Phase II Geoenvironmental Site Assessment
Standen Central Site
Clitheroe

Reference:16-499-R2-2
Date: March 2023

PHASE II GEOENVIRONMENTAL SITE ASSESSMENT

Standen Central Site
Higher Standen
Clitheroe
BB7 1PR

Prepared for:
Eric Wright

ERIC WRIGHT
CONSTRUCTION

Report Ref: 16-499-R2-2
Date Issued: March 2023

E3P

Taylor Road
Trafford Park
Urmston
Manchester
M41 7JQ

+ 44 (0) 161 707 9612
https://e3p.co.uk

Registered in England
CRN: 08725262

QUALITY ASSURANCE

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CHECKED BY	R Walker	R Walker	
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AUTHORISED BY	M. Dyer	R Walker	
QUALIFICATIONS	BSc(Hons), FGS, AIEMA, MIEnvSc, CEnv	BSc(Hons), FGS, AIEMA, AMICE, MIEnvSc, CEnv	

EXECUTIVE SUMMARY

Site Address	Higher Standen. Clitheroe, BB7 1PR	
Grid Reference	E 374890, N 440702.	
Site Area	0.97 Ha.	
Proposed Development	Eric Wright Construction Ltd intends to assist in the construction of a new care facility.	
Current Site Use	The subject site is triangular in shape and located in the southeast of Clitheroe. The subject area forms a part of the wider proposed future residential development and so the boundary falls oddly within the field boundaries existing currently. The land is currently unoccupied agricultural land with a hedgerow in the north and a tree to the centre of the site. The site is predominantly vegetated with no structures present.	
Site History	A review of the pertinent Ordnance Survey mapping suggests that the site comprised agricultural land from before 1847 to present day. The only significant change recorded was the removal of field boundaries between circa 1848 and circa 1884.	
Environmental Setting	**Drift Geology**	Till – Devensian (DIAMICTON)
	Bedrock Geology	Clitheroe Limestone Formation and Hodder mudstone Formation – Undifferentiated (MUDSTONE)
	Faults	There are no fault lines within influencing distance of the site.
	Hydrogeology	Secondary A bedrock aquifer with a secondary undifferentiated superficial aquifer. No groundwater abstraction licences are recorded within 1 km of the site.
	Hydrology	The nearest off-site surface water feature is a drainage ditch 140 m to the northeast. Due to the local topography, it is likely that any shallow groundwater if present will flow in a south westerly direction towards tributaries of the River Ribble (2.00km west).
	Flood Risk	Unaffected by flooding from rivers.
Utility Locations	A formal drainage survey has not been completed, however, the site is undeveloped agricultural land and is not expected to have utilities present. A review of utility mapping suggests major infrastructure can be found in the surrounding residential developments. A drainage ditch connecting to Pendleton brook is noted to the west.	
Landfill Sites and Ground Gases	No landfill sites (current or historic) are located within 250 m of the site. Historic field boundaries have been changed which may present infilled deposits. However, no historical development has occurred and as such limited ground gas is expected to be produced onsite.	

Radon	Between 1-3% of houses are noted to be above the 'Action Level' however, no special precautions are required in the construction of new structures at the site.
Coal Mining/Land Stability	The site is not located within a coal mining reporting area and therefore is not in an area that may be affected by coal mining. No further assessment is considered necessary.
Hazardous Installations	No hazardous installations that could potentially prejudice the proposed construction of highly sensitive residential dwellings have been identified within influencing distance of the subject site.
Initial Conceptual Site Model	**Contaminant Sources:** • Made Ground (historical field boundaries) – Polycyclic Aromatic Hydrocarbons (PAHs), heavy metals, Asbestos containing materials (ACMs), gases **Pathways:** • Direct contact and ingestion • Volatilisation/indoor explosion • Vapour inhalation • Dust inhalation • Vertical and lateral migration • Direct uptake by flora and fauna **Receptors:** • Future site users (end-users and construction workers) • Buildings (proposed care facility) • Underlying aquifer (Bedrock Secondary A aquifer)

GROUND INVESTIGATION

Ground Investigation Works	E3P has completed an intrusive ground investigation comprising: • 15 x mechanically excavated trial pits, • 6 x window sample boreholes, • 3 x BRE365 soakaway tests, • 5 x hand dug pits, • 6 x Dynamic Cone Penetrometers, • 3 x In-situ California bearing ratio (CBR), • 2 x Cable Percussive Boreholes • Construction of environmental monitoring installations.
Ground Conditions	**Topsoil – 0.00m bgl to 0.35m bgl** Natural topsoil was encountered as a dark brown silty sandy CLAY with frequent rootlets across the majority of the site. Topsoil was encountered to a maximum depth of 0.35m below ground level (bgl).

