



Blackley Fire Station, Blackley

Phase 1 Geo-Environmental Investigation

For: Greater Manchester Combined Authority (GMCA)

IGE Consulting
Office 16
Bartle House
Oxford Court
Manchester
M2 3WQ

Ref: 3866b-01
Job: 3866b
Rev: A
By: LM

Tel 0161-914-9170
Email contact@igeconsulting.co.uk

Date: Feb 2023

REVISIONS

Revision	Date	Prepared By	Authorised By	Remarks
First Issue	9 th November 2022	 Agnieszka Stefanowicz	 Andrew Edwards	-
Rev A	24 th February 2023	 Liam McMahon	 Andrew Edwards	Updated CSM based upon further information from GMCA



CONTENTS

1.0 INTRODUCTION

- 1.1 Brief
- 1.2 Third Parties

2.0 SCOPE OF INVESTIGATION WORK

- 2.1 Walkover Survey
- 2.2 Documentation

3.0 FINDINGS

- 3.1 Site Location and Description
- 3.2 Walkover Survey
- 3.3 Site History
- 3.4 Geology
- 3.5 Mining
- 3.6 Hydrology and Hydrogeology
- 3.7 Hazardous Installations, Landfill and Waste
- 3.8 Radon
- 3.9 Services
- 3.10 Unexploded Ordnance (UXO)
- 3.11 Animal Burial Sites
- 3.12 Archaeology

4.0 CONCLUSIONS

- 4.1 General
- 4.2 Ground Conditions
- 4.3 Sources of Contamination and Probable Contaminants
- 4.4 Pathways for Contamination
- 4.5 Receptors of Contamination
- 4.6 Conceptual Model
- 4.7 Preliminary Risk Assessment Summary
- 4.8 Scope of Phase 2 Intrusive Geo-Environmental Ground Investigation

5.0 RECOMMENDATIONS

APPENDICES

APPENDIX 1	LIMITATIONS OF INVESTIGATION WORK AND REPORT AND CONTAMINATED LAND LEGISLATIVE FRAMEWORK
-------------------	--

APPENDIX 2	FIGURES AND DRAWINGS
-------------------	----------------------

- Proposed Development Plan
- SI-01 Site Location Plan
- SI-02 Site Features Plan
- SI-03 Conceptual Site Model

APPENDIX 3	WALKOVER SURVEY PHOTOGRAPHS AND PHOTOGRAPH LOCATION PLAN
-------------------	--

APPENDIX 4	HISTORICAL ORDNANCE SURVEY MAPS
-------------------	---------------------------------

APPENDIX 5	GROUNDSURE COMBINED ENVIRO + GEO INSIGHT REPORT
-------------------	---

APPENDIX 6	BGS BOREHOLE LOGS, MINERAL RESOURCES MAP FOR GREATER MANCHESTER AND GREATER MANCHESTER JOINT MINERALS PLAN MINERAL SAFEGUARDING MAP
-------------------	--

APPENDIX 7	ZETICA UXO RISK MAP AND STAGE 1 PRELIMINARY UXO RISK ASSESSMENT
-------------------	---

1.0 INTRODUCTION

This Phase 1 Geo-Environmental Investigation report has been prepared at the request of Greater Manchester Combined Authority (GMCA).

Instructions to proceed were received in October 2022. Phase 1 desk study work was undertaken between 31st October and 9th November 2022.

Proposed Development

This Phase 1 Geo-Environmental Investigation is to be used for submission to the Local Authority as part of a planning application. It is the Client's intention to demolish the existing fire station and construct a new fire station along with an access road and areas of hardstanding.

A proposed development plan is contained in Appendix 2.

1.1 Brief

The brief was to carry out a Phase 1 Geo-Environmental Investigation for the site based upon the proposed development outlined in Section 1.0. The site area is shown on the site location plan contained in Appendix 2.

The investigation was to include the following:

- a) Assess the probable ground conditions and contaminated land conditions on and below the site based on existing and historic site uses and relevant off-site activities, this is to include a site walkover.
- b) Identify probable contaminants / sources of contamination that may be present at the site using current contaminated land guidance and develop a conceptual site model for potential human health, ground gas and controlled waters receptors.

- c) Undertake a Preliminary Risk Assessment – which will determine the requirement for further environmental (contaminated land) investigation and assessment.
- d) Design on the basis of the anticipated ground conditions appropriate ground investigation works and discuss potential development issues (i.e. sub-surface features – obstructions, infilling, compressible ground, faulting, mineral extraction, mining and land instability).

A summary of the information / data sources is detailed in Section 2.2. A report was to be provided to summarise findings and to provide recommendations.

The limitations of this investigation work and report are included in Appendix 1.

1.2 Third Parties

This report has been prepared for the sole use of GMCA. It must not be copied or passed onto any third party or used for any purpose other than which it was prepared without the permission of the author. This report is copyright.

2.0 SCOPE OF INVESTIGATION WORKS

2.1 Walkover Survey

The site was visited on 31st October 2022 in clear weather conditions and the objectives of the site walkover were, where applicable:

- to identify and assess visual and olfactory evidence of contamination (e.g. staining of concrete / soils, odours, presence of gas protection measures etc.);
- to identify locations of potential sources of contamination and assess their conditions (i.e. tank location, presence / condition of secondary containment / bunds, location of fill points, process areas);
- to identify surrounding land uses and any potentially contaminating activities;
- to identify / verify the presence of potential receptors (on- and off-site) which may be affected by identified sources;
- to obtain information on activities / procedures and standards of housekeeping etc.;
- to assess site access and potential investigation locations and constraints; and
- to assess any visual subsurface geotechnical features / anomalies (e.g. foundations, Made Ground, subsidence etc.).

Photographs were taken of the site during the walkover survey and these photographs, together with a plan indicating their location and direction, are contained in Appendix 3.

2.2 Documentation

The following documents were obtained and examined during the desk study:

- a) A combined Enviro + Geo Insight report was obtained from Groundsure, an environmental database company, which provides a list of recorded past and present activities at or adjacent to the site which could have an impact on the levels of contamination in the soils and groundwater at the site. The report is contained in Appendix 5.

