



**Raise Rochdale PRU
Mayfield Street
Rochdale
OL16 2UZ**

Desk Study &
Ground Investigation



March 2026

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Rev 2





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Executive summary

This executive summary contains an overview of the key findings and conclusions. No reliance should be placed on any part of the executive summary until the whole of the report has been read. Other sections of the report may contain information that puts into context the findings that are summarised in the executive summary.

Brief

This report describes the findings of a site investigation carried out by Geotechnical and Environmental Associates Limited (GEA) on the instructions of Adept Civil and Structural Consulting Engineers, on behalf of Rochdale Borough Council, with respect to the redevelopment of the site through the construction of a SEN school, with a one, two and three storey split level building and associated parking, play space and landscaping.. The purpose of the investigation has been to research the history of the site with respect to possible contaminative uses, to determine the ground conditions, provide an indication of the presence of contamination and to provide information to assist with the design of shallow and deep foundations.

Site history

The earliest map studied, dated 1851, shows the site to have been primarily occupied by open farmland with a drying shed, as well what were probably small residential or farming buildings in the centre and east. On the western boundary, additional residential buildings were present. Two mills and a boiler house were located approximately 50 m to the south, whilst a drying house and dye works were slightly further to the south. By 1893, the drying shed had been removed and residential buildings constructed on the eastern boundary of the site. By 1910, the dye works to the south had been demolished and several large cotton mills constructed. The 1930 map shows the formerly disused mill to the south had been expanded onto the southern boundary of the site. By 1958, the structures in the centre of the site had been removed and allotment gardens were in the western part. What appears to be a large mound was located in the northeastern corner of the site and the mill in the south is labelled as a works. . By 1971, all structures on site had been removed except for the works in the south which was labelled as a shoe factory. The 1984 map labels the site as a yard with the works to the north of the site having expanded and extended onto the northernmost part of the site. Although not clearly shown, it is believed that a significant slope and level change between the northern and southern sites was created at this time. The 2000 aerial image of the site shows that the works in the north had been expanded. By 2006 the works in the south had been demolished and at some time between 2006 and 2025, the remaining works in the north have been removed.

Ground conditions

The investigation encountered a generally significant, locally moderate, thickness of made ground overlying Alluvium which was underlain by Glacial Till. The made ground was encountered as dark greyish brown slightly sandy gravelly humic silt over dark grey, grey, greyish brown and brown sandy very clayey gravel, sandy gravel, gravelly silty clay with fragments of brick, concrete, ash,

clinker, ceramic, plastic and glass. This material extended to depths of between 2.80 m and 6.10 m (128.10 m OD and 132.42 m OD) in the northern part and to depths of between 0.50 m and 3.20 m (124.70 m OD and 127.70 m OD) in the southern part. Beneath this material, Alluvium comprised light grey, yellowish brown very soft and firm sandy silt, clayey silt, slightly gravelly slightly sandy silty clay, pseudo-fibrous peat and sand extended to depths of between 5.60 m and 8.30 m (122.40 m OD and 129.85 m OD). Below this material, Glacial Till was encountered and initially consisted of stiff gravelly sandy silty clay, sandy silty clay and silty clay becoming medium dense becoming dense very silty sand and sandy gravel extended to the full depth of the investigation; 35.45 m (98.75 m OD).

Groundwater was encountered within the made ground at depths of 0.80 m and 3.30 m (127.10 m OD and 131.90 m OD) and locally within the Alluvium at depths of 3.00 m and 7.70 m (122.40 m OD and 126.50 m OD), settling at a depth of 6.03 m (128.17 m OD). Groundwater was also encountered within the granular Glacial Till at 26.50 m (107.70 m OD), rising to a depth of 7.70 m (126.50 m OD).

Recommendations

The thickness of made ground and soft Alluvium is such that shallow spread foundations are not considered to be feasible. For heavier structures, piled foundations will be required, with both bored and driven piles deemed feasible. Preliminary calculations suggest a 250 mm square driven pre-cast concrete pile is likely to have a working load capacity of 640 kN. For CFA bored piles, preliminary calculations suggest a 450 mm diameter pile is likely to have a working load capacity of 900 kN whilst a 600 mm diameter pile should be able to support a safe working load of 1250 kN. Shallow soakaways are not considered to be viable and a CBR value of 'less than 2 %' will be applicable for the preliminary design of pavements formed within made ground.

Samples of made ground have shown elevated concentrations of arsenic, lead, total PAHs, specifically benzo(a)pyrene, benzo(b)fluoranthene and dibenz(a,h)anthracene along with the widespread presence of asbestos. Samples from bodies of perched water within the made ground have revealed elevated concentrations of anthracene, fluoranthene, benzo(b)fluoranthene, benzo(a)pyrene and indeno(1,2,3-cd)pyrene. Any perched water encountered during excavation should therefore be pumped into a secure tank or container and disposed of to appropriate treatment facilities.

Although a gas screening value of less than 0.07 l/hr has been measured throughout the monitoring, elevated concentrations of methane up to 24.0 % have been recorded meaning Characteristic Value 2 conditions are recommended.



Part 1: Investigation Report

This section of the report details the objectives of the investigation, the work that has been carried out to meet these objectives and the results of the investigation. Interpretation of the findings is presented in Part 2.

1.0 Introduction

Geotechnical and Environmental Associates Limited (GEA) has been commissioned by Adept Civil and Structural Consulting Engineers, on behalf of Rochdale Borough Council, to carry out a desk study and ground investigation at the proposed site of Raise Rochdale PRU, Mayfield Street, Rochdale, OL16 2UZ.

1.1 Proposed Development

It is understood that it is proposed to redevelop the site into a new special educational needs (SEN) school. This is to include a one, two and three storey split level building with associated parking, play space and landscaping.

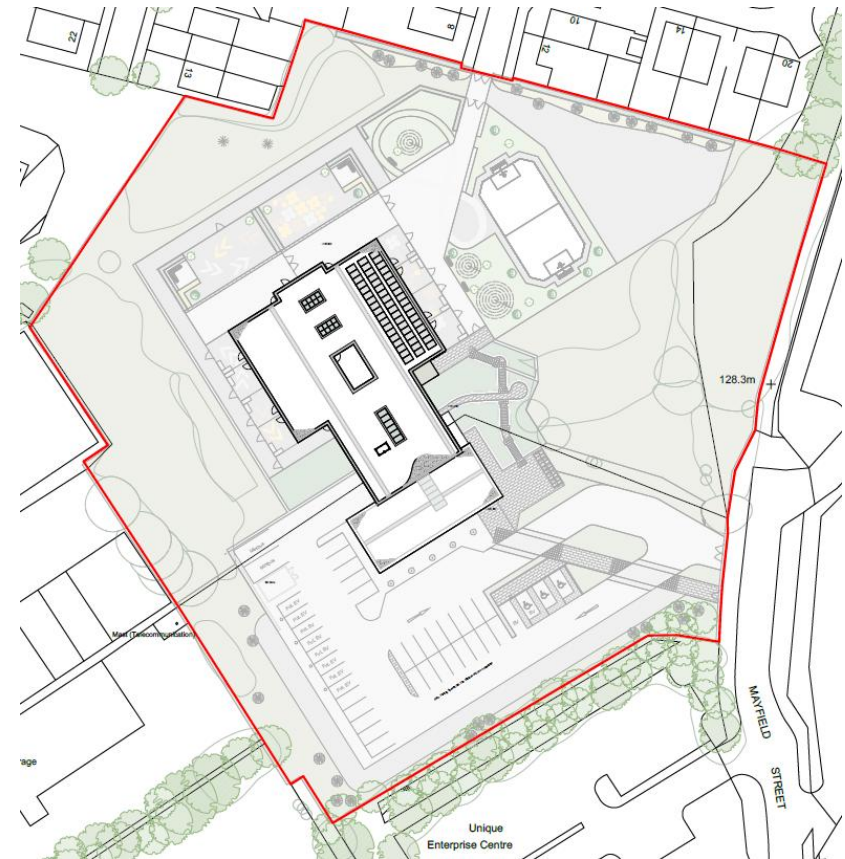
This report is specific to the proposed development and the advice herein should be reviewed once the development proposals are finalised. The proposed layout of the development is shown across the page.

1.2 Purpose of Work

The principal technical objectives of the work carried out were as follows:

-  to check the history of the site with respect to previous contaminative uses;
-  to provide an assessment of the risk of encountering unexploded ordnance (UXO);
-  to research the coal mining risk to the site;
-  to determine the ground conditions and their engineering properties;
-  to use the above information to provide recommendations for shallow and deep foundations;
-  to provide an indication of the degree of soil contamination present; and

-  to assess the risk that any such contamination may pose to the proposed development, its users or the wider environment.





1.3 Scope of Work

In order to meet the above objectives, a desk study was carried out, followed by a ground investigation. The desk study comprised:

- ✎ a review of historical Ordnance Survey (OS) maps and environmental searches sourced from the Envirocheck database;
- ✎ a review of readily available geology maps;
- ✎ commissioning and review of a Preliminary UXO Risk Assessment;
- ✎ sourcing and reviewing a Consultants' Coal Mining risk assessment from the Mining Remediation Authority; and
- ✎ a walkover survey of the site carried out prior to the fieldwork.

