

5.7. CONCRETE DURABILITY

Based upon the results of the chemical analyses it is considered that subsurface concrete can be designed in accordance with Design Sulphate Class DS-1, Aggressive Chemical Environment for Concrete Classification (ACEC) AC-1s in accordance with the recommendations provided in BRE *Special Digest 1* (2005).

5.8. EXCAVATIONS

The sides of the exploratory trial pit excavations appeared to be generally stable during excavation in Made Ground and natural strata.

Site observations indicated that excavations should be feasible in the near surface with normal plant; however, obstructions were identified in the near surface, including concrete and brick obstructions associated with historical landfilling, former foundations and former floor slabs. It is anticipated that any obstructions will be grubbed out during the reduced-level dig for the substructure works.

However, due to the depth and variability of the Made Ground and likelihood of trench collapse, it is considered that all excavations are supported or battered back in accordance with guidance contained in CIRIA R97.

If local pumping of groundwater is required during the advancement of excavations for the proposed foundations then consideration should be given to the potential for dewatering gravels in the surrounding areas that may cause structural damage to building substructures in close proximity to the site.

TABLE 5.4 CIVIL ENGINEERING EXCAVATION RISK MATRIX

RISK ITEM	PRESENT	COMMENT
Running Sands	No	No running sand has been identified.
Minor Water Ingress	No	No groundwater was encountered during the site investigation. Water ingress will require localised dewatering/sump pumping during the construction of site drainage infrastructure. Ingress of water into foundation excavation will potentially flood foundation excavations, limiting the viability of spread foundations to be constructed.
Shallow Bedrock	No	Shallow bedrock has not been identified.



5.9. CONSTRUCTION ACTIVITY AND INSPECTION

The following activities and inspections should be incorporated into the site works:

- ✳ Due to the variability of the soils at the site, it is recommended that sufficient allowance is made for the inspection of formations and sub-formations to foundations and pavement construction.
- ✳ Excavations where access is required should be subject to a risk assessment from a competent person and, where appropriate, mitigation measures such as benching back the sides or use of support systems in accordance with CIRIA R97 should be utilised.
- ✳ It is considered that dewatering may be required, especially following periods of heavy rainfall. Removal of surface water and water within trenches should be possible with conventional sump pumping. Discharge of any water should be agreed with the relevant regulatory body and be undertaken under a trade effluent discharge, where required. Measures to remove silt and suspended solids may be required and consideration should be given to provision of space for settling tanks or an attenuation pond.
- ✳ Where access to confined spaces is required, appropriate mitigation measures should be addressed within the construction stage health and safety plan. Particular account should be taken of the gas results.
- ✳ The presence of potential contamination and mitigation measures should be addressed as part of the construction stage health and safety plan and should include measures to design out the risks, reduce their impact and, finally, to include the use of personnel protective equipment (PPE).



5.10. GEOTECHNICAL RISK REGISTER

POTENTIAL CONSTRAINT	ABNORMAL	LOCATION ON SITE	ESTIMATED AREA OF SITE AT RISK (%)	ASSESSMENT AND MITIGATION
Remediation of contaminated soils		South	50-100%	Elevated total mercury encountered in the Made Ground in TP101 presents a potential volatilisation to indoor air risk (speciation required to confirm). Material deemed to have a potential vapour risk may require hotspot removal, resulting in the requirement to backfill the resulting void. Asbestos was detected within two samples of Made Ground. Remediation may include delineation as a hotspot and removal from site or placement at a depth of >1.00 m below finished level in residential plots, gardens or POS. Elevated concentrations of heavy metals, PAH compounds and heavy end TPH have been encountered in in samples taken from the southern sector of the site (associated with area of former landfill), however, given the sitewide spread of Made Ground, it would be considered prudent to apply the cover system to all plots where Made Ground remains at proposed development level.
Bedrock		N/A	N/A	Shallow bedrock has not been identified.
Obstructions		All	50%	Site has been subject to historical development and infilling associated with the former residential properties to the north and the historical landfill to the south. Significant brick and concrete slabs were encountered in the southern sector and intact bricks and relict foundations were also encountered in the northern sector. All obstructions will require grubbing out and removal in their entirety.
Trench collapse		All	100	Made Ground present beneath the site may be prone to collapse.
Mature trees		Centre and boundaries	50	Arboriculture survey required to determine areas of potential tree influence. Piled foundations likely to be required in areas of tree influence.