- b) Aerial photographs of the site dated: April 2019, June 2015, June 2009 and June 2000. The photographs are contained within the Groundsure Enviro + Geo Insight report in Appendix 5.
- c) Historical Ordnance Survey maps dated between 1848 and 2022, at scales of 1:1,250, 1:2,500, 1:10,000 and 1:10,560.
- d) Groundsure maps, all dated 2022, as follows:
- Historical Land Use map;
 - Environmental Permits, Incidents and Registers map;
 - Landfill and other Waste Sites map;
 - Current Land Use map;
 - Hydrogeology and Hydrology maps;
 - Environment Agency / Natural Resources Wales flood maps;
 - Designated Environmentally Sensitive Sites map;
 - Geological maps and Ground Working map;
 - Mining, Extraction & Natural Cavities map;
 - Natural Ground Subsidence maps;
 - Borehole Records map;
 - Railways and Tunnels map.

These maps are contained within the Enviro + Geo Insight report in Appendix 5.

- e) The following sources were obtained and examined from the British Geological survey. All items were copied under licence; [C18/01] British Geological Survey ©UKRI. All rights reserved:
- The British Geological Survey (BGS) 1:50,000 solid and drift geological maps (Sheet 85 dated 2011).
 - 3 No. BGS Borehole logs were also obtained (Ref: SD80SE1005-1007).
- f) A Zetica UXO Risk Map is included in Appendix 7. A Preliminary UXO Risk Assessment Report was obtained which is also included in Appendix 7.

3.0 FINDINGS

3.1 Site Location and Description

This report pertains to a c. 0.23 Ha site located to the east of Rochdale Road, c. 5.7km north of Manchester City Centre, at the approximate post code M9 7FP. The National Ordnance Survey Grid Reference for the centre of the site is 386071E, 403390N.

The site is currently occupied and comprises a fire station with various facilities, including crew accommodation, offices, appliance storage and car parking. Access to the site is off Rochdale Road at the western boundary. The site is bounded by residential properties to the north, established trees and grassed area to the east and an Ex-Service Men's Club to the south.



Figure 1: Aerial image of the site dated March 2021.

3.2 Walkover Survey

The walkover survey was carried out on 31st October 2022 during clear weather conditions. During the walkover survey the following features were noted.

The site currently comprises a fire station with various facilities, including crew accommodation, offices, appliance storage and car parking. The fire station is a single storey masonry building with a basement across the majority of the site. The basement was inaccessible during the walkover survey thus its extent could not be clarified. The ground underfoot was noted to be hardstanding, with some grassed areas along the eastern and southern site boundaries.



Figure 2: Photographs of the outer site section looking towards the north (left) and inside (right) section, facing south-west.

Services were noted to be present across the site, including numerous manholes enabling access to water networks. A sub-station for electric installations was noted in the southern site section along the southern station wall.



Figure 3: Photograph showing the service access points for water across the site, in the central site section (left) and along the southern boundary (right), with the electricity sub-station visible above the manhole (red).

Slopes

Relatively steep slopes were noted during the site walkover along the northern, western and eastern site boundaries, with these being steep downward slopes of the approximate gradients of 1:1 to 1:2.5 from 79.70m AOD to 77.10m AOD, and a very gentle upward slope along the eastern site boundary, with a gradient of approx. 1:3 from 81.00m AOD to 85.00m AOD. The slopes appear to be predating the construction of the fire station and are anticipated to be associated with the construction of Rochdale Road to the west.



Figure 4: Photographs showing the steep western slope along the western site boundary with the basement wall, looking north, with a pedestrian bridge across the slope (left) and a gentle slope along the southern site boundary, looking west (right).

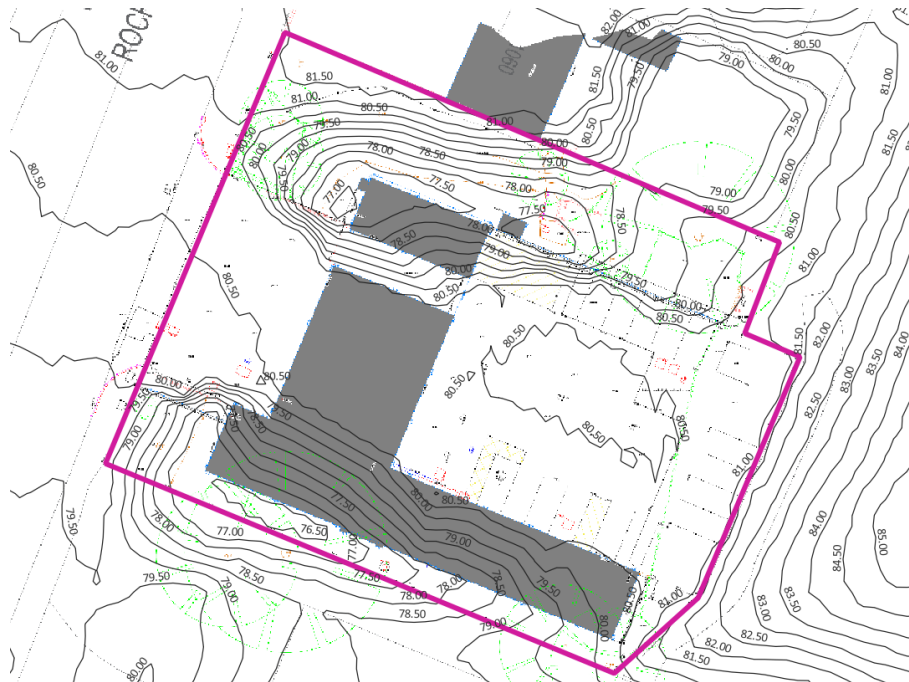


Figure 5: Extract of LiDAR imagery with the steep 1:1 and 1:2.1 slopes along the western site boundary to the east of Rochdale Road, as well as gentle 1:3.1 slopes along the eastern boundary.

Contamination

No evidence of contamination (i.e. spillages or leakages) were identified, however, potential contaminative sources have been noted on-site, with AdBlue drums and cleaning supplies noted during the site walkover in the central site section. A training yard is present in the north-eastern site corner, where disused vehicles are used for firefighter training, potentially being a source of contamination on-site.



Figure 6: Photographs showing AdBlue drum (left) and a storage room containing various cleaning supplies (right), found in the central site section.