In the light of this desk study an intrusive ground investigation was carried out which comprised, in summary, the following activities:

- ✎ four boreholes advanced to depths of between 5.00 m and 35.45 m using a cable percussion rig;
- ✎ seven open-drive boreholes advanced to a maximum depth of 4.45 m;
- ✎ nine mechanically excavated trial pits to a maximum depth of 3.60 m;
- ✎ four large mechanically excavated trial trenches to investigate the potential presence of remnant buried foundations;
- ✎ two mechanically excavated trial pits to depths of 1.50 m and 1.80 m to facilitate soakage testing;
- ✎ standard penetration tests (SPTs) carried out at regular intervals within the boreholes to provide quantitative data on the strength of the soils;
- ✎ equivalent California Bearing Ratio (CBR) testing by means of hand-held in-situ Dynamic Cone Penetrometer (DCP);

- ✎ the installation of five combined gas and groundwater monitoring standpipes, and a subsequent programme of six monitoring visits;
- ✎ testing of selected soil samples for contamination and geotechnical purposes; and
- ✎ provision of a report presenting and interpreting the above data, together with our advice and recommendations with respect to the proposed development.

This report includes a contaminated land assessment which has been undertaken by a suitably qualified and competent professional in accordance with the methodology presented by the Environment Agency in their Land contamination risk assessment (LCRM)¹ Updated 12 June 2025. This involves identifying, making decisions on, and taking appropriate action to deal with, land contamination in a way that is consistent with government policies and legislation within the United Kingdom. Risk management is divided into three stages; Risk Assessment, Options Appraisal and Remediation, and each stage comprises three tiers. The Risk Assessment stage includes preliminary risk assessment (PRA), generic quantitative risk assessment (GQRA) and detailed quantitative risk assessment (DQRA) and this report includes the PRA and GQRA.

The exploratory methods adopted in this investigation have been selected on the basis of the constraints of the site including but not limited to access and space limitations, together with any budgetary or timing constraints. Where it has not been possible to reasonably use an EC7 compliant investigation technique a practical alternative has been adopted to obtain indicative soil parameters and any interpretation is based upon engineering experience, local precedent where applicable and relevant published information.

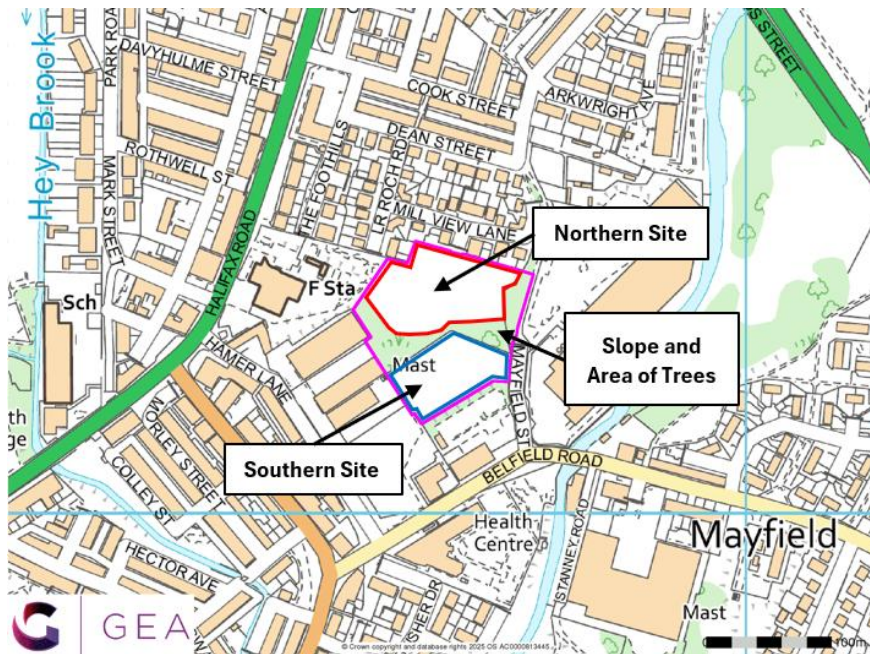
¹ <https://www.gov.uk/government/publications/land-contamination-risk-management-lcrm>



2.0 The Site

2.1 Site Description

The site is located to the northeast of Rochdale town centre, approximately 1.65 km northeast of Rochdale railway station. It is bounded to the north by residential properties and by a fire station as well as commercial and industrial units to the west. To the south, the site is bounded by car parks and to the east by a public footpath and Mayfield Street. The site may be additionally located by National Grid Reference SD907141 and is shown on the map extract below.



A walkover of the site was carried out by a geotechnical engineer from GEA prior to fieldwork on 3rd October 2025. The site is irregular in shape measuring approximately 140 m north to south and 130 m west to east in maximum dimensions. The site is split into a northern part and a southern part, which are separated by an approximately 6 m high slope which is covered in shrubs, semi mature and mature trees.

The southern part of the site, which is located downslope, is an area of waste ground which, at the time of the investigation, was covered in cleared vegetation and felled trees, following a clearance exercise to provide access for this investigation. An area of shrubs, semi mature and mature trees is located along the southern edge, separating the site from the car park beyond the southern boundary. The surface is hummocky and uneven, sloping gently downwards towards the south and is accessed from Mayfield Street in the southeast through a secure gate.

The higher northern part of the site is an area of undeveloped soft landscaping containing numerous areas of shrubs and scattered saplings. An area of semi-mature and mature trees is located along the eastern edge and slopes gently down towards the southeast. This part of the site is accessed from the north through a pedestrian gate off Mill View Lane.

2.2 Site History

The site history has been researched by reference to internet sources and historical Ordnance Survey (OS) maps obtained from the Envirocheck database.

The earliest map studied, dated 1851, shows the site to have been primarily occupied by open farmland with a drying shed as well as what were probably small residential or farming buildings in the centre and east. On the western boundary, additional residential buildings were present. Two mills and a boiler house were located approximately 50 m to the south, whilst a drying house and dye works were slightly further to the south.

By 1893, the drying shed had been removed and residential buildings constructed on the eastern boundary of the site. Further mills had been constructed approximately 90 m to the west, 150 m to the north and 60 m to the east. To the south, the aforementioned mills are noted as either disused or having been converted to unknown works. Reservoirs had been excavated approximately 20 m to the northwest, 110 m to the south and 130 m to the southeast.

By 1910, the dye works to the south had been demolished and several large cotton mills constructed. The mill to the west is noted as a carriage works and the reservoir to the south had been infilled. The 1930 map shows the formerly disused mill to the south had been expanded onto the southern boundary of the site.

By 1958, the structures in the centre of the site had been removed and allotment gardens were in the western part. What appears to be a large mound was located in the northeastern corner of the site and the mill in the south is labelled as a works. On the same



map the carriage works to the west is no longer noted as such and many of the mills to the south are also noted as works. The reservoir to the northwest and one to the southeast had been infilled by this time and additional works had been constructed approximately 40 m to the southwest.

By 1971 all structures on site had been removed except for the works in the south which was labelled as a shoe factory. The works to the southwest had been expanded and the reservoir to the southeast filled in. An additional works had been constructed approximately 40 m to the north. The 1984 map labels the site as a yard with the works to the north of the site having expanded and extended onto the northernmost part of the site. The works in the south have also expanded and additional works had been established along the western boundary. Although not clearly shown, it is believed that a significant slope and level change between the northern and southern sites was created at this time.

The 2000 aerial image of the site shows that the works in the north had been expanded. By 2006 the works in the south had been demolished and at some time between 2006 and 2025, the remaining works in the north have been removed.

2.3 Other Information

A search of public registers and databases has been made via the Envirocheck database and relevant extracts from the search are appended. Full results of the search can be provided if required.

The Envirocheck report has indicated a single historic landfill within 250 m of the site, situated 196 m to the southeast, although a large landfill is also present 732 m to the south. The closer landfill was opened in December 1959 and its last input date is noted as taking place in December 1988, with the deposited waste including inert and industrial waste. The larger landfill was opened in December 1989 and its last input date is noted as taking place in December 1990, with the deposited waste which included inert and industrial waste. No waste management or waste transfer sites are located within 250 m of the site.

Three areas of potentially infilled land (water) are noted within 250 m, the closest being 28 m to the northwest. This appears to correlate with one of the reservoirs noted in the site history.

Two pollution incidents to controlled waters have been recorded within 250 m of the site, approximately 139 m to the southeast and 203 m to the northeast. The closer of the two incidents, which took place in March 1997, is noted to be of minor impact (Category 3) and

involved soils and silts being discharged into a nearby watercourse. The other incident occurred in April 1995, is noted to be of minor impact (Category 3) however no details of the incident have been provided.

