPC.	**0**
Highly Unlikely	EO contamination is highly unlikely to have occurred. Most of the ZPC subsequently excavated or EOC task(s) have been conducted.	**1**
Unlikely	EO contamination is unlikely to have occurred. Part of the ZPC subsequently excavated or EOC task(s) have been conducted.	**2**
Possible	EO contamination could have occurred. Part or none of the ZPC subsequently excavated.	**3**
Likely	EO contamination is likely to have occurred. Only a fraction or none of the ZPC subsequently excavated.	**4**
Almost Certain	Confirmed evidence of local EO contamination. Greenfield land / ZPC remains undisturbed.	**5**

TABLE 12: Factor 1 Scoring

12.3 Factor 2 (F2): Explosive Ordnance Initiation

The likelihood of encountering EO during the proposed works combined with the likelihood of initiating EO during the proposed works. This factor is described and scored in the table below.

Classification	Example Descriptions	F2 Rating
Impossible	The ZPC will not be disturbed during the proposed ground works.	**0**
Highly Unlikely	Fraction of the ZPC will be intruded / excavated. Hand-dug trial pits. Vegetation clearance / soil stripping. Hazard items include relatively insensitive EO.	**1**
Unlikely	Part of the ZPC will be intruded / excavated. Mechanically excavated trial pits. Shallow excavations for traditional foundations. Piling or boreholes. Hazard items include relatively insensitive EO.	**2**
Possible	Moderate to high intrusion / excavation of the ZPC. Large-scale shallow excavations for traditional foundations. Single basement level construction. Piling or boreholes. Hazard items include relatively insensitive and possibly sensitive EO.	**3**
Likely	Almost the entire ZPC will be excavated. Multi-level basement construction. Large scale piling works (including percussive piling). Hazard items include sensitive EO.	**4**
Almost Certain	The entire ZPC will be excavated. Multi-level basement construction. Large scale piling works (including percussive piling). Hazard items include highly sensitive EO.	**5**

TABLE 13: Factor 2 Scoring

12.4 Factor 3 (F3): Calculating the Likelihood of an Explosive Ordnance Initiation Event

The table below includes the calculations of 'Likelihood' and descriptions of the resulting scores.

F1 x F2 = F3	Classification	Example Descriptions	F3 Rating
F3 = 0	**Impossible**	Confirmed evidence that no EO is present or no pathway to sensitive receptors present.	**0**
F3 = 1 to 4	**Highly Unlikely**	EO is highly unlikely to be present. No pathway to sensitive receptors present. Initiation of EO is highly unlikely.	**1**
F3 = 5 to 8	**Unlikely**	EO is unlikely to be present. There is an established pathway to sensitive receptors. Initiation of EO unlikely.	**2**
F3 = 9 to 13	**Possible**	EO could be present. There is an established pathway to sensitive receptors. Initiation of EO is unlikely but possible.	**3**
F3 = 14 to 20	**Likely**	EO is likely to be present. There is an established pathway to sensitive receptors. Initiation of EO could occur.	**4**
F3 = 21 to 25	**Almost Certain**	Confirmed evidence of EO contamination. There is an established pathway to sensitive receptors. Initiation of EO is likely.	**5**

TABLE 14: Factor 3 Scoring

12.5 Factor 4 (F4): Explosive Ordnance Event Magnitude

The potential hazard associated with each hazard item combined with the likely depth of EO initiation. This factor is described and scored in the table below.

Classification	Example Descriptions	F4 Rating
None	British military training device (inert).	**0**
Very Small	British SAA at depth. 1kg German bomb at depth.	**1**
Small	British LSA or HAA projectile at depth. British LAA projectile near the surface. 2kg German bomb at depth. 1kg German bomb near the surface. British SAA near the surface.	**2**
Medium	British LSA or HAA projectile near the surface. 2kg German bomb near the surface. Medium German 'iron' bombs at depth.	**3**
Large	Large German 'iron' bombs at depth. Medium German 'iron' bombs near the surface.	**4**
Very Large	Large German 'iron' bombs near the surface.	**5**

TABLE 15: Factor 4 Scoring

12.6 Factor 5 (F5): Sensitive Receptors

The presence and sensitivity of receptors in the vicinity at the time of the proposed works. This factor is described and scored in the table below.

Classification	Example Descriptions	F5 Rating
Single	Plant / equipment.	**1**
Few	Human, plant / equipment.	**2**
Medium	Human, plant / equipment, buried services.	**3**

Most	Human, plant / equipment, buried services, buildings.	**4**
All	Human, plant / equipment, buried services, buildings, listed buildings, scheduled ancient monuments, protected environment (e.g. TPO).	**5**

TABLE 16: Factor 5 Scoring

12.7 Factor 6 (F6): Calculating the Consequence of an Explosive Ordnance Initiation Event

The table below includes the calculations of 'Consequence' and descriptions of the resulting scores.

F4 x F5 = F6	Classification	Example Descriptions	F6 Rating
F6 = 0	**None**	Contact with inert military device. No initiation event. No risk to human health or damage sustained.	**0**
F6 = 1 to 4	**Insignificant**	Very small magnitude inadvertent initiation at depth. Possible cosmetic damage to plant. No risk to human health or buildings damaged.	**1**
F6 = 5 to 8	**Mild**	Small magnitude inadvertent initiation. Possible damage to plant. Possible risk to human health (minor first aid injury).	**2**
F6 = 9 to 13	**Moderate**	Medium magnitude inadvertent initiation. Damage to plant. Possible damage to buried services. Possible cosmetic damage to buildings. Possible risk to human health (minor injury).	**3**
F6 = 14 to 20	**Severe**	Large magnitude inadvertent initiation. Severe damage to plant, buried services and buildings. Fatality and / or severe injuries.	**4**
F6 = 21 to 25	**Catastrophic**	Large magnitude inadvertent initiation. Catastrophic damage to plant, buried services and buildings (including listed buildings, scheduled ancient monuments, etc). Multiple fatalities and severe injuries.	**5**

TABLE 17: Factor 6 Scoring

12.8 Calculating the Final Risk Level(s)

The 'Likelihood' and 'Consequence' factors are combined in the risk matrix below to produce a final risk score.