Ground Conditions	**Made Ground – 0.00m bgl to 1.20m bgl** Made Ground deposits were encountered within four exploratory hole locations to depths of between 0.20m and 1.20 m bgl to the west of the site, in the area cleared for an access track associated with the school development, adjacent to the western boundary of the site. Within TP106 and WS103 Made Ground deposits comprised a reworked topsoil, within TP105, brick was encountered within the topsoil and underlying clay to 0.70m bgl and a brick land drain was encountered within TP101a at 1.00m bgl.
	DRIFT – 0.15mbgl to >17.00mbgl Drift deposits were encountered within all exploratory locations to a maximum proven depth of 17.00m bgl. The drift deposits generally comprised a greyish brown mottled orange slightly sandy CLAY overlying a very stiff greyish brown sandy gravelly CLAY with occasional cobbles and boulders of mudstone. Gravel also comprised of mudstone. Granular drift deposits were identified in CP101 and CP102 between, 3.00 and 8.00m bgl and comprised a medium dense to dense greyish brown SAND and GRAVEL. Lenses of clay were encountered with CP102. Hand pits dug to 0.90m bgl within the bund to the west of the site, confirmed the bund comprised topsoil, overlying a stiff CLAY.
	SOLID The solid bedrock geology was not encountered during the site investigation. Additionally, the depth to bedrock is not recorded within any nearby freely available BGS borehole records.
	GROUNDWATER – Groundwater was not encountered during the site investigation.

CONTAMINATED LAND ASSESSMENT

Human Health	A Tier I human health risk assessment has been undertaken using the chemical analysis results of 21no soil samples and comparing to the relevant Tier I criteria - residential end use with plant uptake. This assessment has not identified any Tier 1 screening value exceedances on the sampling undertaken to date. Asbestos has not been identified in any of the soils submitted for analysis. Two samples were analysed for volatile organic compound (VOC) and semi-volatile organic compound (SVOC) screening; no elevated VOC or SVOC values were identified from the testing. Chemical analysis of the natural CLAY drift deposits has identified 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. A preliminary chemical analysis of the natural topsoil has identified these soils to be acceptable for use within the proposed garden areas; however, further chemical validation samples will be required to confirm this. Where reworked topsoil is present, this material is not deemed to be suitable for use within proposed garden areas.
Controlled Waters	A low risk to controlled waters has been identified.

Ground Gas	Ground gas monitoring confirms the site is classified as Characteristic Situation 1/Green.
Potable Water Infrastructure	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. Current chemical analysis of soils at the site suggests the polyethylene (PE) pipeline will be suitable for development.

GEOTECHNICAL ASSESSMENT

Underground Obstructions	During a phase of cut-and-fill enabling works to create a developable platform, all below-ground obstructions will require grubbing out to the base of the Made Ground to enable the construction of the proposed plot. To date, no obstructions have been encountered and given the lack of development across the site historically, there are not expected to be substantial anthropogenic obstructions present.
Allowable Bearing Pressure	The underlying natural clay drift deposits have been assessed as being stiff, high strength to very stiff, very high strength. Stiff clay deposits between 1.00m and 2.45m had a net allowable bearing pressure (ABP) of 93 kN/m^2 to 135 kN/m^2. Very stiff clay deposits between 1.00m and 5.00m had an ABP of 160 kN/m^2 to 464 kN/m^2. Very stiff deeper clay deposits from 6.50m to 17.00m bgl, had an ABP of 308 kN/m^2 to 390 kN/m^2. Granular drift deposits were encountered within CP101 and CP102 between 3.00m and 8.00m bgl and were assessed as medium dense with an ABP of 235 kN/m^2 to 290 kN/m^2 from 3.00m to 5.00m bgl and dense between 5.00m and 8.45m bgl, with an ABP of 324 kN/m^2 to 327 kN/m^2
Foundation Options	Based on the assessment of the relative undrained shear strength, relative in-situ densities and corresponding safe net allowable bearing pressure, the suitable target founding stratum has been identified as the underlying stiff medium strength to very stiff very high strength CLAY. Dependent on development levels, it is considered that the optimum foundation solution would be a combination of the following: - Strip/trench foundations bearing into competent stiff to very stiff (medium to very high strength) CLAY - Trench fill to support reinforced strip foundations in areas of variable ground and/or potential tree influence. Foundation depths within the conjectured influence of former, existing or proposed trees will need to be deepened to ensure that structural loading bears within the underlying target founding stratum, which cannot be subject to volumetric instability associated with fluctuation in moisture content. During a phase of cut-and-fill enabling works to create a developable platform, all below-ground obstructions will require grubbing out to the base of the Made Ground to enable the construction of the proposed plot.