Information on Urban Soil Chemistry provided by the BGS indicates that background concentrations for arsenic, cadmium, chromium, lead and nickel on site are likely to range from 15 to 25 mg/kg, 3.0 to 6.0 mg/kg, 60 to 90 mg/kg, 600 to 1200 mg/kg and 30 to 45 mg/kg respectively. Therefore, relatively high concentrations of these metals may be encountered within any near surface soils present on the site and this will need to be taken into account in any subsequent risk assessment.

Reference to records compiled by the Health Protection Agency (formerly the National Radiological Protection Board) indicates that the site falls within an area where less than 1% of homes are affected by radon emissions and therefore radon protective measures will not be necessary.

The site is not within an area of sensitive land uses. There are no contemporary trade directory entries listed on site, but 27 are present within 200 m of the site, with nine being active. The active entries are summarised below.

Distance	Location	Entry	Active / Inactive
30 m W	Hamer Lane	Car Body Repairs	Active
83 m W	Hamer Lane	Tyre Dealers	Active
96 m W	84 Hamer Lane	Garage Services	Active
100 m E	Unit 1-3 Mayfield Centre	Pharmaceutical Manufacturers & Distributors	Active
100 m E	Mayfield Centre	Food Products - Manufacturers	Active
101 m SE	Bellfield Road	Garage Services	Active
126 m W	Halifax Road	Petrol Filling Station	Active
140 m W	Halifax Road	Sewing Machines - Industrial	Active
151 m N	Rochdale	Garage Services	Active

A single fuel filling station is located within 500 m of the site, located 126 m to the west and is listed as active. However it is unlikely to have an impact on the site because of its distance from the site.



A total of 11 Points of Interest relating to commercial services are listed within 250 m of the site, all relating to either vehicle repair, servicing and testing services, vehicle cleaning services or transport, storage and delivery. A further 13 Points of Interest relating to Manufacturing and Production are located within 250 m of the site, all relating to either unspecified works or factories. In addition, eight Points of Interest relating to public infrastructure are listed within 250 m of the site, relating to either a fire station, petrol station or weir/sluiques.

2.4 Preliminary UXO Risk Assessment

A Preliminary UXO Risk Assessment has been completed by 1st Line Defence (report ref PA22685-00, dated 26th September 2025), and the report is included in the appendix. The risk assessment has been carried out in accordance with the guidelines provided by CIRIA², which state that the likelihood of encountering and detonating UXO below a site should be assessed along with establishing the consequences that may arise. The first phase comprises a preliminary risk assessment, which should be undertaken at an early stage of the development planning. If such an assessment identifies a high level of risk then a detailed risk assessment should be carried out by a UXO specialist, which will identify an appropriate course of action with regard to risk mitigation.

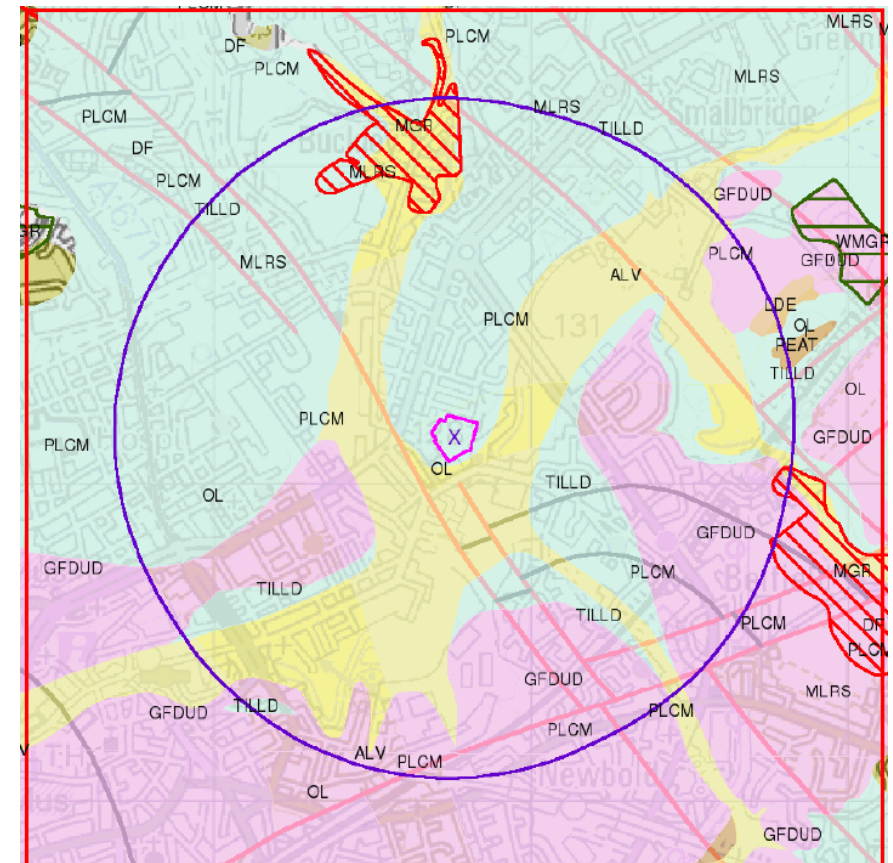
The report indicates that, during World War II (WWII), the site was located within the Rochdale County Borough which sustained an overall very low density of bombing with four items of ordnance recorded across the 9,556 acre borough. No positive evidence has been found to indicate that the site sustained any incidents of bombing throughout WWII and therefore, no further research is recommended.

However, because the risk of encountering UXO can never be entirely discounted, the following actions are recommended as a precaution:

-  All ground operatives to be made aware of potential UXO risk, what to look out for, and what to do in the event that they encounter a suspect item.
-  Compile a UXO Risk Management Plan for the site.

2.5 Geology

The British Geological Survey (BGS) map of the area indicates that the site is underlain by Glacial Till, described as heterogenous mixture of clay, sand, gravel, and boulders varying widely in size and shape. This is in turn underlain by the Old Lawrence Rock, which is sandstone of the Pennine Lower Coal Measures Formation. Alluvium is present 20 m to the south and 100 m to the east of the site. Significant areas of made ground are noted 400 m to the north and 500 m to the southeast of the site.



2 CIRIA C681 (2009) *Unexploded ordnance (UXO) A guide for the construction industry*



A search of the BGS borehole database has found that a number of boreholes have been drilled on site. Below a 1.10 m thickness of made ground, firm to stiff brown, yellowish brown and grey mottled orange very silty sandy clay with bands of clayey silt and occasional gravel were encountered to a depth of 2.90 m. This was underlain by firm dark brown silty slightly sandy clay with fine to coarse gravel of mudstone, sandstone and coal. Bands of soft very silty laminated clay were encountered from a depth of 6.00 and these soils extended to the maximum depth investigated of 15.00 m.

2.6 Hydrology and Hydrogeology

Glacial Till is classified as a Secondary Undifferentiated Aquifer, which refers to aquifers where it is not possible to apply either a Secondary A or B definition because of the variable characteristics of the rock type.

The Pennine Lower Coal Measures Formation is classified as a Secondary A Aquifer, defined as comprising permeable layers that can support local water supplies. The site is not within a Source Protection Zone.

The nearest surface water feature is the River Roch, which is located approximately 74 m to the southeast of the site.

The site is largely covered by vegetated areas resulting in any surface water draining directly into the ground.

The site is noted to have a limited potential for groundwater flooding to occur. It is not shown to be at risk from flooding from river or sea or from surface water flooding.

2.7 Consultant's Coal Mining Report

Mining Remediation Authority maps show the site to be within an area of historical coal mining activity. Therefore, a Consultant's Coal Mining Report (report ref 386266087_2 dated 23rd September 2025) has been completed and the report is included in the appendix. The report notes no underground or opencast mines within 500 m of the site and records no worked seams within the site area.

The report notes no probable unrecorded shallow workings and no recorded mine entries within 100 m. No opencast mines or Mining Remediation Authority managed tips are noted within 500 m. No mine gas or mine water treatment schemes are recorded within 500 m.

2.8 Preliminary Risk Assessment

Part IIA of the Environmental Protection Act 1990, which was inserted into that Act by Section 57 of the Environment Act 1995, provides the main regulatory regime for the identification and remediation of contaminated land. The determination of contaminated sites is based on a "suitable for use" approach which involves managing the risks posed by contaminated land by making risk-based decisions. This risk assessment is carried out on the basis of a source-pathway-receptor approach.

2.8.1 Source

The desk study findings indicate that the site has a potentially contaminative history as it has been developed with mills and works from some time between 1893 and 1910 until prior to 2006 with various other industrial developments including dye works having been present in close proximity to the site. Department of the Environment industry profiles³ suggest contamination relating to metal and metalloids, inorganic compounds, oil and fuels, coolants, solvents as well as asbestos might be present.

The historic map records show that the works located within the northern part of the site and beyond the northern boundary had been demolished prior to 2006, meaning a significant thickness of made ground may be present. As this material was deposited approximately 20 years ago, it is likely that ground gas is currently being produced as these deposits are still within the time of their methanogenic potential.

Two historic landfills are noted within proximity of the site, but the closer of the two ceased accepting waste over 60 years ago meaning it is unlikely to still be producing ground gas. Although larger, the further of the two is at a distance where it should not pose a ground gas risk. On this basis, a viable gas risk from off-site sources is considered unlikely.