3.3 Site History

The site development history has been researched by reference to historical maps, street plans and aerial photographs. The historical maps are included in Appendix 4 to this report and the principal observations which are divided into on-site history and off-site history are summarised below:

On-Site History

Date	Site Feature
1848 – 1909	On the earliest historical map, the site is recorded as a field to the east of Rochdale Road. Slopes are recorded along the western site boundary from the year 1893 along Rochdale Road, anticipated to be associated with the construction of Rochdale Road.
1909 – 1967	The slope along Rochdale Road is now recorded to extend further towards the site area, and a new residential neighbourhood is now recorded to the north of the site.

1967 – 2022	A fire station is now recorded on-site, with further residential developments and a Club to the east and south of the site. The site appears relatively unchanged since.
-------------	--



Figure 7: Extracts of the OS historical maps dated 1893, 1922, 1963-67 and 2003 from left to right, top to bottom

Off Site History

Date	Site Feature	Distance (m)	Direction
1893 – 1977	A Sand Pit is recorded from 1893, no longer present in 1977.	150	S
1893 – 1985	A Pond is recorded from 1893, by 1932 a second Pond is also recorded on the historical maps, both no longer recorded by 1985.	250, 300	SE, SW
1848 – 1985	Numerous Reservoirs are recorded to the south and south-west from site, some associated with nearby industrial buildings, all disused and no longer present from 1985.	250 – 650	S - SW
1848 – 1985	Bleach Works are recorded to the south-west of the site, are referred to as Lion Field Works by 1891 and are then recorded as disused by 1909, the works are then called Pickle Works by 1922, lastly, they are recorded as Works from 1977, and finally the works are no longer recorded from 1985.	300	SW
1915 – 1968	A Sand Pit is noted to the west from site, no longer recorded by 1968	300	W
1907 – 1933	A Rope Walk is recorded to the north-west from site, no longer present by 1933.	350	NW
1933 - 2022	Allotment Gardens are recorded to the west of the site from the year 1933.	450	W

1985 – 2001	Works are first recorded in 1985, no longer present on the records by 2001.	500	SW
1891 – 1938	Blackley Steel Works are recorded from 1891, an additional building called Engraving Works next to it from 1907, the Steel Works are no longer recorded by 1915, and the Engraving Works are no longer present by 1938.	550	SW
1907 – 2010	The Booth Hall Infirmary is recorded to the south-east from site, referred to as Booth Hall Children's Hospital in 1933, Booth Hall Hospital by 1956, Hospital from 1988, no longer present by 2010.	600	SE
1891 – 1933	The Lion Mills are recorded, later referred to as Mills from 1915, no longer recorded as such from 1933.	600	SW
1848 – 1891	Print Works are recorded to the south west from the site, no longer present by 1891.	750	SW
1915 – 2001	Central Mills are noted on the historical maps to the south-west of the site, these are referred to as Works from 1968 and as Mill by 1988, no longer recorded by 2001.	750	SW

3.4 Geology

3.4.1 BGS Geological Map

The BGS 1:50,000 Solid and Drift Geological Maps of the area (Sheet No: 85, both dated 2011) indicate that the site is underlain by superficial deposits comprising **Glacial Till** which typically comprises a heterogenous mixture of clays, sands and gravels. The superficial deposits are underlain by bedrock of the **Chester Pebble Beds Formation**, comprising sandstone. It should be noted that Glaciofluvial Deposits, typically comprising sand and gravel, are recorded in close proximity to the southern site boundary and therefore may be present on-site.



Figure 8: Extracts of the BGS 1:50,000 Drift (left) and Solid (right) Geological Maps. Light blue = Glacial Till, Pink = Glaciofluvial Deposits, Grey = Chester Pebble Beds Formation, Light Orange = Collyhurst Sandstone Formation, Orange = Manchester Marls Formation.

The BGS geological maps record Made Ground along the western boundary (dark purple on the below extract), anticipated to be associated with the construction of the Rochdale Road to the west of the site and possible on-site level adjustments.



Figure 9: Extract showing the location of the Made Ground (Dark purple).

The solid geological map indicates that a fault is recorded within 188m south of the site, downthrowing to the north. No bedrock dips are recorded, however based on the younging direction of the bedrock, the bedrock is anticipated to be dipping to the south.

3.4.2 BGS Borehole Logs

There were no available BGS boreholes on-site. There were 3 No. BGS boreholes available in close proximity to the site within a comparable geological setting. The pertinent information from the borehole logs is outlined below:

BGS Borehole Reference: SD80SE1003-1005

These boreholes are located approximately c.137m – 169m north-east, east and south-east of the site and were excavated to depths of between 7.32m and 24.69m bgl at in December 1963. The logs recorded the following pertinent information:

- **Topsoil** to a depth of 0.15m to 0.61m bgl, underlain by;

- **Glacial Till** comprising brown, silty, slightly clayey sand with occasional laminations of sandy silt, and stiff, brown, laminated, sandy clay to a depth of between 7.32m and 24.69m bgl.

3.4.3 BGS Geohazards

Data Type	Details
Ground Stability Data	➤ The Potential for Shrinking or Swelling Clay Ground Stability Hazards is regarded as very low. ➤ The Potential for Landslide Ground Stability Hazards is regarded as very low to low. ➤ The Potential for Dissolution Ground Stability Hazards is regarded as negligible. ➤ The Potential for Compressible Ground Stability Hazards is regarded as negligible. ➤ The Potential for Collapsible Ground Stability Hazards is regarded as very low. ➤ The Potential for Running Sand Ground Stability Hazards is regarded as very low.

3.4.4 BGS Estimated Soil Chemistry

The BGS have estimated that the superficial deposits across the site to naturally comprise the following determinands:

- Arsenic – 15mg/kg – 25mg/kg
- Cadmium – 1.8mg/kg
- Chromium – 60mg/kg – 90mg/kg
- Nickel – 15mg/kg – 45mg/kg
- Lead – 100mg/kg
- Bioaccessible Lead – 60mg/kg

3.5 Mining

3.5.1 Coal Mining

The site lies within a Coal Authority Coal Mining Reporting Area, however a Development High Risk Area is not recorded on-site, nor is it located in the vicinity of mine entries or coal outcrops. The nearest coal outcrop and associated Development High Risk Area is located 1000m to the east of the site, the nearest mine entry is situated 1200m to the north-east of the site.