		Consequence (F6)						
		0	**1**	**2**	**3**	**4**	**5**	
Likelihood (F3)	**5**	**0**	**5**	**10**	**15**	**20**	**25**	Final Risk Score
	4	**0**	**4**	**8**	**12**	**16**	**20**	
	3	**0**	**3**	**6**	**9**	**12**	**15**	
	2	**0**	**2**	**4**	**6**	**8**	**10**	
	1	**0**	**1**	**2**	**3**	**4**	**5**	
	0	**0**	**0**	**0**	**0**	**0**	**0**	

Final Risk Rating (score)						
0 - 1	**2 - 5**	**6 - 9**	**10 - 12**	**15 - 16**	**20**	**25**
Very Low	**Low**	**Low-to-Moderate**	**Moderate**	**Moderate-to-High**	**High**	**Very High**
Risk Levels						

TABLE 18: Risk Matrix

12.9 Conceptual Site Model

Site-specific risk model calculations have identified two risk zones. These are illustrated on a Risk Map displayed at **FIGURE 6** and the conceptual model is displayed in the tables below.

	Low Risk Table						
	Hazard Item	Pathway	Receptor	Likelihood (F3)	Consequence (F6)	Final Risk Rating	Risk Level
German	**WW2 'iron' HE Bombs**	SI boreholes. Blast + frag.	Human, Plant, Structures.	**1** (F1:1 x F2:3)	**4** (F4:4 x F5:4)	**4** (1 x 4)	**Low**
		Mech excavations. Blast + frag.	Human, Plant, Structures.	**1** (F1:1 x F2:3)	**4** (F4:4 x F5:4)	**4** (1 x 4)	**Low**
		Piling. Blast + frag.	Human, Plant, Structures.	**1** (F1:1 x F2:4)	**4** (F4:4 x F5:4)	**4** (1 x 4)	**Low**
	WW2 'iron' Incendiary Bombs	SI boreholes. Heat + Blast + frag.	Human, Plant, Structures.	**1** (F1:1 x F2:3)	**3** (F4:3 x F5:3)	**3** (1 x 3)	**Low**
		Mech excavations. Heat + Blast + frag.	Human, Plant, Structures.	**1** (F1:1 x F2:3)	**3** (F4:3 x F5:3)	**3** (1 x 3)	**Low**
		Piling. Heat + Blast + frag.	Human, Plant, Structures.	**1** (F1:1 x F2:4)	**3** (F4:3 x F5:3)	**3** (1 x 3)	**Low**
	WW2 1kg Incendiary Bombs	SI boreholes. Heat.	Human, Plant.	**1** (F1:1 x F2:1)	**2** (F4:2 x F5:3)	**2** (1 x 2)	**Low**
		Mech excavations. Heat.	Human, Plant.	**1** (F1:1 x F2:2)	**2** (F4:2 x F5:3)	**2** (1 x 2)	**Low**
		Piling. Heat.	Human, Plant.	**1** (F1:1 x F2:2)	**2** (F4:2 x F5:3)	**2** (1 x 2)	**Low**
	WW2 2kg Incendiary + HE Bombs	SI boreholes. Blast + heat.	Human, Plant.	**1** (F1:1 x F2:2)	**3** (F4:3 x F5:3)	**3** (1 x 3)	**Low**
		Mech excavations. Blast + heat.	Human, Plant.	**1** (F1:1 x F2:3)	**3** (F4:3 x F5:3)	**3** (1 x 3)	**Low**
		Piling. Blast + heat.	Human, Plant.	**1** (F1:1 x F2:3)	**3** (F4:3 x F5:3)	**3** (1 x 3)	**Low**
British	**AA Artillery Projectiles**	SI boreholes. Blast + frag.	Human, Plant, Structures.	**1** (F1:1 x F2:2)	**3** (F4:3 x F5:4)	**3** (1 x 3)	**Low**
		Mech excavations. Blast + frag.	Human, Plant, Structures.	**1** (F1:1 x F2:3)	**3** (F4:3 x F5:4)	**3** (1 x 3)	**Low**
		Piling. Blast + frag.	Human, Plant, Structures.	**1** (F1:1 x F2:3)	**3** (F4:3 x F5:4)	**3** (1 x 3)	**Low**

TABLE 19: Low Risk Table

	Moderate Risk Table						
	Hazard Item	Pathway	Receptor	Likelihood (F3)	Consequence (F6)	Final Risk Rating	Risk Level
German	**WW2 'iron' HE Bombs**	SI boreholes. Blast + frag.	Human, Plant, Structures.	**3** (F1:3 x F2:3)	**4** (F4:4 x F5:4)	**12** (3 x 4)	**Moderate**
		Mech excavations. Blast + frag.	Human, Plant, Structures.	**3** (F1:3 x F2:3)	**4** (F4:4 x F5:4)	**12** (3 x 4)	**Moderate**
		Piling. Blast + frag.	Human, Plant, Structures.	**3** (F1:3 x F2:4)	**4** (F4:4 x F5:4)	**12** (3 x 4)	**Moderate**
	WW2 'iron' Incendiary Bombs	SI boreholes. Heat + Blast + frag.	Human, Plant, Structures.	**2** (F1:2 x F2:3)	**3** (F4:3 x F5:3)	**6** (2 x 3)	**Low-to-Moderate**
		Mech excavations. Heat + Blast + frag.	Human, Plant, Structures.	**2** (F1:2 x F2:3)	**3** (F4:3 x F5:3)	**6** (2 x 3)	**Low-to-Moderate**
		Piling. Heat + Blast + frag.	Human, Plant, Structures.	**2** (F1:2 x F2:4)	**3** (F4:3 x F5:3)	**6** (2 x 3)	**Low-to-Moderate**
	WW2 1kg Incendiary Bombs	SI boreholes. Heat.	Human, Plant.	**1** (F1:2 x F2:1)	**2** (F4:2 x F5:3)	**2** (1 x 2)	**Low**
		Mech excavations. Heat.	Human, Plant.	**1** (F1:2 x F2:2)	**2** (F4:2 x F5:3)	**2** (1 x 2)	**Low**
		Piling. Heat.	Human, Plant.	**1** (F1:2 x F2:2)	**2** (F4:2 x F5:3)	**2** (1 x 2)	**Low**
	WW2 2kg Incendiary + HE Bombs	SI boreholes. Blast + heat.	Human, Plant.	**1** (F1:2 x F2:2)	**3** (F4:3 x F5:3)	**3** (1 x 3)	**Low**
		Mech excavations. Blast + heat.	Human, Plant.	**2** (F1:2 x F2:3)	**3** (F4:3 x F5:3)	**6** (2 x 3)	**Low-to-Moderate**
		Piling. Blast + heat.	Human, Plant.	**2** (F1:2 x F2:3)	**3** (F4:3 x F5:3)	**6** (2 x 3)	**Low-to-Moderate**
British	**AA Artillery Projectiles**	SI boreholes. Blast + frag.	Human, Plant, Structures.	**1** (F1:2 x F2:2)	**3** (F4:3 x F5:4)	**3** (1 x 3)	**Low**
		Mech excavations. Blast + frag.	Human, Plant, Structures.	**2** (F1:2 x F2:3)	**3** (F4:3 x F5:4)	**6** (2 x 3)	**Low-to-Moderate**
		Piling. Blast + frag.	Human, Plant, Structures.	**2** (F1:2 x F2:3)	**3** (F4:3 x F5:4)	**6** (2 x 3)	**Low-to-Moderate**