POTENTIAL CONSTRAINT	ABNORMAL	LOCATION ON SITE	ESTIMATED AREA OF SITE AT RISK (%)	ASSESSMENT AND MITIGATION
Volume Change Potential Clay		All	100%	The clay soils are of low volume change potential. Arboriculture survey required to determine areas of potential tree influence. Piled foundations likely to be required in areas of tree influence.
Peat		N/A	N/A	Peat has not been identified within the site investigation.
Running Sands		N/A	N/A	Data searches indicate low risk.
Ground Dissolution		N/A	N/A	Data searches indicate no hazard.
Concrete Design		All	100%	The soils meet class DS-1, AC-1s.
Low-Permeability Ground		On site	70	Soakaways unlikely to be effective in areas where low permeability cohesive deposits are present or where areas of potentially contaminated soil and groundwater are present.
Services/Sensitive Structures		All	40	A full ground penetrating radar (GPR) survey has not been undertaken for the site; however, a full review of the available service plans has identified the following services: ✿ A low pressure gas main and water distribution main enter the site in the northeastern corner and run northwest (following same route). ✿ Low voltage electric cables enter the site in the east and run north and south towards a junction box. A further low voltage cable enters the site in the southwest and runs northeast. ✿ Foul and combined sewers (150 mm and 825 mm diameter) enter the site in the northeast and run along the north eastern boundary. Other surface water (225 mm) and combined (225 mm) sewers run north east through the site to join sewers in the main road. Driven piling may be restricted within close proximity to sensitive infrastructure.



POTENTIAL CONSTRAINT	ABNORMAL	LOCATION ON SITE	ESTIMATED AREA OF SITE AT RISK (%)	ASSESSMENT AND MITIGATION
Historically Infilled Features		South	30%	There is an area of historical landfill which encroaches into the site from the south. The type of waste included inert and industrial waste. Deep boreholes have confirmed the fill extends to at least 7.10 m bgl. The highwall of the former landfill will need to be accurately located and extent delineated. Foundations straddling the highwall will require an engineered foundation solution to tolerate potential differential settlement (raft).
Abnormal Foundation Solutions		All	100%	Given the ground conditions encountered and considering future potential cut/fill works to create a development platform, foundation options may include: ✿ Piled foundations in areas of tree influence where cohesive soils are present and in area of former landfill in the southern sector where fill extends to depths >7.0 m bgl. ✿ Ground improvement using VSC in areas of deep Made Ground outside of tree influence or landfill area. ✿ Raft foundations for plots straddling the landfill highwall to mitigate risks of potential differential settlement. ✿ In the centre of the northern sector, it may be possible to utilise deep mass trench foundations, where firm CLAY is present at depths shallower than 2.50 m bffl, outside of tree influence.
Areas Not Investigated		North and Centre	50%	Several services are present within the site boundary, therefore easements had to be applied and exploratory hole locations could not be advanced within these areas.



Kenyon Lane, Failsworth

Phase II Geoenvironmental Site Assessment

September 2023

POTENTIAL CONSTRAINT	ABNORMAL	LOCATION ON SITE	ESTIMATED AREA OF SITE AT RISK (%)	ASSESSMENT AND MITIGATION
				An area of woodland is also present in the centre of the site, occupying approximately 35-40% of the entire site area, therefore exploratory hole locations could only be advanced to the north and south.



5.11. FURTHER WORKS

Based on the findings of the intrusive site investigation, the following additional works are recommended to be completed in due course:

- ✦ Further investigation in centre of site following tree removal (if proposed).
- ✦ Completion of ground gas monitoring programme.
- ✦ Collection of groundwater samples, subject to groundwater depth.
- ✦ Location/delineation of landfill highwall in southern sector.
- ✦ Plot-specific foundation schedule (upon receipt of the final development levels).
- ✦ Arboricultural survey.
- ✦ Geotechnical earthworks strategy (infrastructure).
- ✦ Remediation and enabling works strategy.



6. CONCLUSIONS AND RECOMMENDATIONS

6.1. CONTAMINATED LAND ASSESSMENT

Human Health	A Tier II human health risk assessment identified exceedances of residential end use with plant uptake GAC values for the following contaminants in samples taken from the southern sector of the site (associated with area of former landfill): ☛ Lead, arsenic and mercury [potentially volatile] ☛ Benzo(b)fluoranthene, Benzo(a)Pyrene and Dibenzo(a,h)Anthracene ☛ TPH Aromatic C12-C16 ☛ Chrysotile and Amosite asbestos fibres at 0.003% wt/wt and Chrysotile at 0.002% wt/wt Elevated total mercury encountered in the Made Ground in TP101 presents a potential volatilisation to indoor air risk (speciation required to confirm). Material deemed to have a potential vapour risk may require hotspot removal, resulting in the requirement to backfill the resulting void. Asbestos was detected within two samples of Made Ground. Remediation may include delineation as a hotspot and removal from site or placement at a depth of >1.00 m below finished level in residential plots, gardens or POS Risks associated with heavy metals, PAH compounds and heavy end TPH can be mitigated through installation of a clean cover system in gardens and soft landscaped areas. These have been encountered in samples taken from the southern sector of the site (associated with area of former landfill), however, given the sitewide spread of Made Ground, it would be considered prudent to apply a cover system to all plots where Made Ground remains at proposed development level. Chemical analysis of natural subsoils has indicated these soils to be acceptable for use as subsoil within the proposed garden areas; however, further chemical validation samples will be required to confirm this. Two samples of the reworked topsoil (noted to contain brick and anthropogenic inclusions) were also submitted for chemical analysis (TP102 and WS106). Chemical analysis has indicated these soils to be acceptable for use as topsoil within the proposed garden areas; however, further chemical validation samples will be required to confirm this. Should material be found to be chemically suitable, inspection of the soil composition should be undertaken along with suitable screening of unsuitable anthropogenic inclusions.
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Controlled Waters	The primary receptor has been identified as the underlying principal aquifer (bedrock). No exceedances of DWS values have been found in the two leachate samples analysed. It has not been possible to obtain groundwater samples for a full appraisal due to boreholes either being dry or containing insufficient volumes of water. The drift deposits across the site are variable. Given the presence of lower permeability fine grained soils which will reduce downward migration of contamination and the absence of any exceedances in the leachate, or shallow groundwater to mobilise soil contamination, the overall risk may be considered low. Given the absence of a groundwater abstraction point or surface watercourse within close proximity to the site, there is not considered to be a complete pollutant linkage. However, given the nature of the site and presence of deep Made Ground / landfill materials, it would be prudent to obtain water samples for assessment if resting water levels are found to rise over the monitoring period.
Ground Gas	The southern part of the site forms part of a larger historical landfill and deep Made Ground (up to 7.10 m bgl in CP102), with degradable inclusions of wood and timber have been encountered. Other degradable organic materials may be present at intervening locations and cannot be discounted. WS102, WS103, WS104 and WS106, predominantly in the south of the site and area of former landfill, have recorded carbon dioxide above 5% v/v threshold, however the GSV is noted to be within a CS1 classification due to the absence of flow. A precautionary allowance for CS2 gas protection measures is recommended at this stage. The final classification will be confirmed on completion of the full ground gas monitoring programme.
Potable Water	Barrier pipe likely to be required. This will need to be confirmed following the completion of a UKWIR risk assessment. Post-remediation and enabling works ground conditions may be different from those identified during this site investigation.