3.5.2 Non-Coal Mining

The Groundsure Enviro + Geo Insight report (contained in Appendix 5) indicates that no non-coal mining activities have been recorded on-site or within 1000m from site.

3.5.3 Salt Mining / Brine Extraction

The site does not lie within the Cheshire Brine Subsidence Compensation Board Compensation District or a Consultation Area.

3.5.4 Historical Surface Excavations

A single historical activity involving excavations is recorded on-site on the historical maps. The BGS maps record worked ground on-site in the year 1906, however the nature of these works is unspecified. It is anticipated that these works were associated with significant site level changes, including the construction of Rochdale Road. Numerous Ponds and Sand Pits were recorded in the vicinity of the site (c. 250-600m E, S and SW). Consequently, the presence of unrecorded historical excavations on-site cannot be discounted.

3.5.5 Mineral Safeguarding

Where mineral resources are present the mineral planning authority may designate areas as Mineral Safeguarding Areas (MSA) and Mineral Consultation Areas (MCA). These are aimed to safeguard mineral resource areas from unnecessary sterilization by non-mineral development. The BGS Mineral Resources maps designate the areas of potential mineral resources and where active / lapsed planning permission was granted for mineral extraction.

The BGS Mineral Resources Map for Greater Manchester and Greater Manchester Joint Minerals Plan Mineral Safeguarding Map indicates that the site does not lie within an area designated as containing mineral resources, however, there are shallow coal resources recorded on-site on the Greater Manchester Joint Minerals Plan Mineral Safeguarding Map. The BGS Mineral Resources Map for Greater Manchester and Greater Manchester Joint Minerals Plan Mineral Safeguarding Map are included in Appendix 6.

3.6 Hydrology and Hydrogeology

Environmental data relevant to the site and its immediately surrounding area has been obtained from sources available in the public domain. In addition, an environmental report was obtained from Groundsure. The Enviro + Geo Insight report and associated maps that have been inspected are presented in Appendix 5 and the principal observations in relation to waters and flooding can be summarised as follows:

Data Type	Details
Flooding	➤ With respect to rivers and seas, the site lies within Flood Zone 1. ➤ Localised areas of the site, primarily in the northern site section, are recorded to be susceptible to surface water flooding, the highest risk being a 1 in 250 year event with a floodwater depth of greater than 1.0m. ➤ With respect to groundwater flooding, the highest risk on-site recorded as Low.
Surface Water Features	➤ There are no surface water features recorded on-site. ➤ A small unnamed stream is present 175m south of the site.
Surface Water Abstractions	➤ There are no licensed surface water abstractions located on-site or within 2km of the site.
Superficial Aquifer	➤ The site is underlain by superficial deposits classified as a Secondary Undifferentiated Aquifer.
Bedrock Aquifer	➤ The underlying bedrock is classified as a Principal Aquifer - <i>Geology of high intergranular and/or fracture permeability, usually providing a high level of water storage and may support water supply/river base flow on a strategic scale.</i>
Groundwater Abstractions	➤ There are no recorded groundwater abstraction licenses located on-site. ➤ There are 8 No. groundwater abstraction licenses located within 2km of the site, the majority are historical. The nearest active groundwater abstraction is located 1217m west of the site and pertains to abstraction from a borehole at British Cables Company Limited, Blackley for general cooling.
Source Protection Zones	➤ There are no recorded Source Protection Zones recorded on-site or within 500m of the site.
Nitrate Vulnerable Zones	➤ There is a single Nitrate Vulnerable Zone recorded on-site pertaining to the River Irk. ➤ There is a further Nitrate Vulnerable Zone recorded within 2000m from site, located 1936m west from site, also pertaining to the River Irk.
Licensed Discharge Consents	➤ There are no recorded licensed discharge consents to controlled waters located on-site or within 500m of the site.
Pollution Incidents to Controlled Waters	➤ There are no recorded pollution incidents to controlled waters located on-site. ➤ There are 4 No. pollution incidents recorded within 500m of the site, all pertaining to an incident in June 2001 involving tyres, general biodegradable materials and waste, and commercial waste, located within 472m south-west of the site. The incidents were recorded as a Category 4 (No Impact) incident to controlled waters.

3.7 Hazardous Installations, Landfill and Waste

The following information relating to hazardous installations, landfill and waste obtained from the Groundsure Enviro + Geo Insight report, published information and the walkover survey can be summarised as follows:

Data Type	Details
Environment Agency Recorded Active Landfill Sites	➤ There are no Environment Agency recorded landfill sites located on-site or within 500m of the site.
Environment Agency Recorded Historic Landfill Sites	➤ There are no Environment Agency recorded historical landfill sites located on-site. ➤ There is a single Environmental Agency recorded historical landfill site within 500m of the site, located 55m south of the site off White Moss Road, Blackley. No information pertaining to the landfill operation dates or type of waste is available for either landfill. From historical records the approximate dated for the landfill activity are from 1891 to 1977, based on evidence for the occurrence of sand pits. 
BGS Recorded Historic Landfill Sites	➤ There are no BGS recorded landfill sites located on-site or within 500m of the site.
Local Authority Recorded Landfill Sites	➤ There are no Local Authority recorded landfill sites located on-site. ➤ 6 No. refuse heaps were recorded 286m and 310m north-west of the site on the 1962 and 1964 historical maps respectively.
Local Authority Pollution Prevention and Control (Part A(2) and Part B Activities and Enforcements)	➤ There are no Local Authority Part A2 or Part B Activities or Enforcements located on-site. ➤ There is a single Local Authority Part A2 or Part B Activity located within 500m of the site, pertaining to a current Part B permit for unloading of petrol into storage at service stations, located 316m south west of the site.
Registered Radioactive Substances	➤ There are no Registered Radioactive Substances recorded on-site or within 500m of the site.
Registered Waste Treatment, Transfer or Disposal Sites	➤ There are no waste exemptions recorded on-site. ➤ There are 2 No. historical waste sites recorded within 500m from site, both pertaining to refuse pits, the closest located within 201m south of the site in 1932.