2.8.2 Receptor

The proposed redevelopment of the site for educational purposes will result in the end users representing relatively high sensitivity receptors. The underlying Secondary Undifferentiated Aquifer is a low sensitive receptor, as are adjacent sites. The deeper Secondary A aquifer would be a high sensitive receptor.



Buried services are likely to come into contact with any contaminants present within the soils through which they pass and site workers are potential receptors during construction or maintenance works.

2.8.3 Pathway

The presence of potentially negligibly permeable Glacial Till will limit the potential for groundwater percolation into the underlying Secondary A Aquifer.

Within the site, end users will be isolated from direct contact with any contaminants present within the made ground by the presence of the buildings and the extent of hardstanding, although a direct pathway will exist in areas of soft landscaping. Buried services may be exposed to any contaminants present within the soil through direct contact and site workers will come into contact with the soils during groundworks.

A ground gas risk is anticipated within the northern part of the site but a risk of ground gas from recorded landfills is not considered likely.

2.8.4 Preliminary Risk Appraisal

On the basis of the above it is considered that there is a MODERATE / LOW risk of there being a significant contaminant linkage at this site which would result in a requirement for major remediation work.

3.0 Exploratory Work

In order to meet the objectives described in Section 1.2, a total of four boreholes were advanced to depths of between 5.00 m and 35.45 m using a cable percussion rig. Three boreholes were undertaken within the proposed footprint of the SEN building, with two undertaken to a depth of 15.45 m and another scheduled to a depth of 25.00 m, but extended to a depth of 35.00 m due to the bedrock not being present. Lastly, a shallower borehole was undertaken to a depth of 5.00 m to facilitate the installation of a gas / groundwater standpipe.

An opendrive sampling rig was used to advance an additional seven boreholes to depths of between 1.30 m and 4.45 m. The original purpose of these boreholes was to provide additional information on ground conditions across both sites, but upon encountering a layer of peat within Borehole No 4, these boreholes were used to investigate the extent of the peat present in the southern site.

Nine mechanically excavated trial pits were undertaken to depths of between 2.50 m and 3.60 m to confirm the presence or absence of remnant below ground structures relating to the previous buildings on site as well as to provide further coverage of the ground conditions of both sites. Additionally, upon encountering remnant structures within the central part of the southern site, four trial trenches were undertaken to depths of between 1.35 m and 1.75 m to expose and investigate the extent of these structures.

Additionally, two further mechanically excavated trial pits were undertaken to depths of 1.50 m and 1.80 m to facilitate soakage testing and three fill and empty cycles were undertaken within each pit.

Five standpipes have been installed, within Borehole Nos 1 to 4 and 11, to depths of between 1.00 m and 8.50 m to facilitate gas and groundwater monitoring. The response zones in Borehole Nos 1, 3 and 11 have been installed to target the made ground, a layer of peat within Borehole No 4 and the Alluvium within Borehole No 2. Monitoring has been carried out on six occasions between two weeks and four months since the completion of the siteworks.

During boring, disturbed and undisturbed samples were obtained from the boreholes for subsequent laboratory examination and testing. Standard Penetration Tests (SPTs) were carried out at regular intervals to provide additional quantitative data on the strength of soils encountered. A selection of the samples recovered from the boreholes was submitted



to a soil mechanics laboratory for a programme of geotechnical testing and an analytical laboratory for a programme of contamination testing.

All of the above work was carried out under the supervision of a geotechnical engineer from GEA. The borehole and trial pit records are appended, together with a site plan indicating the exploratory positions. The Ordnance Datum (OD) levels on the borehole and trial pit records have been interpolated from a topographical survey drawing provided by the consulting engineers (S250277-DR-T-001 rev A, dated 29 August 2025).

3.1 Sampling Strategy

The trial pit and borehole locations were agreed with the consulting engineers, Adept Civil and Structural Consulting Engineers with the final positions adjusted by the onsite GEA engineer in the light of site constraints and findings.

Sixteen samples of the made ground, seven from the southern part and nine from the northern part, have been tested for the presence of contamination. The analytical suite of testing was selected to identify a range of typical industrial contaminants for the purposes of general coverage. The analytical suite for the soil included a range of metals, speciation of total petroleum hydrocarbons (TPH), polycyclic aromatic hydrocarbons (PAH), total cyanide and monohydric phenols. Selected samples were also screened for the presence of asbestos. The analyses were carried out at an MCERTs accredited laboratory with the majority of the testing suite accredited to MCERTS standards. A summary of the MCERTs accreditation and test methods are included with the attached results and further details are available upon request.

In addition to the above analysis, two Waste Acceptance Criteria (WAC) tests of the made ground were carried out.

4.0 Ground Conditions

The investigation has not encountered the expected ground conditions in that a generally significant but locally moderate thickness of made ground was present over Alluvium. This was shown to be present to the south and east of the site but its presence had not been anticipated.

Beneath the Alluvium, Glacial Till was encountered to maximum depth of the investigation; 35.45 m (98.75 m OD). The expected Old Lawrence Rock was not encountered during the investigation.

4.1 Made Ground

4.1.1 Northern Site

The made ground initially comprised dark greyish brown slightly sandy gravelly humic silt over dark grey, grey, greyish brown and brown sandy very clayey gravel, sandy gravel, gravelly silty clay with fragments of brick, concrete, ash, clinker, ceramic, plastic, glass and metal with a slight organic odour. This material extended to a maximum depth of 6.10 m (128.10 m OD), but was generally encountered to depths of between 2.80 m and 4.70 m (130.30 m OD and 132.42 m OD).

From the presence of fragments of extraneous material noted above and the site history, there is evidence of contamination within the made ground. Based on these observations, seven samples of the made ground have been analysed for a range of contaminants and the results are detailed within Section 4.5.

Compaction testing on the made ground within the northern part has indicated a maximum dry density of 1.75 kg/m³ and optimum moisture content of 14 %.

4.1.2 Southern Site

The made ground in this part of the site initially comprised dark greyish brown slightly sandy gravelly humic silt or a thickness of shrubs and felled vegetation over dark grey, grey, greyish brown and brown sandy very clayey gravel, sandy gravel, gravelly silty clay with fragments of brick, concrete, ash, clinker, ceramic, plastic, glass and metal. This material extended to depths of between 2.40 m and 3.20 m (124.70 m OD and 125.05 m OD) in the central, southern and eastern areas of the site, which coincides with the position of previous structures noted.



Within the northern and western parts, the made ground only extended to depths of between 0.50 m and 1.20 m (126.70 m OD and 127.70 m OD). Borehole Nos 08 and 10 terminated within these deposits.

Within the central part of the southern site remnant structures were encountered and four mechanically excavated trial trenches were undertaken in order to expose and investigate their extent. The findings of these excavations are summarised in the table below.

Position No	Type of Service	Depth to top of feature (m) [Level (m OD)]	Depth to base of feature (m) [Level (m OD)]
TT01 West	Concrete slab	1.55 [126.02]	1.65 [125.92]
TT01 West	Brick structure leading to slab	0.74 [126.83]	1.55 [126.02]
TT01 East	Brick wall and footings	0.50 [127.07]	1.36 [126.21]
TT02	Brick wall and footings	0.60 [126.97]	1.16 [126.41]
TT03	Brick wall and footings	0.80 [126.77]	1.23 [126.34]
TT04	Edge of concrete slab	1.70 [125.87]	n/a

From the presence of fragments of extraneous material noted above and the site history, there is evidence of contamination within the made ground. Based on these observations, nine samples of the made ground have been analysed for a range of contaminants and the results are detailed within Section 4.5.

Compaction testing on the made ground within the southern part has indicated maximum dry density of 1.87 kg/m³ and optimum moisture content of 11 %.

4.2 Alluvium

4.2.1 Clay, Silt and Sand

Directly beneath the made ground, Alluvium was encountered as light grey, yellowish brown very soft to firm sandy silt, clayey silt, slightly gravelly slightly sandy silty clay and sand extending to depths of between 5.60 m and 8.30 m (122.40 m OD and 129.85 m OD). Borehole Nos 04 to 07 and 11, and Trial Pit Nos 01 to 09 terminated within these deposits.

Natural moisture content of the clay has been measured at between 29 % and 35.9 %. Atterberg testing of the clay has indicated liquid limits of 38 % and 39 %, a plasticity limit of 15 % and plasticity indexes of 23 % and 24 %. This indicates that the Alluvium is of medium volume change potential.

The results of quick undrained triaxial compression tests indicate the clay to be of low strength.

No visual or olfactory evidence of contamination was observed within the Alluvium.

4.2.2 Peat

Within the Alluvium in Borehole Nos 04, 07 and 09, brown and dark grey pseudo-fibrous peat with a slight putrid odour was encountered at depths of between 2.90 m and 3.70 m (123.77 m OD and 125.30 m OD) and extended to depths of between 3.40 m and 4.00 m (123.477 m OD and 124.80 m OD), with Borehole No 09 terminating within these deposits.