TABLE 20: Moderate Risk Table

13 Risk Mitigation

13.1 ALARP Principle

ALARP is a risk principle associated with the Health and Safety at Work Act 1974. It is used in the regulation and management of construction industry risks and states that risk must be averted unless there is a gross disproportion between the costs and benefits of doing so.

The ALARP principle arises from the fact that infinite time, effort and money could be spent attempting to eliminate a risk entirely. It should not be understood as simply a quantitative measure of benefit against detriment. Instead, a best common practice of judgement, balancing risk and societal benefit.

13.2 Risk Levels and Risk Tolerance

The table below outlines the relationship between final risk scores / levels (the output of the IAL semi-quantitative risk model), risk tolerance and the available industry standard risk mitigation measures. An elevated UXO risk should always be reduced to ALARP level.

Risk Level	IAL Recommendation	Risk Tolerance	Mitigation Measures
Very High	**Proactive** mitigation measures considered essential	Intolerable risk level in all but extreme circumstances.	► EOD Engineer supervision of ground works ► Magnetometer surveying prior to ground works ► Explosive Ordnance Safety & Awareness Briefing(s) ► Explosive Ordnance Site Safety Instructions
High			
Moderate-to-High	**Proactive** mitigation measures recommended	Intolerable level of risk where risk mitigation to ALARP is cost effective. A client may consider the risk tolerable due to impracticability of the available risk mitigation measures or disproportionately high cost of mitigation.	
Moderate		Tolerable risk level providing the recommended mitigation measures have been adopted.	
Low-to-Moderate	**Reactive** mitigation measures recommended	Possibly tolerable risk level, however **reactive** risk mitigation measures would be the prudent course of action. For sensitive, high value sites, a zero-tolerance policy may exist, mandating **proactive** risk mitigation measures.	► Explosive Ordnance Safety & Awareness Briefing(s) ► Explosive Ordnance Site Safety Instructions
Low	**Reactive** mitigation measures considered prudent (not recommended)	Likely to be a tolerable risk level for most clients. However, adoption of the basic precautionary mitigation measure would be the prudent (and very cost effective) course of action, especially for greenfield sites.	► Explosive Ordnance Safety & Awareness Briefing(s) considered prudent ► Explosive Ordnance Site Safety Instructions considered prudent
Very Low	No mitigation measures	N/A	N/A

TABLE 21: Risk Levels and Risk Tolerance

13.3 Site-Specific Recommendation(s)

The following table describes the available industry standard risk mitigation measures and identifies those (if any) that are recommended to reduce an elevated risk to ALARP level.

Mitigation Measure	Appropriate For	Site-Specific
Explosive Ordnance Site Safety Instructions: EO Safety Instructions (compiled by an EO specialist) provide a written record of the key points that make up an EO Safety & Awareness Briefing. Including instructions on making a preliminary suspicious object threat assessment, a visual catalogue of commonly found EO types, and the steps to take in the event of a potential EO find. The instructions should be included within the site-specific Health & Safety Manual.	▶ Provided to Site personnel prior to commencement of excavations. ▶ Not appropriate for 'blind' intrusions (e.g. boreholes)	**Recommended** to be held on Site for the duration of the development phase ground works.
Explosive Ordnance Safety & Awareness Briefings: All personnel conducting ground works on Site should receive this briefing. It should feature as a key element of the CDM Regulations 2015 Health & Safety training package for the site. The briefing should be conducted by a trained EO specialist. Such briefings instruct recipients in the identification of EO hazards and actions to be taken in the event of an EO incident.		**Recommended** for all development phase personnel conducting intrusive ground works throughout the Site.
Explosive Ordnance Disposal (EOD) Engineer Supervision: An EOD engineer (banksman) providing a 'watching brief' of mechanical excavations. Any suspicious objects will be quickly identified, allowing works to continue if the object is not EO. This reduces the risk of delays to the project. EOD engineers can use portable / handheld magnetometer instruments to scan ground ahead of boreholes.	▶ SI (including some boreholes) ▶ Small volume earthworks on greenfield land ▶ Excavations within made ground	**Recommended** supervision of SI boreholes and all development phase mechanical excavations within the Moderate Risk Zone only.
Intrusive Magnetometer Probe Survey: A range of intrusive magnetometer methodologies can be deployed. Which equipment is most appropriate will depend upon the ground conditions and site access. This survey will scan the ground down to the maximum bomb penetration depth and therefore is the most appropriate option for clearing pile locations ahead of 'blind' piling works. Multiple overlapping surveys can be conducted, providing matrix clearance of made ground, e.g basement dig.	▶ Pile locations ▶ Boreholes ▶ Large volume earthworks on brownfield land	**Recommended** at each pile position within the Moderate Risk Zone only. Survey only required down to 10.0m bgl.
Non-Intrusive Magnetometer Survey: A range of non-intrusive magnetometer survey methodologies can be deployed to survey ground to a limited depth. Such surveys can typically detect a 50kg 'iron' bombs at a depth of 4.5m bgl, providing the ground is 'magnetically clean'. Such surveys are not appropriate for brownfield land where 'magnetic noise' will result in unusable data.	▶ Large volume earthworks on magnetically clean (greenfield) land	**Not Recommended**