Industrial Land Use	➤ There is a single current industrial land use on-site, pertaining to the Blackley Fire Station. ➤ There are 3 No. recent industrial uses recorded within 500m of the site, the nearest is located 93m north-west and pertains to an electricity substation. ➤ There is a single petrol / fuel station recorded within 500m of the site, located 310m south-west. ➤ There are 2 No. historic industrial site uses recorded on-site pertaining to unspecified ground workings and a fire station. ➤ There are an additional 75 No. historic industrial land-uses recorded within 500m of the site including unspecified ground workings, sand pits, refuse heaps, field works, unspecified works, cemetery, mortuary, brick kiln, bleach works, rope walk, cuttings, hospital, infirmary, engraving works, unspecified mills, unspecified tank and more.
Dangerous Substances	➤ There are no recorded discharges of dangerous substances on-site or within 500m of the site.
Hazardous Building Materials	➤ Asbestos associated with the Fire Station building could be encountered on-site.

3.8 Radon

The Indicative Atlas of Radon in England and Wales produced by the Health Protection Agency and British Geological Survey indicates the site lies within a lower probability area as less than 1% of homes are above the action level. Consequently, BR211 (2015) indicates that no radon protection measures are required.

3.9 Services

BT Comms as well as multiple manholes were recorded on-site during the walkover survey. Based on the current site use, it is anticipated that extensive service coverage will be present on-site. Full service plans and a GPR scan should be obtained prior to any intrusive works.

3.10 Unexploded Ordnance (UXO)

The Zetica UXO risk map, contained in Appendix 7, indicates that the site lies within an area of moderate risk. A Stage 1 Preliminary UXO Risk Assessment has been obtained. Based upon a review of the assessment, a further Stage 2 Detailed Risk Assessment is not deemed necessary.

The Zetica UXO Risk map and the Stage 1 Preliminary UXO Risk Assessment is included within Appendix 7.

3.11 Animal Burial Sites

The Animal Health and Veterinary Laboratories Agency (AHVLA) no longer routinely respond to consultations relating to records of animal burial sites. Based upon a review of the site history it is considered unlikely that the site has been subject to recorded animal burials.

3.12 Archaeology

We do not anticipate that the site will be affected by archaeological issues, however consultation with the county archaeologist is recommended.

4.0 CONCLUSIONS

4.1 General

The site is an active fire station with various facilities, including crew accommodation, offices, appliance storage and car parking, historically comprising a field with slopes associated with the construction of Rochdale Road. The site is surrounded by steep slopes, most prominent in the western site section.

4.2 Ground Conditions

The anticipated typical ground conditions across the site are as follows:

- **Made Ground** to an unknown depth, anticipated to be deep in places due to the presence of steep slopes mainly along the western site boundary, underlain by;
- **Glacial Till** comprising firm to stiff, dark brown, sandy clay with thin laminations of brown, silty, slightly clayey sand and sandy silt to a depth of between 7.32m and 24.69m bgl, underlain by;
- **Chester Pebble Beds Formation** comprising sandstone.

4.2.1 Geotechnical Hazard Identification

Potential geotechnical hazards based on the expected ground conditions that may require further consideration at the site are outlined below:

Factors	Remarks	Considerations	Risk
On-Site Made Ground	Widespread Made Ground is anticipated on-site, as well as the nearby BGS records noting an area of Made Ground off-site. Deep Made Ground is possible along the western site boundary associated with the construction of Rochdale Road.	Made Ground may settle variably, have highly inconsistent bearing capacity and may suffer significant movements that may be problematic for foundations, externals and infrastructure elements without treatment. The presence of Made Ground may be problematic for foundations as there may be loose / soft spots within the Made Ground and it may not be suitable to utilise traditional foundations.	Low to Moderate

Aggressive Ground and Groundwater	While the risk posed from the natural strata is anticipated to be very low, given the anticipated presence of Made Ground and associated hotspots there is potential for aggressive ground conditions to be present on-site, however, the risk remains low.	Acidic ground / groundwater and sulfate may attack the concrete and steel used in foundations and react with aggregates. The oxidation of pyrite and other sulfides can also occur due to geotechnical activities. This can lead to the generation of high concentrations of sulfate and low pH that attacks construction materials and may lead to the precipitation of gypsum resulting in the heave of foundations and floor slabs. Pyrite oxidation can also be triggered by mixing susceptible materials with lime or cement resulting in high pH that can lead to the expansion of some sulfates that cause heave of stabilised soils.	Low to Moderate
Shrink and Swell Clays	Established trees are present along the site boundaries. Moderate to high plasticity and low to moderate volume change potential Glacial Till deposits are present at shallow depth.	Some types of ground (e.g., clay soils) can change volume due to changes in moisture content that may be induced by weather variations (e.g., drought), vegetation (e.g., growth or removal of trees) or man-made activities (e.g., changes to local drainage). This shrink / swell behaviour typically causes ground movement to a depth of approx. 3m potentially damaging building foundations, externals, pipes or services by differential movements.	Low to Moderate
Slope Stability	Steep slopes are present along site boundaries. The slopes are most prominent along the western site boundary, possibly associated with the construction of Rochdale Road. The slope gradients are between 1:1 and 1:2.1 (approx. 2.00 - 2.60m tall) in the western site section, and 1:3.1 (approx. 4m tall) along the eastern boundary, where they become gentler.	A relatively rapid outward and downward movement of a mass of rock or soil on a slope due to the force of gravity. Typically slope instability is caused by either a decrease in soil strength or an increase in shear stress. Numerous factors are involved but usually loading on or at the crest of the slope, increasing the amount of water entering the slope or cutting at the toe of the slope cause failure. Damage by landslide can occur through the removal of supporting ground from under structures, externals or services or by the movement of material onto property.	Moderate to High
Obstructions (including the basement)	Obstructions associated with the current and historical site buildings may be present on-site.	May act as obstructions to excavations and / or the chosen foundation solution or act as 'hard spots' within the ground if left in-situ.	Low to Moderate

4.3 Sources of Contamination and Probable Contaminants

Based on the desk study information the following potentially contaminative on-site sources have been identified:

Potentially Contaminative Source	Associated Determinands	Remarks	Hazard
On-Site Made Ground	Unknown, anticipated to be metals, semi-metals, PAHs, TPH, asbestos. Ground Gas – carbon dioxide, methane, hydrogen sulfide, VOCs	Widespread Made Ground of unknown composition is expected on-site. Potentially deep in places, e.g. associated with the construction of the basement of the fire station and along the western site boundary along Rochdale Road. Contaminative hotspots possible within the Made Ground associated with historical and current site uses.	Moderate
On-Site Existing Fire Station	Wide range of determinands, including metals, semi-metals, PAHs, TPH, asbestos, and possible firefighting foams, including PFOS, PFOA, fluorinated hydrocarbons, surfactants.	AdBlue drums, a training yard and an electricity sub-station are also present on-site, therefore contaminative hotspots may be present.	Moderate
Historical and Existing Off-Site Industrial Uses	Unknown, anticipated to be metals, semi-metals, PAHs, TPH, asbestos.	Numerous mills (largely unspecified), steel and engraving works, and a hospital have been present within 300-750m of the site since the mid to late 19 th century.	Low
Off-Site Reservoirs (250-650m S-SW, 1848-1985)	Ground Gas – carbon dioxide, methane, hydrogen sulfide, VOCs	Historical reservoirs were present c. 250-650m to the south and south-west of the site, associated with off-site mills and solitary reservoirs. Although unknown, it is anticipated that these reservoirs were infilled following the development of the area and the subsequent lack of historical evidence for the existence of reservoirs after the year 1985.	Low
Historical Landfill (1891-1977, 55m S)	Ground Gas – carbon dioxide, methane, hydrogen sulfide, VOCs	A historical landfill was present 55m south of the site between approx. 1891 and 1977. Based on historical map records and the occurrence of sand pits, the approximate infill date is the year 1977. Due to the proximity to site and relatively recent anticipated infill date, the historical landfill poses a significant ground gas risk to the site,	Moderate to High

It should be noted that potentially contaminative unrecorded historic activities may have occurred (e.g. the use or deposition of Made Ground from off-site during historic on-site developments) and in this event, further contaminative sources may be present.

Fire Fighting Foam (PFAS)

Anecdotal evidence from the station suggests that firefighting foam has never been used or stored on site. It has been communicated to IGE that training with foam only

took place at designated stations where fighting foam was stored in tanks and that Blackley Fire Station was not one of these.

4.3.1 Unknowns

Following the desk study, the areas of uncertainty are summarised as follows:

- Depth to bedrock
- Depth and composition of the anticipated widespread on-site Made Ground
- Levels of groundwater across the site
- Extent and condition of basement on site
- Condition of slopes at site boundaries

4.4 **Pathways for Contamination**

4.4.1 Human Health

The pathways along which contamination could potentially reach the receptors on-site during use and after completion of development works are detailed in 'Updated Technical Background to the CLEA Model' (Environment Agency 2009) but can be summarised as follows:

End Users (Residential Land Use Scenario):

- Ingestion of soil directly and indoor dust* including on home-grown produce;
- Inhalation of soil dust (indoor and outdoor);
- Dermal contact with soil (indoor and outdoor);
- Inhalation of soil vapours (indoor and outdoor);
- Oral background;
- Inhalation background.

** Treated as one pathway*

4.4.2 Controlled Waters

The pathways along which contamination could potentially reach the controlled waters receptors during use and after completion of development works are as follows:

- Vertical migration along current and / or future foundations and pooling at base / beneath foundations.
- Vertical migration through possible granular Made Ground and granular lenses in natural cohesive deposits.
- Lateral migration along low permeability natural deposits and pooling at relative low points.
- Negligible infiltration through low-permeability natural cohesive deposits.
- Migration through porous sandstone bedrock.
- Migration along groundwater flow.
- Overland flow

4.4.3 Ground Gas Pathways

The pathways along which ground gas could potentially reach the receptors on-site during use and after completion of the development works are as follows;

- Migration through fractures and fissures in bedrock
- Preferential migration along foundations, service ducts / trenches
- Migration within groundwater
- Ingress through wall cavities and floors and accumulation
- Inhalation of ground gas and vapours

4.5 **Receptors of Contamination**

Human Health receptors for these pathways include the following:

- End Users (commercial land use scenario)
- Construction workers.
- The general public and adjacent site users.

Controlled waters receptors for these pathways include the following:

- Groundwater contained within the underlying Secondary Undifferentiated Aquifer in superficial deposits and Principal Aquifer in bedrock.
- Surface Water – unnamed stream 175m south of the site.

Other receptors for these pathways include the following:

- Subsurface plastic (e.g. potable plastic water pipe).
- Building fabric (e.g. concrete foundations, etc.)

4.6 Conceptual Model

4.6.1 Conceptual Model for Human Health Assessment

A site conceptual model in the form of a linkage table for the purposes of a preliminary risk assessment for the human health of site occupants has been produced as a result of the probable contaminants, pathways and receptors identified above.

Sources of Contamination	Pathway	Receptor	Hazard (severity)	Likelihood	Risk
On-Site Made Ground On-Site Blackley Fire Station Off-Site Historical and Current Industrial Site Uses	Ingestion of contaminated soil and dust (indoor and outdoor)	End users and general public	Effect on human health (Medium)	Likely: Widespread Made Ground is anticipated on-site, with potential hotspots of contamination also possible to be found, in association with the site being used as a fire station, specifically in the training yard in the north-eastern site corner, as well as a training yard, AdBlue and cleaning supply storage areas. Whilst anecdotal evidence suggests that the storage and use of firefighting foam potentially containing PFAS did not take place at the site, it cannot be completely discounted. Dermal, ingestion and inhalation pathways will be negated across the majority of the site due to the presence of hardstanding and soft landscaping will be limited on-site, however, areas of soft landscaping at increased risk.	Low to Moderate
	Dermal contact with contaminated soil (outdoor and indoor)				
	Inhalation of contaminated dust (indoor and outdoor)	Construction workers		Likely: Construction workers will be at increased risk due to their acute interaction with soils, and based on the contaminative linkages identified, the risk was deemed to be low to moderate. The appropriate use of PPE, Good Practice and Health and Safety Measures may help significantly reduce the risk.	Low to Moderate
	Inhalation of soil vapours (indoors and outdoors)	End users and general public		Low Likelihood: No widespread potential sources of VOCs (including PFAS) have been identified. If localised contaminative hotspots of VOCs are present (i.e. from possible spillage from hydrocarbon spirit storage or diesel tank), given their relative mobility and volatility, VOCs are unlikely to remain at significant concentrations.	Low to Moderate
		Construction workers		Likely: Construction workers at increased risk if any disturbance of soil occurs as this may generate a temporary increase in the release of soil vapours, however risk remains low to moderate given the nature of the concentration and mobility of VOCs.	Low to Moderate

A diagram of the conceptual site model is contained within Appendix 2.