The organic content of the peat has been measured at 39.9 % and 48.8 %.

4.3 Glacial Till

4.3.1 Cohesive

The Glacial Till initially comprised stiff dark greyish brown slightly gravelly slightly sandy silty clay extending to a depth of 20.20 m (114.00 m OD), whereupon stiff dark greyish brown silty clay with occasional lenses of brown sand extended to a depth of 26.80 m (107.40 m OD). Cohesive Glacial Till was again encountered as stiff thinly laminated dark greyish brown silty clay to a depth of 30.50 m (103.70 m OD). Borehole No 01 and 03 terminated within these deposits.

Natural moisture content of the clay has been measured at between 15.5 % and 23.4 %. Atterberg testing of the clay has indicated liquid limits of 34 % and 42 %, plasticity limits of between 14 and 16 % and plasticity indexes of between 20 and 26 %. This indicates that the Glacial Till is to be of medium volume change potential.

The results of quick undrained triaxial compression tests indicate the clay to be of medium to high strength.

4.3.2 Granular

Below the initial significant layer cohesive Glacial Till, granular deposits were encountered and consisted of medium dense greyish brown very gravelly silty sand to a depth of 29.10 m (105.10 m OD). Granular Glacial Till was again encountered initially as medium dense greyish brown very gravelly silty sand to a depth of 31.40 m (105.10 m OD) whereupon



medium dense becoming dense very sandy silty gravel was encountered and extended to the maximum depth of the investigation; 35.45 m (98.75 m OD). Borehole No 02 terminated within these deposits at a depth within the range of a commercially viable pilling rig.

4.4 Groundwater

Groundwater was encountered as seepages within and at the base of the made ground at depths of 0.80 m and 3.30 m (127.10 m OD and 131.90 m OD) at eight locations and is believed to represent perched bodies of groundwater.

Groundwater was encountered locally within the Alluvium at depths of between 3.00 m and 5.60 m (122.40 m OD and 124.90 m OD) at two locations within the southern site and 7.70 m (126.50 m OD) at one location in the northern site, rising to a depth of 6.03 m (128.17 m OD) after 20 minutes.

Groundwater was also encountered locally within the granular Glacial Till at a depth of 26.50 m (107.70 m OD), rising to a depth of 7.70 m (126.50 m OD) respectively after 20 minutes.

Standpipes were installed in five of the boreholes and the findings of the six groundwater monitoring visits are presented in the table below.

Borehole No	Response Zone (m) and Target Lithology	Date	Depth to water (m) [Level (m OD)]
1	0.50 to 1.00 Made Ground	19/11/2025	0.68 [127.32]
		05/12/2025	0.45 [127.55]
		16/12/2025	0.32 [127.68]
		12/01/2026	0.70 [127.30]
		17/02/2026	0.46 [127.54]
		06/03/2026	0.46 [127.54]
2	6.00 to 8.50 Alluvium	19/11/2025	3.00 [131.20]

Borehole No	Response Zone (m) and Target Lithology	Date	Depth to water (m) [Level (m OD)]
		05/12/2025	2.75 [131.45]
		16/12/2025	2.84 [131.36]
		12/01/2026	2.95 [131.25]
		17/02/2026	2.83 [131.37]
		06/03/2026	2.92 [131.28]
3	0.60 to 4.60 Made Ground	19/11/2025	4.14 [131.31]
		05/12/2025	3.47 [131.98]
		16/12/2025	3.52 [131.93]
		12/01/2026	3.49 [131.96]
		17/02/2026	3.49 [131.96]
		06/03/2026	3.47 [131.98]
4	3.90 to 4.40 Alluvium (Peat)	19/11/2025	2.00 [126.20]
		05/12/2025	0.65 [127.55]
		16/12/2025	0.67 [127.53]
		12/01/2026	0.69 [127.51]
		17/02/2026	0.70 [127.50]
		06/03/2026	0.36 [127.84]
11	0.30 to 4.30 Made Ground	19/11/2025	3.80 [131.20]
		05/12/2025	4.06 [130.94]



Borehole No	Response Zone (m) and Target Lithology	Date	Depth to water (m) [Level (m OD)]
		16/12/2025	3.94 [131.06]
		12/01/2026	4.15 [130.85]
		17/02/2026	4.16 [130.84]
		06/03/2026	4.26 [130.74]

Determinant	Maximum	Minimum	Number of samples below detection limit
Benzo(a)pyrene	5.2	0.20	None
Naphthalene	1.4	<0.05	One
Benzo(b)fluoranthene	6.5	0.32	None
Dibenz(a,h)anthracene	0.82	<0.05	Two
EPH (C8-C40)	180	10	None
Total Organic Carbon %	3.3	0.70	None

4.5 Soil Contamination

4.5.1 Made Ground – Northern Site

The table below sets out the values measured within the seven samples from within the northern site; all concentrations are in mg/kg unless otherwise stated.

Determinant	Maximum	Minimum	Number of samples below detection limit
pH	8.3	7.6	-
Arsenic	180	6.2	None
Cadmium	6.6	0.40	None
Chromium (Hexavalent)	<1.8	<1.8	All
Lead	1700	45	None
Mercury	0.40	<0.30	Six
Selenium	4.5	<1.0	Four
Copper	530	27	None
Nickel	84	17	None
Zinc	550	94	None
Total Cyanide	<1.0	<1.0	All
Total Phenols	<1.0	<1.0	All
Total PAH	71	2.98	None
Sulphide	42	<1.0	Three

In addition, the seven samples of made ground have been screened for the presence of asbestos and the results are shown in the table overleaf.

BH/TP ref	Sample depth (m)	Asbestos detected	Quantification; total asbestos in sample	Potentially respirable fibres (fibres/g)
BH02	0.50	None	-	-
TP04	1.10	Chrysotile– Loose fibres	<0.001%	-
TP04	2.90-3.00	Chrysotile– Loose fibres	<0.001%	-
TP06	1.20	None	-	-
TP07	0.60	Chrysotile– Loose fibres	<0.001%	-
TP08	0.80	Chrysotile– Loose fibres	<0.001%	-
TP09	0.20	Chrysotile– Loose fibres	<0.001%	-

4.5.2 Made Ground – Southern Site

The table below sets out the values measured within the nine samples from within the southern site; all concentrations are in mg/kg unless otherwise stated.

Determinant	Maximum	Minimum	Number of samples below detection limit
pH	10.4	7.2	-
Arsenic	30	5.0	None
Cadmium	1.7	0.20	None



Determinant	Maximum	Minimum	Number of samples below detection limit
Chromium (Hexavalent)	3.4	<1.8	Seven
Lead	510	75	None
Mercury	0.60	<0.30	Six
Selenium	1.6	<1.0	Four
Copper	110	30	None
Nickel	32	15	None
Zinc	250	78	None
Total Cyanide	<1.0	<1.0	All
Total Phenols	<1.0	<1.0	All
Total PAH	121	4.21	None
Sulphide	9.1	<1.0	One
Benzo(a)pyrene	9.4	<0.05	None
Naphthalene	0.37	<0.05	One
Benzo(b)fluoranthene	10	0.52	None
Dibenz(a,h)anthracene	0.82	<0.05	Two
EPH (C8-C40)	550	75	None
Total Organic Carbon %	3.7	1.0	None

In addition, these nine samples have been screened for the presence of asbestos and the results are shown in the table overleaf.

BH/TP/TT ref	Sample depth (m)	Asbestos detected	Quantification; total asbestos in sample (%)	Potentially respirable fibres (fibres/g)
BH01	0.30	None	-	-

BH/TP/TT ref	Sample depth (m)	Asbestos detected	Quantification; total asbestos in sample (%)	Potentially respirable fibres (fibres/g)
BH04	0.30-0.50	Amosite / Chrysotile– Loose fibres, Loose fibrous débris	0.006%	-
BH05	0.80-1.00	Chrysotile– Loose fibres	0.001%	-
BH07	0.60-0.80	Chrysotile– Loose fibres	<0.001%	-
BH08	0.30-0.40	None	-	-
TP02	1.00	Amosite / Chrysotile– Loose fibrous débris	0.001%	-
TP03	1.80	Chrysotile– Loose fibres, Loose fibrous débris	0.002%	-
TP03	2.30	None	-	-
TT01 East	1.00	Chrysotile– Loose fibres	0.002%	-

4.5.3 Generic Quantitative Risk Assessment

The use of a risk-based approach has been adopted to provide an initial screening of the test results to assess the need for subsequent site-specific risk assessments. Contaminants of concern are those that have values in excess of generic human health risk-based guideline values, which are either the CLEA⁴ Soil Guideline Values where available, the Sutable 4 Use Values⁵ (S4UL) produced by LQM/CIEH calculated using the CLEA UK Version 1.07⁶ software, or the DEFRA Category 4 Screening values⁷, assuming a residential end use without plant uptake. The key generic assumptions for this end use are as follows:

- that groundwater will not be a critical risk receptor;
- that the critical receptor for human health will be young female children aged less than six years old;
- that the exposure duration will be six years;
- that the critical exposure pathways will be indoor dust ingestion, skin contact with

⁴ Updated Technical Background to the CLEA Model (Science Report SC050021/SR3) Jan 2009 and Soil Guideline Value reports for specific contaminants; all DEFRA and Environment Agency.