Building Floor Slabs	Ground-bearing floor slabs are unlikely to be viable, given the shallow cohesive soils. However, where a ground-bearing slab is required as part of the design, this should be detailed by the structural engineer with tolerance for potential instability and volumetric change in below-ground soils.
Heave Precautions	Given that the underlying clay is of low volume change potential, heave precautions will not be required for the internal face of a foundation less than 1.5 m in depth. Heave precautions will be required to the underside of floor slabs (where there is no 200 mm void), and pile ground beams are required within the modelled influencing distance of trees.
Soakaway Drainage	Shallow natural deposits comprise cohesive clays. Soakaway testing in line with BRE 365 was undertaken in three locations (SA101 – SA103). Within all three locations, soakaway testing failed, with the water level failing to soakaway below 75% effective storage. As such, soakaway drainage is not unlikely to be suitable on the site.
Sulphate Assessment	The concrete classification will be DS1 AC1s.
CBR Design %	Granular soils can be re-engineered to ensure 5% within the subgrade during favourable climatic conditions. Natural clay soils will provide a CBR in the order of 3–5% during drier climatic periods. However, if water is allowed to shed onto the formation, the CBR will reduce to < 2%, which will require specialist engineering of the subgrade.
Cut/Fill	Development levels are unknown at this time; however, cut-and-fill work will be required to prepare the development platform. The site 'strip' works will also generate a significant quantum of topsoil; this is likely to result in a net excess that may require removal from the site.
Civil Engineering Excavations	The E3P intrusive ground investigation has not identified the presence of shallow bedrock. It is anticipated excavations can be undertaken using standard plant equipment. Due to the presence of low permeability cohesive deposits across the site, 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 upon 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 the provision of space for settling tanks or an attenuation pond.
Waste Characterisation	Any material that is to be disposed off-site should undergo assessment using Technical Guidance WM3: *Waste Classification – Guidance on the classification and assessment of waste*.

RECOMMENDATIONS

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

- Plot-specific foundation schedule (upon receipt of the final development levels).
- Arboricultural survey.
- Geotechnical earthworks strategy (infrastructure).
- Remediation and enabling works strategy.

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DRAWING LIST

16-499-001 - Site Location Plan
16-499-002 - Proposed Development Plan
16-499-004 - Site Features Plan
16-499-003 - Historical Features Plan
16-499-005 - Exploratory Hole Location Plan
16-499-006 - Depth of Made Ground Plan
15-898-007 - Depth of Topsoil Plan
16-499-008 - Depth to Founding Strata Plan
16-499-010 - Conceptual Site Model

1. INTRODUCTION

1.1. BACKGROUND

Eric Wright has commissioned E3P on behalf of their client (Wrightcare) to undertake a detailed Phase II Geoenvironmental Site Assessment for a parcel of land known as Higher Standen Farm, Clitheroe, BB7 1PR.