TABLE 22: Recommendations for Risk Mitigation

Figures: 1 - 6

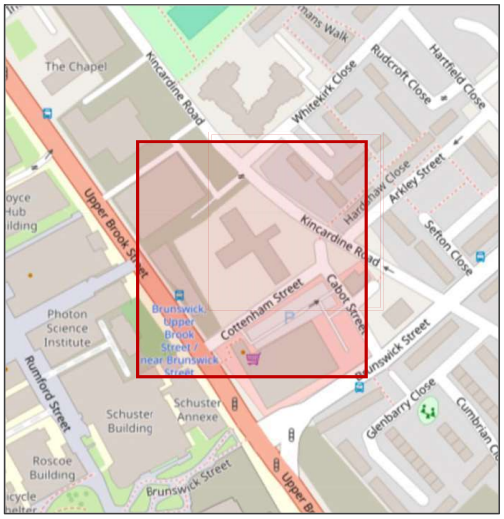






Figure: 01

Figure Title:
Site Location Maps and Recent Aerial Photograph

Legend:

Approx. Site boundary

General Site location

Notes:

Source: Google
OpenStreetMap

N

Project: Upper Brook Street, Manchester

Client: Delta-Simons

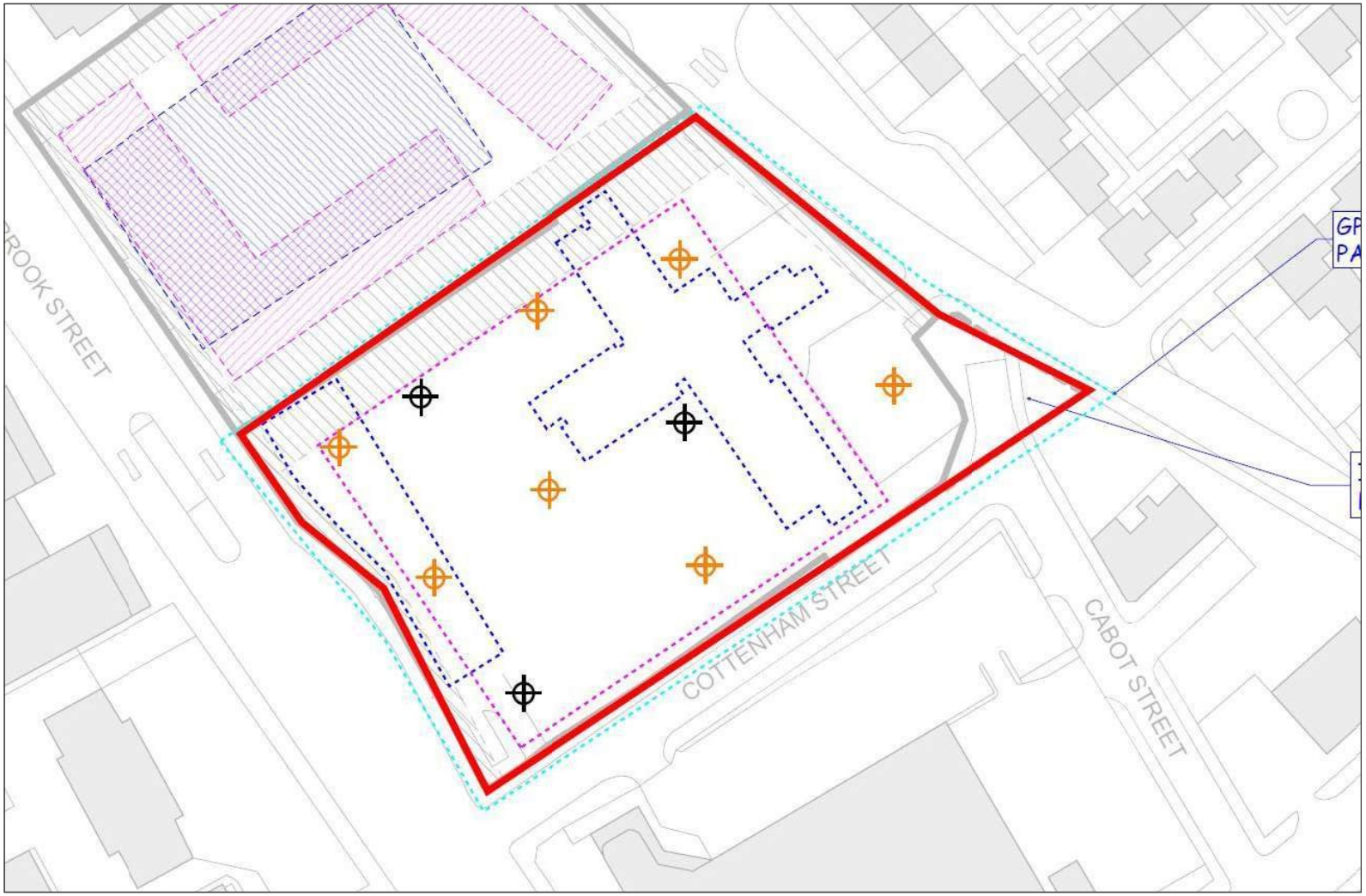
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Figure: 02

Figure Title:
Proposed SI Positions Plan



Legend:

Site boundary

Notes:

Source: Delta-Simons

N

Project: Upper Brook Street, Manchester

Client: Delta-Simons

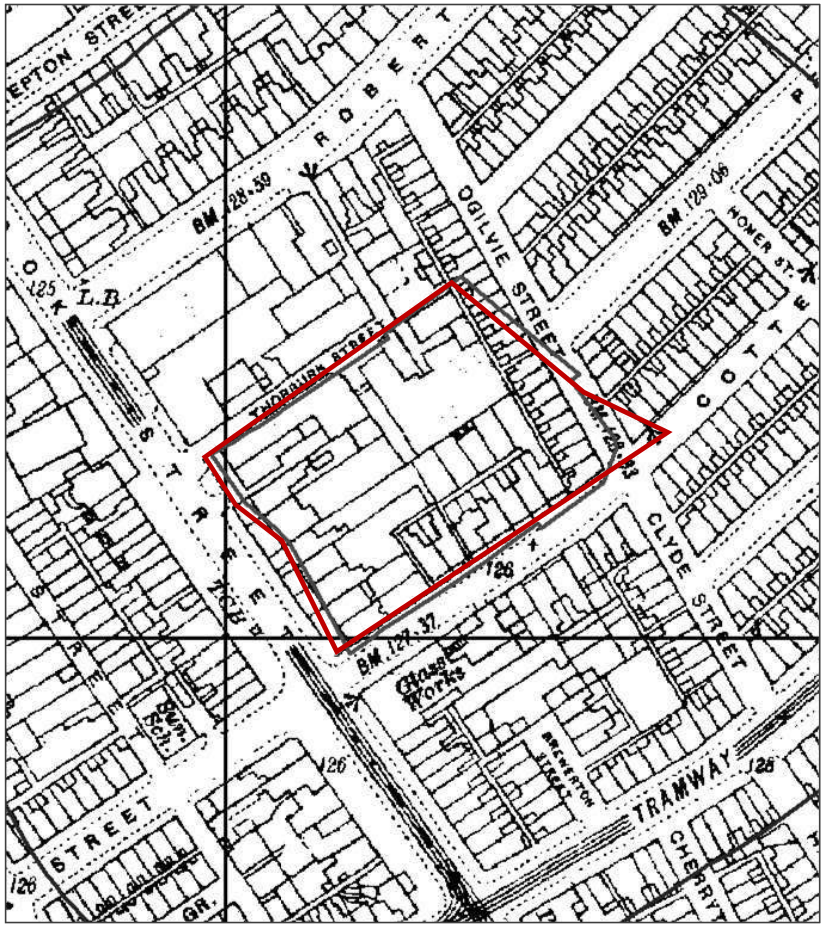
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1932