⁵ The LQM/CIEH S4ULs for Human Health Risk Assessment S4UL3065 November 2014

⁶ Contaminated Land Exposure Assessment (CL|EA) Software Version 1.071 Environment Agency 2015

⁷ CL:AIRE (2013) Development of Category 4 Screening Levels for Assessment of Land Affected by Contamination Final Project Report SP1010 and DEFRA (2014) Development of Category 4 Screening Levels for Assessment of Land Affected by Contamination Policy Companion Document SP1010



indoor dust, and inhalation of indoor and outdoor dust and vapours; and

- that the building type equates to a two-storey small terraced house.

It is considered that these assumptions are acceptable for this generic assessment of this SEN development site. The tables of generic screening values derived by GEA and an explanation of how each value has been derived are included in the Appendix.

Where contaminant concentrations are measured at concentrations below the generic screening value it is considered that they pose an acceptable level of risk and thus further consideration of these contaminant concentrations is not required. However, where concentrations are measured in excess of these generic screening values there is considered to be a potential that they could pose an unacceptable risk and thus further action will be required which could include;

- additional testing to zone the extent of the contaminated material and thus reduce the uncertainty with regard to its potential risk;
- site specific risk assessment to refine the assessment criteria and allow an assessment to be made as to whether the concentration present would pose an unacceptable risk at this site; or
- soil remediation or risk management to mitigate the risk posed by the contaminant to a degree that it poses an acceptable risk.

On the basis of the above, the presence of widespread asbestos and elevated concentrations of arsenic, lead and total PAHs more specifically benzo(a)pyrene, benzo(b)fluoranthene and dibenz(a,h)anthracene were present within the made ground. The table below indicates the locations of the samples where the elevated concentrations were measured.

Determinant	Location	Depth (m)	Stratum	Concentration (mg/kg)	Screening Value (mg/kg)
Arsenic	TP04	2.90-3.00	Made Ground	180	40
Lead	BH05	0.80-1.00	Made Ground	510	310
	BH08	0.30-0.40		310	
	TP04	1.10		1700	
Benzo(a)pyrene	TP03	1.80	Made Ground	7.5	5.3

Determinant	Location	Depth (m)	Stratum	Concentration (mg/kg)	Screening Value (mg/kg)
Benzo(b)fluoranthene	TT01 East	1.00	Made Ground	9.4	4.0
	BH07	0.60-0.80		4.1	
	TP01	0.50		5.3	
	TP03	1.80		8.4	
	TP04	1.10		5.4	
	TP07	0.60		6.5	
	TT01 East	1.10		10	
Dibenz(a,h)anthracene	BH07	0.60-0.80	Made Ground	0.40	0.32
	TP01	0.50		0.39	
	TP03	1.80		0.53	
	TP04	1.10		0.37	
	TP07	0.60		0.45	
	TT01 East	1.00		0.82	

The significance of these results is considered further in Part 2 of the report.

4.6 Groundwater Contamination

Three samples of groundwater, one from within made ground and two within the Alluvium, have been tested for the presence of contamination. The full results are included in Appendix B. The results have indicated elevated concentrations of anthracene, fluoranthene, benzo(b)fluoranthene, benzo(a)pyrene and indeno(1,2,3-cd)pyrene from the sample taken from the made ground. The elevated contaminants are consistent with what is outlined within the industry profiles and is likely to have derived from ash and clinker rich material and the part burnt elements within the clinker that are typically PAH rich.

Additionally, surface water was noted running off the site and into a drainage channel located on the footpath, which ran along the eastern site boundary. Within the channel, orange residue was noted, as shown in the photograph across the page and therefore a sample of the water was tested for the presence of contamination. The results have not indicated elevated concentrations of contaminants.



4.7 Soakage Testing

Two trial pit soakage tests were carried out, at depths of 1.50 m and 1.80 m (126.10 m OD and 126.85 m OD respectively) within the Alluvium and measured infiltration rates of between 5.3×10^{-7} m/s and 1.7×10^{-6} m/s. The full results are included in the Appendix and are summarised right.

Location	Soakage Test No	Soakage Rate (m/s)	Stratum	Response Zone (m)	Comments
SA01	1	1.7×10^{-6}	Alluvium	0.60 to 1.50	Did not reach 25 % effective depth after 112 minutes.
		0.14 m/day			
	2	1.4×10^{-6}			Did not reach 25 % effective depth after 120 minutes.
		0.12 m/day			
	3	1.4×10^{-6}			

Location	Soakage Test No	Soakage Rate (m/s)	Stratum	Response Zone (m)	Comments
		0.12 m/day			Did not reach 25 % effective depth after 60 minutes.
SA02	1	1.1×10^{-6}	Alluvium	0.53 to 1.80	Did not reach 25 % effective depth after 108 minutes.
		0.09 m/day			
	2	1.3×10^{-6}			Did not reach 25 % effective depth after 99 minutes.
		0.11 m/day			
	3	5.3×10^{-7}			Did not reach 25 % effective depth after 118 minutes.
		0.05 m/day			

4.8 Soil Gas

Six rounds of monitoring have been carried out and the full results are included within the appendix. The monitoring measured significant concentrations of methane and carbon dioxide gas within the first three monitoring visits, however not within the last three. Minimal positive and negatives pressures or flow were measured within the standpipes.

In determining the significance of soil gas concentrations, both the gas concentrations and borehole flow rates are used to define a characteristic situation for a site based on the limiting borehole gas volume flow, renamed as the Gas Screening Value (GSV) for methane and carbon dioxide. In this case the following GSVs have been determined, in accordance with guidance provided by CIRIA.

Gas	Max concentration % vol.	Ave flow rate l/hr	GSV
Methane	24.0	0.10	0.024
Carbon dioxide	16.1	0.10	0.016

Although a gas screening value of less than 0.07 l/hr has been measured throughout the monitoring, the elevated concentrations of methane measured within the first three visits of up to 24.0 % indicate that consideration should be given to the implementation of Characteristic Value 2 conditions.



These concentrations were not encountered within the last three monitoring visits meaning the methane is likely to have been present in pockets within the made ground and has since dispersed. However, due to the significant thickness of made ground across northern part of the site, it is likely that other pockets exist and therefore recourse to Characteristic Value 2 conditions is recommended.

Based on the six rounds of monitoring, Table 4 of BS 8485:2015 indicates the minimum gas protection score (points) for each type of building (A-D) using the CS level (1-6) previously determined. A Type B building with CS2 requires 3.5 points in reference to gas protection measures and on the NHBC “traffic light” system⁸ the site may be considered to be Amber 1.

8 Boyle, R and Witherington, P (2006) *Guidance on evaluation on development proposals on sites where methane and carbon dioxide are present, incorporating ‘traffic lights’*. Report Ref 10627-R01-(02) for National House-Building Council



Part 2: Design Basis Report

This section of the report provides an interpretation of the findings detailed in Part 1, in the form of a ground model, and then provides advice and recommendations with respect to the proposed development.

5.0 Ground Model

It is proposed to redevelop the site from an area of wasteland into a new SEN school. This is to include a one, two and three storey split level building with associated parking, play space and landscaping. The loads are not known but are anticipated to be moderate.

The desk study findings indicate that the site does have a potentially contaminative history as it has been developed with mills and works from sometime between 1893 and 1910 until 2006. On the basis of the fieldwork, the ground conditions can be characterised as follows:

- Ⓒ below a moderate to significant thickness of made ground, Alluvium is present, and is underlain by Glacial Till which extends to the maximum depth of the investigation, of 35.45 m (98.75 m OD);
- Ⓒ the made ground within the northern part of the site initially comprises dark greyish brown slightly sandy gravelly humic silt over dark grey, grey, greyish brown and brown sandy clayey gravel, sandy gravel, gravelly silty clay with fragments of brick, concrete, ash, clinker, ceramic, plastic, glass and metal with a slight organic odour to depths of between 2.80 m and 6.10 m ();
- Ⓒ the made ground within the southern part of the site initially comprises dark greyish brown slightly sandy gravelly humic silt or felled vegetation over dark grey, grey, greyish brown and brown sandy clayey gravel, sandy gravel, gravelly silty clay with fragments of brick, concrete, ash, clinker, ceramic, plastic, glass and metal to depths of between 0.50 m and 3.20 m (124.70 m OD and 127.70 m OD);
- Ⓒ obstructions such as remnant concrete slabs, brick walls and footings are present within the made ground within the southern part of the site;
- Ⓒ the Alluvium comprises light grey, yellowish brown very soft to firm sandy silt, clayey silt, slightly gravelly slightly sandy silty clay, pseudo-fibrous peat and sand extending to depths of between 5.60 m and 8.30 m (122.40 m OD and 129.85 m OD);

- Ⓒ Glacial Till consisting of stiff slightly gravelly slightly sandy silty clay, slightly sandy silty clay and silty clay and medium dense becoming dense very gravelly silty sand and very sandy gravel extending to the maximum depth of the investigation; 35.45 m (98.75 m OD);
- Ⓒ perched groundwater was encountered within the made ground at depths of 0.80 m and 3.30 m (127.10 m OD and 131.90 m OD) and groundwater was also encountered locally within the Alluvium at depths of 3.00 m and 7.70 m (122.40 m OD and 126.50 m OD), settling at 6.03 m (128.17 m OD). Groundwater was also encountered within the granular Glacial Till at 26.50 m (107.70 m OD), rising to a depth of 7.70 m (126.50 m OD);
- Ⓒ contamination testing has revealed the presence of arsenic, lead, total PAHs specially benzo(a)pyrene, benzo(b)fluoranthene and dibenz(a,h)anthracene and asbestos contamination within the made ground;
- Ⓒ groundwater contamination testing has revealed elevated concentrations of anthracene, fluoranthene, benzo(b)fluoranthene, benzo(a)pyrene and indeno(1,2,3-cd)pyrene within the sample taken from the made ground; and
- Ⓒ the six rounds of gas monitoring undertaken have measured no or minimal positive flows and maximum concentrations of 24.0 % and 16.6 % for methane and carbon dioxide respectively.