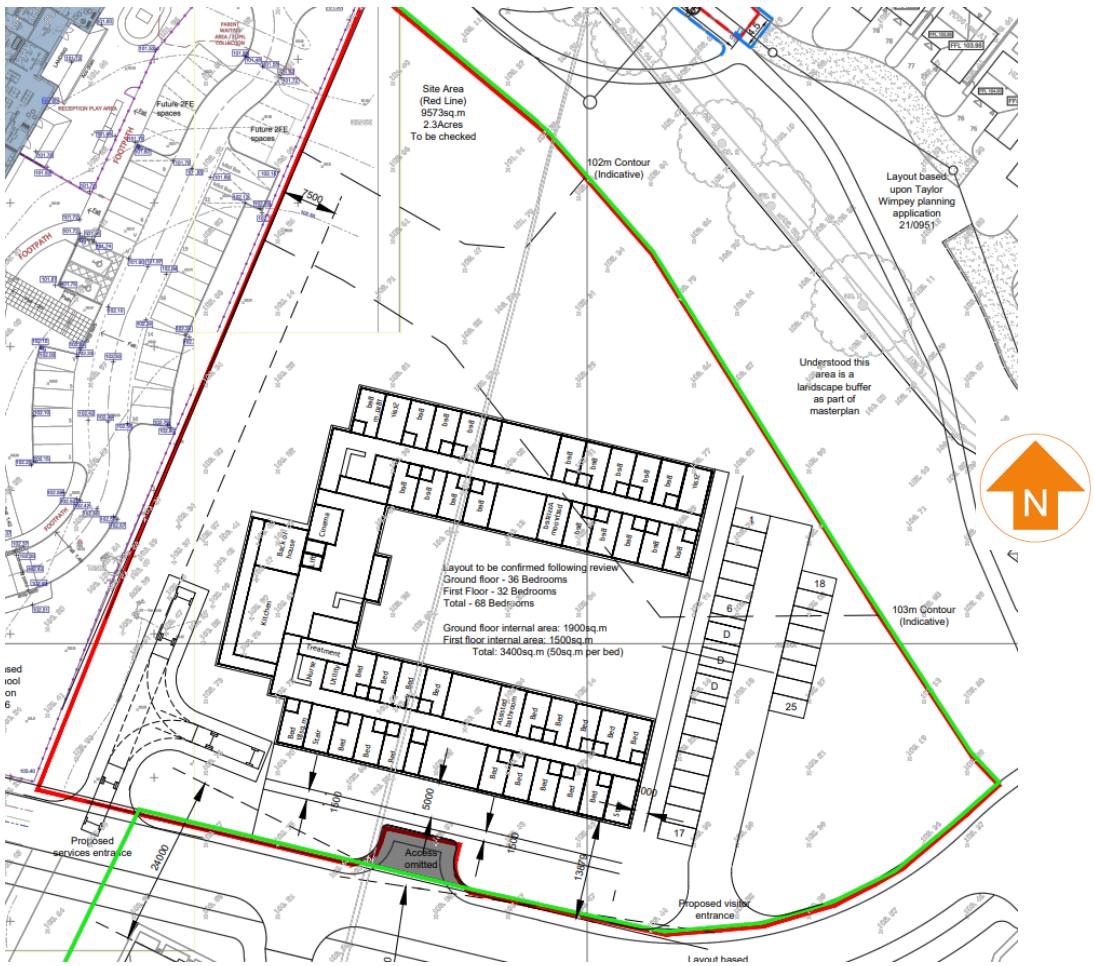
This report is required to determine potential contaminated land liabilities, remediation requirements and geotechnical engineering works that will be required as part of the proposed development for a proposed Care Home development.

1.2. PROPOSED DEVELOPMENT

Eric Wright, on behalf of Wrightcare, intend to construct a new care facility.

A snapshot of the proposed development layout is indicated in Figure 1.1.

FIGURE 1.1 SNAPSHOT OF THE PROPOSED DEVELOPMENT



1.3. OBJECTIVES

The objectives of the geoenvironmental assessment are as follows:

- Review historical plans, geology, hydrogeology, site sensitivity, floodplain issues, mining records and any local authority information available in order to complete a desk study in line with Environment Agency (EA) document *Land Contamination:Risk Management (LCRM) (2019).*
- Undertake a preliminary stage of sampling and analysis to provide an overview of environmental issues identified.
- Assess the implications of any potential environmental risks, liabilities and development constraints associated with the site in relation to the future use of the site and in relation to off-site receptors.
- Assess the geotechnical information and provide preliminary recommendations in relation to foundations, pavement construction and floor slabs.
- Provide recommendations regarding future works required.

1.4. SCOPE OF WORKS

The scope of work includes the following elements:

- Detailed review of historic information;
- Design of suitable intrusive ground investigation;
- Window sample probeholes with, and construction of, environmental monitoring installations;
- Deep cable percussive boreholes;
- Mechanically excavated trial pits;
- BRE365 permeability soakaway testing;
- In-situ geotechnical testing;
- Chemical and geotechnical laboratory analysis;
- Groundwater monitoring and sampling;
- Ground gas monitoring;
- Contamination risk assessment and conceptual site model;
- Geotechnical assessment and interpretation; and
- Factual and interpretive reporting.