4.6.2 Conceptual Model for Ground Gas Risk Assessment

A conceptual model in the form of a linkage table for the purposes of a preliminary risk assessment for ground gas has been produced as a result of the probable contaminants, pathways and targets identified above as follows:

Source	Pollutant	Pathway	Receptor	Hazard (severity)	Likelihood of Occurrence	Risk
On-Site Made Ground	Methane Carbon Dioxide Hydrogen Sulfide	Preferential migration along foundations, service ducts / trenches	Human occupants Site Workers	Effect on human health (Mild to Severe*)	Likely: Widespread Made Ground deposits are anticipated on-site, along with potential contaminative hotspots associated with the current site use. Consequently, the Made Ground is anticipated to be a low to moderate ground gas generation source, as it is unlikely to contain much organic rich or putrescible deposits and possibly of limited thickness in locations other than the western site boundary.	Low to Moderate
Off-Site Historical Landfill (1891-1977, 55m S)		Ingress through wall cavities and floors and accumulation Inhalation of ground gas	Building and Structures	Damage to building (Mild)	Likely: A historical landfill was located 55m south of the site, possibly infilled by 1977. Due to significant distance from site and lack of feasible contaminative pathways due to the underlying ground conditions, the risk is deemed moderate.	Moderate

*Due to the risk of explosion.

A diagram of the conceptual site model is included within Appendix 2.

4.6.3 Conceptual Model for Waters Risk Assessment

A site conceptual model in the form of a linkage table for the purposes of a preliminary risk assessment for pollution of waters has been produced as a result of the probable contaminants, pathways and targets identified above as follows:

Source	Pathway	Receptor	Hazard (severity)	Likelihood of Occurrence	Risk
On-Site Made Ground	Vertical migration along current and future foundations	Groundwater within the Secondary Undifferentiated and Principal Aquifers	Effects to controlled waters (Mild)	Pre-Development Site Low Likelihood: Potential sources of contamination have been identified on-site. Widespread Made Ground is anticipated due to the site uses. The anticipated presence of cohesive Glacial Till (c. 27m) will negate any vertical migration into the underlying aquifers, however granular lenses could be present. The site mostly comprises hardstanding with associated drainage, with all potential contaminative sources located above hardstanding. Consequently, the vertical migration will be further reduced as there would be no water infiltration to facilitate vertical migration.	Low
	Vertical migration through granular Made Ground and / or natural deposits			Whilst the use of fire-fighting foam is considered unlikely at the site, any historical use could lead to the presence of PFAS across the site. If present, higher concentrations may be recorded within drainage runs, joints in concrete slabs and manhole sumps. Given that anecdotal evidence suggests no known use, any concentrations noted are likely to be residual.	
	Negligible infiltration through low permeability cohesive deposits			Post Development Site Low Likelihood: Following development the site will remain largely covered with hardstanding with the small exception of rare soft landscaping along the site boundaries. Therefore infiltration and vertical migration of any potential contaminative sources will be reduced.	
On-Site Blackley Fire Station	Migration through porous bedrock				Low
Off-Site Historical and Current Industrial uses	Lateral migration along low permeability cohesive deposits	Surface water courses (Unnamed Stream 175m south from site)	Effects to controlled waters: (Mild)	Pre-Development Site: Low Likelihood: Lateral migration of contaminants is considered likely given there are potentially contaminative sources identified on-site and adjacent. The presence of cohesive Glacial Till at shallow depths may facilitate lateral migration, and although depth to groundwater is unknown, the risk remains low due to the presence of hardstanding and distance to the nearest surface water feature (stream)	Low
	Lateral migration along historic drainage				
	Migration along groundwater flow			Post Development Site: Low Likelihood: The site is currently mostly covered with hardstanding and will remain so following development. However contaminative sources are present. Due to the presence of hardstanding and on-site drainage, lack of evidence of shallow groundwater to facilitate lateral migration, significant distance to the nearest surface water feature (175m), water infiltration and migration will be reduced.	

	Overland flow	Surface water courses (Unnamed Stream 175m S)	Effects to controlled waters: (Mild)	Low Likelihood: A surface water feature is located near the southern boundary of the site, however it is at a significant enough distance from site (175m) to not be considered part of a contaminative linkage. The overland flow is considered likely as hardstanding is currently widely present on-site that will help facilitate overland flow, however due to the presence of on-site drainage associated with the fire station, the risk is considered low.	Low
--	---------------	---	--------------------------------------	--	-----

A diagram of the conceptual site model is included within Appendix 2.

4.7 Preliminary Risk Assessment Summary

Human Health

Based on the human health conceptual model the risk to human health is deemed low to moderate to end users and construction workers as feasible contaminative linkages have been identified in areas. Although the risk to construction workers is increased due to their acute interaction with site soils, it is envisaged that with appropriate PPE and site management, risks to construction workers can be mitigated therefore the risk remains low to moderate.

Ground Gas

Ground gas sources have been identified on-site and off-site. Consequently, the ground gas risk for the site was assessed to be low to moderate. Therefore undertaking ground gas monitoring is recommended, including 6 visits over 3 months.

If any organic rich Made Ground deposits are identified or if previously unrecorded potential ground gas sources are recorded during the ground investigation works, then ground gas monitoring may be required. The length and frequency of the ground gas monitoring regime and the sampling method, initial results and alterations to the conceptual model are subject to the findings of the ground investigation works and development constraints (i.e. development timescales and liaison with the local authority).

Controlled Waters

Although sensitive receptors have been identified on-site (Secondary Undifferentiated and Principal Aquifers), no feasible pathways for contamination exist

on-site due to anticipated deep cohesive Glacial Till and significant distance to the nearest surface water feature, therefore the risk to controlled waters is deemed low.

If unrecorded contaminative sources are noted, the above conceptual models may require re-assessment / re-appraisal.