6.0 Advice & Recommendations

The thickness of made ground and soft Alluvium is such that shallow spread foundations and ground improvement are not considered to be feasible even though the proposals for the site are to only contain low-rise buildings, piled foundations are considered necessary.

6.1 Piled Foundations

Where the thickness of the made ground and soft Alluvium means that spread foundations are not feasible or the loads are too high for ground improvement, recourse to piled foundations will be required.

6.1.1 Driven Piles

Driven piles are considered to provide a suitable foundation solution. The piles are formed of reinforced precast concrete and would be driven to a set in the cohesive Glacial Till. They would not generate any spoil, are fully reinforced and with a smooth surface would be least affected by negative skin friction applied by settlement of the made ground or Alluvium. Each pile is effectively tested as it is driven and piles up to 15 m could be brought to site as single lengths whilst longer piles could be jointed.

The following table outlines the ultimate coefficients may be used for the preliminary design of piles on the northern part of the site, based on the SPT / depth graph in the Appendix.

Stratum	Depths m	kN/m ²
Ultimate Skin Friction		
Made Ground	GL to 6.10	Ignore / NSF
Alluvium	6.10 to 8.30	20
Cohesive Glacial Till	8.30 to 26.80	70
Granular Glacial Till	26.80 to 29.10	100
Cohesive Glacial Till	29.10 to 30.50	70
Granular Glacial Till	Below 30.50 m	120
Ultimate End Bearing		
Cohesive Glacial Till	8.30 to 26.80	900
Granular Glacial Till	26.80 to 29.10	1500

BS EN 1997-1:2004; Eurocode 7: Geotechnical Design Part 1 (Eurocode 7) provides factors to be applied to the ultimate skin friction and ultimate end bearing capacity in calculating pile resistance ($R_{d,GEO}$). For driven piles, in the absence of either working load tests or combined working load tests and preliminary pile tests, a model factor of 1.3 should be combined with a factor of 1.5 to be applied to the skin friction, and with a factor of 1.7 to be applied to the end bearing.

On the basis of the above, and using the values outlined in the previous table, a 250 mm square pile driven to a depth of 18.00 m bearing within the cohesive Glacial Till shows the estimated pile resistance to be 400 kN, whilst a 350 mm square pile shows the estimated pile resistance to be 550 kN. If the piles were to extend to a depth of 23.00 m, estimated pile resistance would increase to 575 kN and 810 kN respectively.

6.1.2 Bored Piles

Conventional rotary open-bored or continuous flight auger (CFA) piles bearing in the Glacial Till are also considered to be capable of providing a suitable foundation solution. The choice between the two techniques will be largely dependent on the installation levels and the choice of piling rig. In a rotary open-bored pile, the depth and thickness of significant layers of granular soils together with variable groundwater levels within the Alluvium mean that temporary casing will be difficult to install and recover after concreting. As significant thicknesses of granular soils have been encountered, bentonite suspension, or similar such support fluid, may therefore be needed to support the bore during drilling. Such bored piles are unlikely to prove economical for a development of this size and nature.

The use of a continuous flight auger (CFA) technique would avoid the need for temporary casing and/or bentonite to deal with any granular soil and groundwater ingress and potential instability in the fill. Furthermore, the depth of 25.00 m for the stiff cohesive Glacial Till within the 25 m depth range of a medium sized CFA piling rig as might typically be adopted for a development of this size and nature.

BS EN 1997-1:2004; Eurocode 7: Geotechnical Design Part 1 (Eurocode 7) provides factors For CFA bored piles, in the absence of either working load tests or combined working load tests and preliminary pile tests, a model factor of 1.4 should be combined with a factor of 1.6 to be applied to the skin friction, and with a factor of 2.0 to be applied to the end bearing.

On the basis of the above, and using the values outlined in the previous table, 450 mm and 600 mm diameter CFA bored piles constructed to a depth of 18.00 m bearing within the



cohesive Glacial Till shows the estimated pile resistance to be 500 kN and 725 kN respectively. If the piles were to extend to a depth of 23.00 m, estimated pile resistance would increase to 725 kN and 1000 kN respectively.

Specialist piling contractors should be consulted with regard to the design of a suitable piling scheme and their attention should be drawn to potential groundwater inflows present within the Glacial Till.

6.2 Shallow Excavations

On the basis of the observations on site, it is considered that it will not be generally feasible to form excavations without the requirement for lateral support due to the thickness and density of the made ground.

As shallow groundwater has been recorded on site within the made ground, it is recommended that provision be made for battered side slopes or lateral support. Where personnel are required to enter excavations, a risk assessment should be carried out and temporary lateral support or battering of the excavation sides considered in order to comply with normal safety requirements.

6.3 Surface Water Drainage

The soakage testing has measured poor rates of infiltration within the shallow Glacial Till. Provision should therefore be made for attenuation on site and controlled discharge into the main drainage system.

6.4 Ground Floor Slab

The made ground is not considered to provide a suitable bearing material for ground bearing floor slabs.

If piled foundations are to be adopted for the proposed structure, a suspended floor slab should be assumed to avoid any damage caused by differential settlement.

6.5 Pavement Design

A series of equivalent CBR tests in the form of a hand-held dynamic cone penetrometer have been carried out at ten locations (CBR01 to CBR10) positioned to provide general coverage of both sites and the results are presented in the appendix.

The testing indicates a high degree of variability within the made ground. Assuming that it will be screened and recompacted during the reprofiling of the site, a CBR of 5% should be achievable, but this will need to be confirmed by additional testing. In areas without such treatment, they should be designed for a CBR value of 'less than 2 %'.

6.6 Effect of Sulphates

Chemical analyses of the made ground have revealed relatively low concentrations of soluble sulphate and pHs which range near neutral to mildly alkaline. The majority of the made ground has a Class DS-1, which shows that an ACEC Class of AC-1s is required for static water conditions and AC-1 is required for mobile water conditions, however four samples of made ground have revealed high concentrations of soluble sulphate, leading to Classes of DS-2 and DS-3, and therefore an ACEC Class of AC-3 is required for mobile water conditions. It is assumed that the majority of the made ground is to remain on site, therefore for any concrete which will come into contact with the made ground, such as pile cap and small-scale structures, DS-3 conditions should be assumed..

Two samples of Alluvium and seven samples of Glacial Till all fall within Class DS-1 conditions showing that an ACEC class of AC-1 for mobile water conditions and AC-1s for static water conditions would be appropriate for the site. The guidelines contained in the digest should be followed in the design of foundation concrete.

6.7 Contamination Risk Assessment

The desk study findings indicate that the site does have a potentially contaminative history as it has been developed with mills and works from sometime between 1893 and 1910 until 2006. The results of the chemical analyses have indicated elevated concentrations arsenic, lead, total PAHs specially benzo(a)pyrene, benzo(b)fluoranthene and dibenz(a,h)anthracene along with widespread asbestos contamination within the made ground.

The exact source of the arsenic, lead and total PAH contamination is unknown but the made ground was noted as containing fragments of extraneous material and it is likely that fragments of such material, for example, ash, clinker, coal or old paint fragments, could account for the elevated concentration. The results of the WAC testing show that this contamination is not likely to be in a soluble state and should not, therefore, pose a risk to adjacent sites, groundwater or buried services.



Asbestos is only a risk to humans if the asbestos fibres become airborne. Given the positive identification of asbestos within eleven samples out of the sixteen samples of made ground tested, it can be assumed that some of the made ground contains a degree of asbestos. Quantification testing revealed the maximum concentration of asbestos found by this investigation to be 0.006 % to less than the detectable limit of 0.001% but it may be present at higher concentrations elsewhere on site.

According to the HSE, there is now significant monitoring evidence available within the ground investigation and remediation industry to suggest that significant visible quantities of bound ACMs will need to be present to give rise to exposures above 0.01 f/ml, equivalent to one tenth of the control limit, unless they are being subject to highly energetic processes (e.g. crushing, power screening and grading of demolition waste and made ground or soil). As the preparation of the site is likely to involve the excavation of the fill material, there is a risk of the release of asbestos fibres.