6.2. GEOTECHNICAL ASSESSMENT

Frequent concrete and brick obstructions have been identified, indicative of historical landfilling in the southern sector of the site and relict foundations in the northern sector. During a phase of cut-and-fill enabling works to create a developable platform, all obstructions (including redundant services) will require grubbing out to enable the construction of proposed plots.

The suitable target founding stratum has been identified as the underlying firm to stiff CLAY or medium dense silty SAND (if encountered). Based on existing levels, the depth to suitable founding strata is generally greater than 2.50 m bgl due to the presence of deep Made Ground and unsuitable soft low strength shallow SILT deposits.

In addition, there is an area of historical landfill which encroaches into the site from the south, with fill extending to at least 7.10 m bgl. The highwall of the former landfill will need to be accurately located and extent delineated.

An area of woodland is also present in the centre of the site, occupying approximately 35-40% of the entire site area, therefore exploratory hole locations could only be advanced to the north and south. The clay soils are of low volume change potential. An arboriculture survey is required to determine areas of potential tree influence.

At this time it is not possible to accurately define the foundation types due to the absence of a detailed tree survey and final development levels; however, given the ground conditions encountered and considering future potential cut/fill works to create a development platform, foundation options may include:

- ✿ Piled foundations in areas of tree influence where cohesive soils are present and in area of former landfill in the southern sector where fill extends to depths >7.0 m bgl.
- ✿ Ground improvement using VSC in areas of deep Made Ground outside of tree influence or landfill area.
- ✿ Raft foundations for plots straddling the landfill highwall to mitigate risks of potential differential settlement.
- ✿ In the centre of the northern sector, it may be possible to utilise deep mass trench foundations, where firm CLAY is present at depths shallower than 2.50 m bffl, outside of tree influence.

Foundation depths should take account of the presence of existing and proposed trees with foundations deepened locally, to mitigate the potential for volumetric instability attributed to fluctuations in moisture content, in accordance with the requirements of NHBC standards.

END OF REPORT



APPENDIX I LIMITATIONS

1. This report and its findings should be considered in relation to the terms of reference and objectives agreed between E3P and the client as indicated in Section 1.3.
2. For the work, reliance has been placed on publicly available data obtained from the sources identified. The information is not necessarily exhaustive and further information relevant to the site may be available from other sources. When using the information it has been assumed it is correct. No attempt has been made to verify the information.
3. This report has been produced in accordance with current UK policy and legislative requirements for land and groundwater contamination which are enforced by the local authority and the Environment Agency. Liabilities associated with land contamination are complex and requires advice from legal professionals.
4. During the site walkover, reasonable effort has been made to obtain an overview of the site conditions. However, during the site walkover, no attempt has been made to enter areas of the site that are unsafe or present a risk to health and safety, are locked, barricaded, overgrown, or the location of the area has not been made known or accessible.
5. Access considerations, the presence of services and the activities being carried out on the site limited the locations where sampling locations could be installed and the techniques that could be used.
6. Site sensitivity assessments have been made based on available information at the time of writing and are ultimately for the decision of the regulatory authorities.
7. Where mention has been made to the identification of Japanese Knotweed and other invasive plant species and asbestos or asbestos-containing materials, this is for indicative purposes only and do not constitute or replace full and proper surveys.
8. The executive summary, conclusions and recommendations sections of the report provide an overview and guidance only and should not be specifically relied upon without considering the context of the report in full.
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10. New information, revised practices or changes in legislation may necessitate the re-interpretation of the report, in whole or in part.



APPENDIX II

GLOSSARY