1951



Figure: 03

Figure Title:
Historic OS Mapping

Legend:

- Approx. Site boundary
- Clearance

Notes:

Latest pre-WW2 and earliest post-WW2 large-scale OS maps comparison.

Source: Groundsure

N

Project:	Upper Brook Street, Manchester
Client:	Delta-Simons
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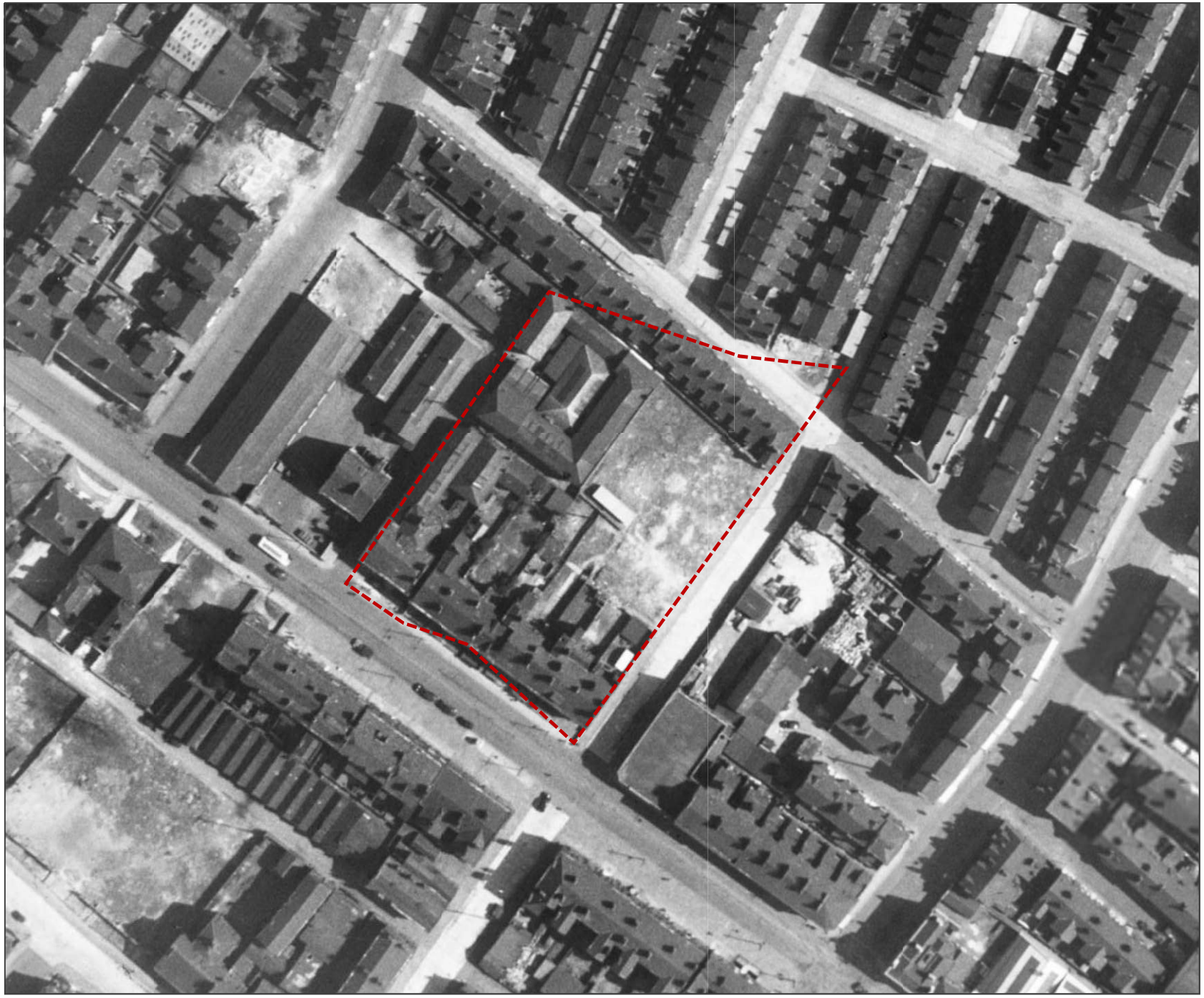


Figure: 04

Figure Title:
Historic Aerial Photography:
7th May 1946

Legend:

Approx. Site boundary

Notes:

Source: Historic England

N

Project: Upper Brook Street, Manchester

Client: Delta-Simons

Doc Ref: DRA.10140.23 **Version:** 1

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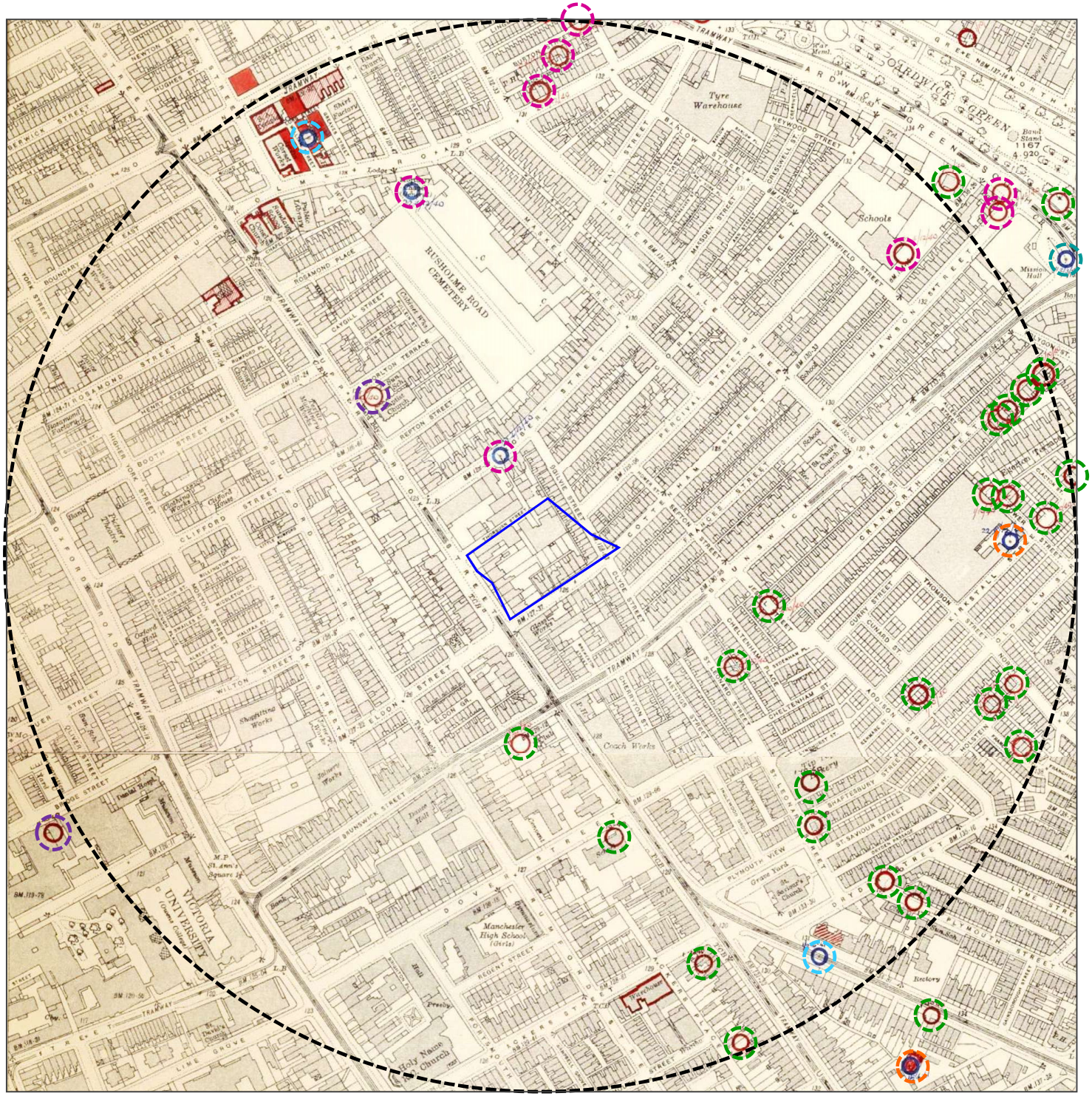


Figure: 05

Figure Title:
Manchester Bomb and Damage Plot Map

Legend:

- Approx. Site boundary
- HE bomb strike
- IB strike(s)
- 1st Oct 1940
- 11th Oct 1940
- 22nd/23rd or 23rd/24th Dec 1940
- 22nd Dec 1940
- 11th Mar 1941
- 1st / 2nd Jun 1941

Notes:

Black dash circle marks ~400m radius from the Site centre point

Source: Greater Manchester County Record Office

N

Project: Upper Brook Street, Manchester

Client: Delta-Simons

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Recommendations

- ► **Explosive Ordnance Disposal (EOD) Engineer** supervision of the SI boreholes and all development phase mechanical excavations within the Moderate Risk Zone only.
- ► **Intrusive Magnetometer Probe Survey** at each pile position within the Moderate Risk Zone only. Survey only required down to 10.0m bgl.
- ► **Explosive Ordnance Safety & Awareness Briefing** to all development phase personnel conducting intrusive ground works throughout the Site.
- ► **Explosive Ordnance Site Safety Instructions** held on Site for the duration of the development phase ground works.

Figure: 06

Figure Title:
Risk Map

Legend:

- Site boundary
- Low Risk Zone
- Moderate Risk Zone

Notes:

The moderate risk zone include a buffer area to account for the J-Curve Effect and the potential for UXB ricochet off building foundations.

Within each mapped risk zone, the risk levels relating to each EO hazard item vary.

Source: IAL

N

Project: Upper Brook Street, Manchester

Client: Delta-Simons

Doc Ref: DRA.10140.23 **Version:** 1

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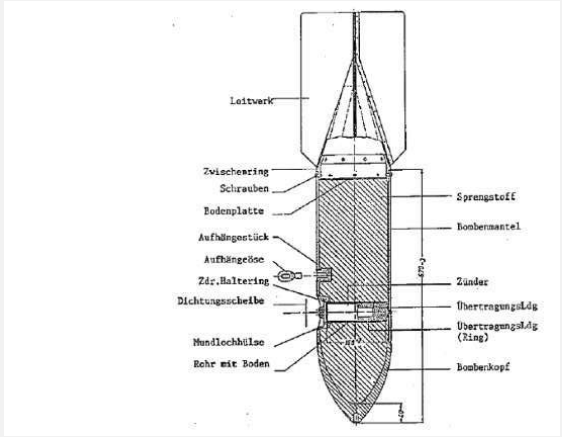
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Appendices: 1 - 3

German WW2 High Explosive 'Iron Bombs' - most likely to be encountered

SC 50

Bomb Weight:	54kg (119lb)
Explosive Weight:	25kg (55lb)
Filling:	TNT, Amatol or Trialen
Charge/Weight Ratio:	46%
Fuze Type:	Side fuzed. Electrical impact or mechanical delay
Body Dimensions:	670 to 762mm x 203mm
Material:	Steel
Appearance:	Grey/green with yellow stripe on the tail unit
Variants:	Grades I, II and III. Body length / construction