The results from the six rounds of gas monitoring undertaken are included within the appendix. The results indicate maximum concentrations of methane of 24.0 % and of carbon dioxide of 16.1 %, with minimal positive flow having been measured. These concentrations were not encountered within the last three monitoring visits meaning the methane is likely to have been present in pockets within the made ground and has since dispersed. However, due to the significant thickness of made ground across northern part of the site, it is likely that other pockets exist and therefore recourse to Characteristic Value 2 conditions is recommended.

The British Standard indicates that all building types with CS2 soil gas conditions require a Gas Protection Point score of 3.5, such that gas protection measures would need to include the following:

-  ventilation of confined spaces within buildings;
-  well-constructed raft or ground floor slab;
-  minimum penetration of ground slab by services;
-  low-permeability gas membrane; or

-  a passively ventilated underfloor sub-space with very good performance, which may take the form of an open void or void former beneath a suspended slab or a granular sub-venting layer beneath a raft.

The groundwater monitoring has indicated elevated concentrations of PAH species including anthracene, fluoranthene, benzo(b)fluoranthene, benzo(a)pyrene and indeno(1,2,3-cd)pyrene. Any perched water encountered within the made ground during excavation and site preparation should therefore be pumped into a secure tank or container and disposed of to appropriate treatment facilities as to not spread any such contamination into the surrounding soils.

6.7.1 Services

Consideration will need to be given to the protection of buried plastic potable water supply services laid within the made ground. Details of the proposed protection measures for buried plastic services will need to be approved by the EHO and the relevant service authority prior to the adoption of any scheme. Barrier pipe will be required or additional testing will need to be carried out.

6.7.2 Site Workers

Apart from the physical hazards represented by the fill materials, concentrations of potentially carcinogenic lead have been measured in the shallow soils in the southwest of the site. Site workers should be made aware of the contamination and a programme of working should be identified to protect workers handling any soil. The method of site working should be in accordance with guidelines set out by HSE⁹ and CIRIA¹⁰ and the requirements of the Local Authority Environmental Health Officer. Contractors should be made aware of the presence of asbestos in the soil and appropriate measures taken to prevent exposure and / or fugitive emissions of fibres. These may include but are not limited to:

-  dampening down of ground to minimise the generation of dust;
-  sheeting of stockpiles;
-  road going vehicles separated from potentially contaminated soil by 'clean' haul roads

9 HSE (1992) HS(G)66 *Protection of workers and the general public during the development of contaminated land*
HMSO

10 CIRIA (1996) *A guide for safe working on contaminated sites* Report 132, Construction Industry Research and Information Association



- G wheel wash facilities at the access point to site; and
- G all lorries containing contaminated fully sheeted prior to leaving site.

6.7.3 End Users

In its current form, it is considered there is a risk to human health as there is a viable pathway between the contamination encountered and the end users. It is recommended in locations of proposed soft landscaping, suitable precautions will be required through the removal of sufficient thickness of made ground to allow the placement of certified clean subsoil, topsoil and a brightly coloured anti-dig membrane. The thickness of clean subsoils and topsoil should be at least 300 mm below communal grassed areas and 450 mm below planting beds, in accordance with recommendations from BRE, with an anti-dig membrane placed at the base. It may be possible to reduce the final thickness of cover required, but this will need to be determined once final levels have been established and concentrations of potential contaminants within the imported materials are known. A clean cover system will also have the benefit of protecting end users from any asbestos in the made ground as it will create a barrier between the end users and any airborne fibres which could be released.

6.8 Waste Disposal

Under the Waste Framework Directive, waste is classified as being either Hazardous or Non-Hazardous and landfills receiving waste are classified as accepting hazardous or non-hazardous wastes or the non-hazardous sub-category of inert waste in accordance with the Waste Directive. Waste classification is a staged process and this investigation represents the preliminary sampling exercise of that process. Once the extent and location of the waste that is to be removed has been defined, further sampling and testing may be necessary. The results from this ground investigation should be used to help define the sampling plan for such further testing, which could include WAC leaching tests where the totals analysis indicates the soil to be a hazardous waste or inert waste from a contaminated site. It should however be noted that the Environment Agency guidance WM3¹¹ states that landfill WAC analysis, specifically leaching test results, must not be used for waste classification purposes.

Any spoil arising from excavations or landscaping works, which is not to be re-used in accordance with the CL:AIRE¹² guidance, will need to be disposed of to a licensed tip. Waste going to landfill is subject to landfill tax at either the current standard rate of £126.15 per tonne (about £231.00 per m³) or at the lower rate of £4.05 per tonne (roughly £7.50 per m³). However, the classifications for tax purposes and disposal purposes differ and currently all made ground and topsoil is taxable at the 'standard' rate and only naturally occurring soil and stones, which are accurately described as such in terms of the 2011 Order, would qualify for the 'lower rate' of landfill tax.

Based on the technical guidance provided by the EA it is considered likely that the soils encountered during this ground investigation, as represented by the chemical analyses carried out, would be generally classified as follows.

Soil Type	Waste Classification (Waste Code)	WAC Testing Required Prior to Landfill Disposal?	Current applicable rate of Landfill Tax
Made ground (TP04 – 1.10 m)	Hazardous (17 05 03)	Yes	£126.15/tonne (Standard rate)
Made ground	Non-hazardous (17 05 04)	No	£126.15/tonne (Standard rate)
Alluvium and Glacial Till	Inert non-hazardous (17 05 04)	Should not be required but confirm with receiving landfill	£4.05 / tonne (Reduced rate for uncontaminated naturally occurring rocks and soils)

Under the requirements of the Waste Directive all waste needs to be pre-treated prior to disposal. The pre-treatment process must be physical, thermal, chemical or biological, including sorting. It must change the characteristics of the waste in order to reduce its volume, hazardous nature, facilitate handling or enhance recovery. The waste producer can carry out the treatment but they will need to provide documentation to prove that this has been carried out. Alternatively, the treatment can be carried out by an approved contractor. The Environment Agency has issued a position paper¹³ which states that in certain circumstances, segregation at source may be considered as pre-treatment and thus excavated material may not have to be treated prior to landfilling if the soils can be segregated onsite prior to excavation by sufficiently characterising the soils insitu prior to excavation.

11 Environment Agency 2015. *Guidance on the classification and assessment of waste*. Technical Guidance WM3 First Edition

12 CL:AIRE March 2011. *The Definition of Waste: Development Industry Code of Practice* Version 2



The above opinion with regard to the classification of the excavated soils is provided for guidance only and should be confirmed by the receiving landfill once the soils to be discarded have been identified. The local waste regulation department of the Environment Agency (EA) should be contacted to obtain details of tips that are licensed to accept the soil represented by the test results. The tips will be able to provide costs for disposing of this material but may require further testing.

7.0 Outstanding Risks & Issues

This section of the report aims to highlight areas where further work is required as a result of limitations on the scope of this investigation, or where issues have been identified by this investigation that warrant further consideration. The scope of risks and issues discussed in this section is by no means exhaustive, but covers the main areas where additional work may be required.

7.1 Site-Specific Risks

Monitoring of the standpipes should be continued to determine equilibrium groundwater levels and to establish any seasonal fluctuations. In addition, any perched water encountered during excavation should be pumped into a secure tank or container and left to dry, with remaining material tested and disposed of appropriately.

The full six rounds of gas monitoring have not yet been completed, meaning no characteristic value can be given, however at this time, gas protection measures are anticipated to be required.

If any obstructions are anticipated below the proposed structure, they will need to be removed to avoid any issues for the piling rigs and the formation of hard spots causing differential settlement.

This investigation has identified the presence of contamination and there is a requirement for a separate remediation proposals report to be prepared to comply with planning requirements. The remediation will need to be supervised and verified by a geoenvironmental engineer and a completion or validation report will also probably be required to support the planning application.

These areas of doubt should be drawn to the attention of prospective contractors and further investigation will be required or sufficient contingency should be provided to cover the outstanding risk.



7.2 General Risks

The ground is a heterogeneous natural material and variations will inevitably arise between the locations at which it is investigated. This report provides an assessment of the general ground conditions based on the discrete points at which the ground was sampled, but there may be ground conditions (including soil, rock, gas and groundwater) elsewhere on site that have not been revealed by this investigation and therefore could not have been taken into account in this report. The ground conditions should be subject to review as the development proceeds to ensure that any variations from the Ground Model are properly assessed by a suitably qualified person.

The comments made regarding gas and groundwater are based on observations made during the period the work has been carried out. Conditions may vary as a result of seasonal or other effects.

Where any conclusions and recommendations contained in this report have been based upon information provided by others, it has been assumed that all relevant information has been provided by those parties and that such information is accurate. Any such information has not been independently verified by GEA, unless otherwise stated in the report. GEA accepts no liability for any inaccurate conclusions, assumptions or actions taken resulting from any inaccurate information supplied to GEA from others.