4.8 Scope of Phase 2 Intrusive Geo-Environmental Ground Investigation

As a result of the preliminary risk assessment a Phase 2 intrusive geo-environmental ground investigation should be carried out to quantify the identified risks. This intrusive ground investigation works should include the collection of appropriate samples – solid, leachate and / or liquid, if deemed necessary, across the site for appropriate chemical testing as detailed above.

Furthermore, to determine the geotechnical and geological properties of the underlying ground conditions, appropriate intrusive works and associated testing should be undertaken. The rationale and aims for these Phase 2 environmental, geotechnical and geological investigative works are detailed below.

In order to provide adequate assessment in terms of both environmental and geotechnical site parameters, ground investigation works will be required on a spatial basis and targeting any potential contaminative hotspots associated with the current fire station.

The proposed initial ground investigation works are subject to confirmation with the designer for the scheme, but it is recommended that the works should comprise at least the following:

- Dynamic Sampling Boreholes or Trial Pits
- Cable Percussive Boreholes
- Installation of gas and groundwater monitoring wells

The rationale for the exploratory holes is discussed below:

- To allow the collection of samples from the Made Ground and natural deposits for chemical laboratory testing (solid samples) for an appropriate suite of determinands and for soluble sulfate (2:1 extract) and / or total sulfate and pH testing to determine the suitable concrete classification in associated with relevant guidance e.g. BRE Special Digest 1.
- To determine the extent, composition and depth of any Made Ground deposits.
- To determine the nature, thickness and extent of superficial deposits.
- Enable in-situ and ex-situ geotechnical testing, including density testing (SPTs), hand shear vane (HSV) testing and undrained shear strengths of the underlying Made Ground and natural deposits for the purposes of sub-structure design;
- To allow installation of ground gas monitoring wells.

Based on the findings of the initial ground investigation works, further works may be required for detail design including CBR determinations and infiltration (soakaway) testing.

4.8.1 Scope of further works – PFAS

Anecdotal evidence suggests that firefighting foam has never been used or stored at the site. However, this cannot be confirmed.

The controlled waters conceptual model for the site indicates a significant thickness of Glacial Till beneath the site. This is classified as a Secondary (undifferentiated) Aquifer and is anticipated to be broadly cohesive in nature and to act as a barrier to any lateral and vertical migration of contaminants. Any bands of granular strata which may be present within the Glacial Till are anticipated to not be laterally continuous nor in hydraulic connectivity with the above Made Ground.

Upon consideration of the low likelihood of the historical use of fire fighting foam and the conceptual site model for controlled waters, it is assessed that the risk of potential PFAS compounds reaching sensitive receptors, especially the Principal Aquifer within the bedrock, is low.

In order to confirm the classification of the site as a **low level risk**, it is recommended that a baseline survey be conducted involving the collection and testing of samples for the presence of PFAS compounds. These samples should be taken from the material directly below the concrete slab i.e. sub-base materials, with exploratory hole locations chosen in areas beneath clearly visible joints or cracks within the concrete i.e. high risk pathways through the concrete slab.

Sampling will also include for a 'site blank' i.e. sample of site superstructure to give a background concentration and a laboratory blank. It is not proposed to test either the overlying concrete or any deeper material (either Made Ground or natural deposits) unless significant concentrations are recorded within the initial round of testing on the sub-base. The testing should be in-line with specification from a laboratory with MCERTS accreditation in line with Environment Agency standards.

It is assessed that if PFAS compounds are present within the sub-base material, they will be present within the overlying concrete slab. It is currently proposed to process and re-use the concrete on site as a site-won aggregate. The presence of PFAS compounds does not preclude this, though it may restrict the use of this material to within unsaturated zones.

Further testing on concrete, deeper Made Ground and natural deposits may also be necessary if significant concentrations of PFAS are recorded on the sub-base material. Following discussion with MCERTS accredited laboratory sampling methods / techniques supplied will be adhered to mitigate risk of acute cross contamination.

It is recommended that the above strategy is confirmed to be acceptable by the Environment Agency before it is undertaken.

5.0 RECOMMENDATIONS

- 5.1 As a result of the information gathered and the risks identified in this report, there is a low to moderate risk to human health on the basis that feasible contaminative linkages have been identified for end users and construction workers in localised areas. The risk to controlled waters is deemed low given the possibility of significant contaminative linkages and viable contamination sources.
- 5.2 A low to moderate ground gas risk has been identified based on ground gas sources and feasible pathways for ground gas migration. Ground gas monitoring is recommended, including 6 visits over 3 months. On the basis that the site lies within an area where between less than 1% of homes are above the action level no radon protection measures are necessary.
- 5.3 Due to geotechnical requirements, ground investigation works should be undertaken in order to determine the ground conditions with a greater degree of certainty and allow design of the proposed development, drainage, services and immediate external areas to be undertaken. It is therefore recommended that exploratory holes are constructed where access is permitted across the site. The use of soakaways is unlikely to be suitable given the presence of low-permeability shallow Glacial Till across the site.
- 5.4 From the results of the Phase 2 ground investigation work – if this report identifies a potential risk and / or a requirement for further detailed site-specific assessment, a Phase 3 environmental investigation report and / or a Remedial Strategy (informing on potential remediation solutions) may be required.
- 5.5 The nature and extent of the proposed targeted chemical and environmental testing should be confirmed, if time / commercial constraints allow, with the relevant Local Authority Environmental Health Officer and the Environment Agency prior to undertaking works on-site. Proceeding without agreement between regulatory authorities may result in further assessment being required.

-
- 5.6 It should be noted that, if any visual or olfactory evidence of contamination is encountered during remediation or construction work, then the Local Authority Environmental Health Officer and Environment Agency should be contacted immediately in order to agree any necessary remediation measures.
- 5.7 Given the possibility of services on-site, full service plans and a GPR survey should be obtained prior to any intrusive ground investigation works.
- 5.8 Due to the presence of established trees along site boundaries and the presence of cohesive deposits, an arboricultural survey is recommended.
- 5.9 It is recommended that a slope stability assessment is undertaken along the site boundaries to ensure safety for the site redevelopment following demolition.
- 5.10 The further works to identify the risk from PFAS at the site as detailed in §4.8.1 should be completed, including liaison with the Environment Agency.