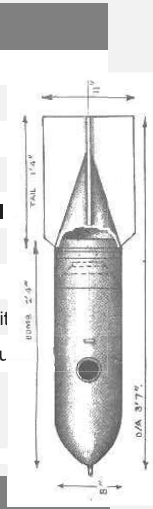


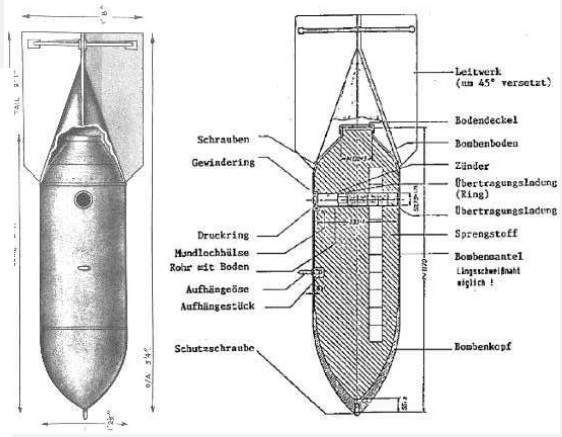




SC 250

Bomb Weight:	256kg (564lb)
Explosive Weight:	125 to 130kg (276 to 287lb)
Filling:	TNT, Amatol or Trialen
Charge/Weight Ratio:	44%
Fuze Type:	Side fuzed. Electrical impact or mechanical
Body Dimensions:	1,173 to 1,193mm x 368mm
Material:	Steel
Appearance:	Grey/green with yellow stripe on the tail unit
Variants:	Grades I and II. Body length and doubled fu



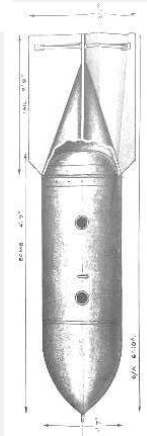






SC 500

Bomb Weight:	480 to 520kg (1,058 to 1,146lb)
Explosive Weight:	220kg (485lb)
Filling:	TNT, Amatol or Trialen
Charge/Weight Ratio:	44%
Fuze Type:	Side fuzed. Electrical impact or mechanical delay
Body Dimensions:	1,414 to 1,486mm x 470mm
Material:	Steel
Appearance:	Grey/green or buff with yellow stripe on the tail unit
Variants:	Grades I, II and III. Body length / construction







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Appendix: 01.1

Appendix Title:
Data Sheets - Commonly Deployed German WW2 Bombs

Project: Upper Brook Street, Manchester

Client: Delta-Simons

Doc Ref: DRA.10140.23 | **Version:** 1

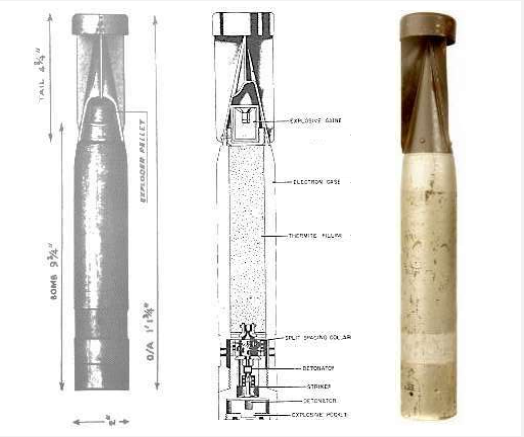
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German WW2 Incendiary Bombs - most likely to be encountered

B1 Series Sub-Munition

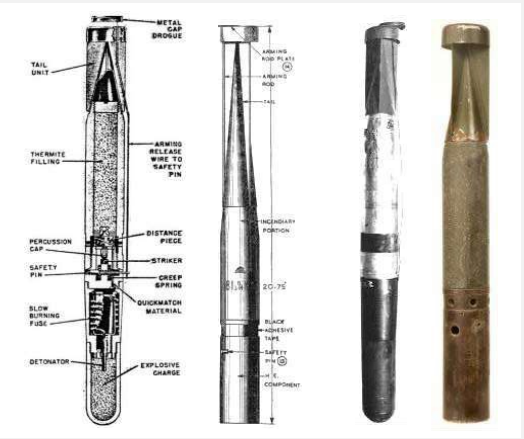
Bomb Weight:	1.0 to 1.3kg (2.20 to 2.87lb)
Incendiary Weight:	680g
Filling:	Thermite
Fuze Type:	Nose fuzed, impact
Body Dimensions:	247mm x 50mm
Material:	Magnesium alloy body, steel tail
Appearance:	Grey body, dark green tail unit
Variants:	Four types. Two delayed action and one steel nosed
Bomb Container:	Various sizes holding between 36No. and 620No. B1s

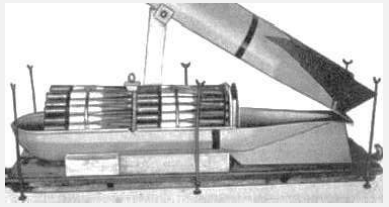


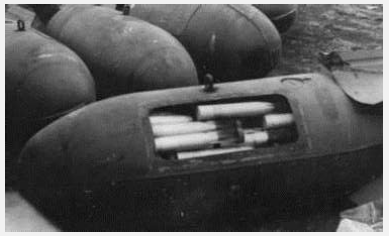


B2 Series Sub-Munition

Bomb Weight:	2.0 to 2.2kg (4.40 to 4.85lb)
Fill Weight:	680g incendiary plus 100g HE
Filling:	Thermite and Penthrite or TNT
Fuze Type:	Nose fuzed, impact
Body Dimensions:	311mm x 50mm
Material:	Magnesium alloy and steel body, steel tail
Appearance:	Green body and tail, explosive black, red or unpainted
Variants:	Two types; round nose or flat nose plus longer tail unit
Bomb Container:	Various sizes holding up to 372No. B2s. Usually mixed with B1s.

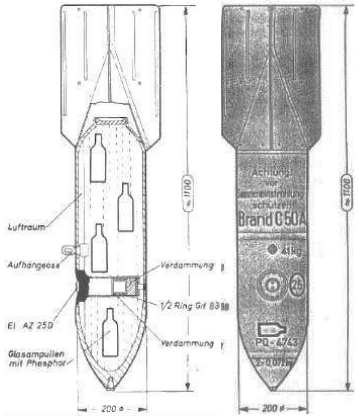






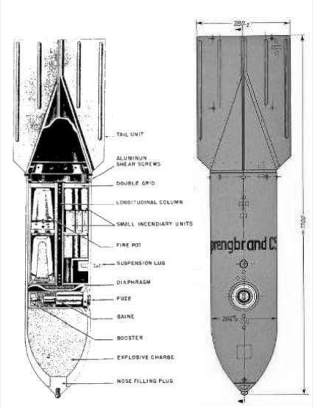
Brand C50 A

Bomb Weight:	41kg (75lb)
Incendiary Weight:	13kg (30lb)
Filling:	15 litres (86% Benzine, 10% Rubber, 4% Phosphorus)
Fuze Type:	Side fuzed. Electrical impact
Body Dimensions:	762mm x 203mm
Material:	Steel
Appearance:	Grey or green body, red base, red band around the centre of the body
Variants:	C50 B (77% Phosphorus fill)



Sprengbrand C50 'Fire Pot'

Bomb Weight:	50kg (110lb)
Fill Weight:	10kg (22lb)
Filling:	7kg TNT and 3kg Thermite in multiple small containers
Fuze Type:	Side fuzed. Electrical impact
Body Dimensions:	711mm x 203mm
Material:	Steel
Appearance:	Grey or green body, red or brown stencilling on body
Variants:	None



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Appendix: 01.2

Appendix Title:
Data Sheets - Commonly Deployed German WW2 Bombs

Project: Upper Brook Street, Manchester

Client: Delta-Simons

Doc Ref: DRA.10140.23 | **Version:** 1

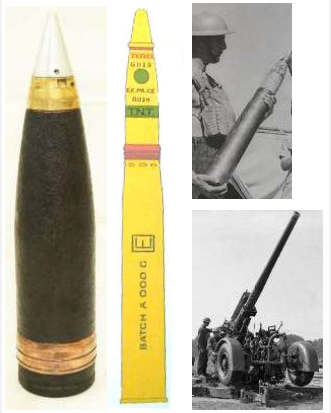
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British WW1 and WW2 Anti-Aircraft Projectiles

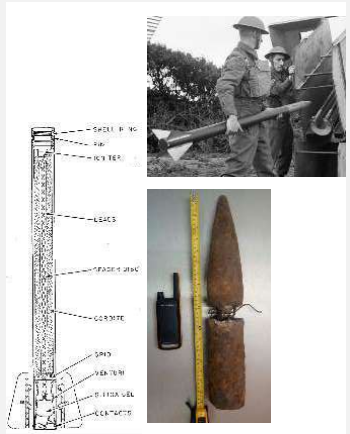
3.7-inch QF Heavy AA Gun (WW2)

Shell Weight:	12.7kg
Fill Weight:	1.1kg
Filling:	Amatol, TNT or RDX and TNT
Fuze Type:	Nose mechanical time delay fuze
Shell Dimensions:	94mm x 360 or 438mm
Shell Appearance:	Yellow or Grey body, copper driving bands, brass neck, grey nose fuze
Max Range:	12,000m
Rate of Fire:	10 to 20rpm



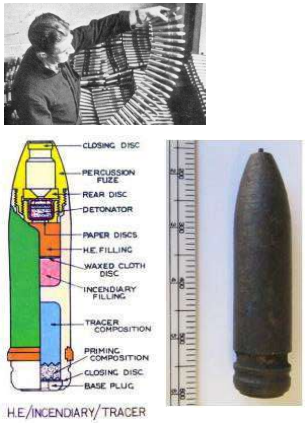
3-inch UP Rocket - Z Battery (WW2)

Rocket Weight:	24.5kg
Warhead Weight:	3.4kg
Fill Weight:	0.96kg
Filling:	TNT warhead. Black Powder solid fuel rocket motor
Fuze Type:	Nose mechanical time delay fuze
Rocket Dimensions:	1,930mm x 82mm
Shell Appearance:	Pointed bronze or black nose
Max Range:	6,770m



20mm Light AA Gun (WW2)

Shell Weight:	123g or 116g or 130g
Fill Weight:	6.0 to 11.0g
Filling:	Incendiary comp and/or TNT or Tetryl
Fuze Type:	Nose impact fuze
Shell Dimensions:	20mm x 110mm or 128mm
Shell Appearance:	Blue, orange, red or green bodies indicate TNT fill
Max Range:	4,389m
Rate of Fire:	250 to 450rpm



40mm Light AA Gun (WW2)

Shell Weight:	0.84kg
Fill Weight:	68g
Filling:	TNT
Fuze Type:	Nose impact fuze
Shell Dimensions:	40mm x 180mm
Shell Appearance:	Yellow or orange body, copper driving band, grey nose fuze
Max Range:	7,160m
Rate of Fire:	120rpm



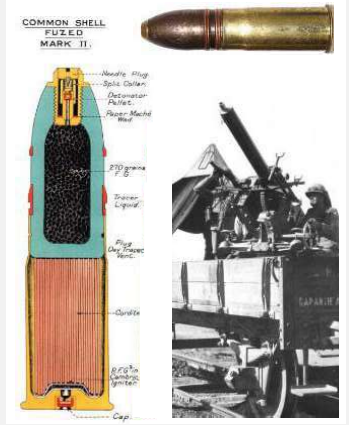
3 inch QF Heavy AA Gun (WW1)

Shell Weight:	5.7kg or 7.3kg
Fill Weight:	<0.6kg (explosive)
Filling:	TNT or TNT plus ball bearings
Fuze Type:	Nose mechanical time delay fuze
Shell Dimensions:	76.2mm x 384mm or 420mm
Shell Appearance:	Black body, copper driving bands, brass nose fuze
Max Range:	6,700m
Rate of Fire:	16 to 18rpm



37mm Light AA Gun (WW1)

Shell Weight:	0.45kg
Fill Weight:	17.0g
Filling:	Gunpowder / black powder
Fuze Type:	Nose impact fuze
Shell Dimensions:	93mm x 37mm
Shell Appearance:	Brown body, copper driving bands and brass fuze.
Max Range:	4,110m
Rate of Fire:	300rpm



Appendix: 02

Appendix Title:
Data Sheets - Commonly Deployed British Anti-Aircraft Projectiles

Project:	Upper Brook Street, Manchester
Client:	Delta-Simons
Doc Ref:	DRA.10140.23
Version:	1

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Web: www.impartialassessments.com
Email: info@impartialassessments.com

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Appendix: 03

Appendix Title:
Bibliography

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Tel: +44 (0) 2071 268 164
Web: www.impartialassessments.com
Email: info@impartialassessments.com



Impartial Assessments Ltd, 7 Bell Yard, Holborn, London, WC2A 2JR
+44 (0) 207 126 8164
www.impartialassessments.com
info@impartialassessments.com
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