1.5. LIMITATIONS

The limitations of this report are presented in Appendix I.

1.6. CONFIDENTIALITY

E3P has prepared this report solely for the use of the client and those parties with whom a warranty agreement has been executed, or with whom an assignment has been agreed. Should any third party wish to use or rely upon the contents of the report, written approval must be sought from E3P; a charge may be levied against such approval.

2. GROUND INVESTIGATION

2.1. GENERAL OVERVIEW

A ground investigation has been designed based on the findings of the desk study, with exploratory holes advanced to target specific potential contaminant sources identified within the previous site investigations. The investigation has also been used to collect geotechnical information to assist in the design and construction of the proposed development.

Exploratory fieldwork was completed between 19th December 2022 and 20th December 2022. The works are summarised in Table 2.1.

2.2. SCOPE OF INVESTIGATION

TABLE 2.1 SUMMARY OF FIELDWORK

POTENTIAL SOURCE/RATIONALE	LOCATION HOLE	TYPE	MAXIMUM DEPTH (m bgl)	MONITORING WELLS RESPONSE ZONE (m bgl)
General Ground Conditions, Including the Presence/Nature of Obstructions	WS101	Window Sample Probehole	4.95	N/A
	WS102		3.42	1.00-3.00
	WS103		4.34	1.00-4.00
	WS104		3.42	N/A
	WS105		3.23	1.00-3.00
	WS106		5.45	1.00–5.00
Investigation of Deeper Soil Horizons	CP101	Cable Percussive Borehole	14.32	N/A
	CP102		17.32	N/A
General Ground Conditions / Investigation of Permeability Characteristics	SA101/TP101b	Mechanically Excavated Trial Pit/ Soakaway Test Location	2.10	N/A
	SA102/TP102		1.70	N/A
	SA103/TP103		1.90	N/A
General Ground Conditions Including the Presence/Nature of Obstructions	TP101a and TP104-TP115	Mechanically Excavated Trial Pit	2.80	N/A
Investigation of bund on site	HP101-HP105	Hand Pit	0.95	N/A

Mechanically excavated trial pits were advanced to investigate ground conditions and to retrieve environmental samples, spatially distributed to offer the maximum site coverage whilst also being advanced to target specific contaminant sources.

Window sample probeholes were advanced to undertake in-situ detailed geotechnical testing, obtain environmental samples and install groundwater and ground gas monitoring wells.

Deep cable percussive boreholes were advanced to undertake in-situ detailed geotechnical testing and investigate groundwater beneath the site.

Hand pits were dug into the bund onsite to investigate ground conditions and obtain environmental samples to identify if the materials required disposal as a waste or could be utilised within the future development.

The sampling locations are illustrated in Drawing 16-499-005 (Appendix III). The ground conditions encountered are indicated on the logs, which are provided in Appendix V.

Return visits were made to monitor installations for groundwater level and gas concentrations. In addition, selected wells were purged and samples of groundwater recovered for chemical analysis.

2.3. IN-SITU STANDARD PENETRATION TESTING (SPT)

In-situ geotechnical testing was conducted using the standard penetration test (SPT) and, where the ground is granular, a 60° cone (SPT(C)) was used instead of the sampling tube. The results are shown in the probehole logs in Appendix V and presented in Table 3.6 and discussed in Section 5.

2.4. IN-SITU CALIFORNIA BEARING RATIO (CBR)

In-situ CBR tests were undertaken at selected locations using a TRL probe. Tests were undertaken at depths of between 0.3 m and 1 m below ground level in order to intersect the likely pavement sub-formation level. The results are presented in Table 3.9, and test certificates are included in Appendix X.

2.5. PERMEABILITY TESTS

BRE 365 soakaway tests were undertaken within trial pits SA101-SA103 in order to assess the likely permeability of the underlying strata to determine the potential suitability for soakaway drainage within the proposed development. The results are presented in Table 3.7 and the test certificates are included in Appendix IX.

2.6. LABORATORY ANALYSIS

Selected soil samples were submitted for a range of chemical analysis comprising:

- Metals.
- pH, total sulphate, water-soluble sulphate (2:1 extract).
- Sulphide.
- Cyanide.
- Phenols.
- Total and speciated polycyclic aromatic hydrocarbons (PAHs).
- Semi Volatile Organic Compounds (SVOC).
- Volatile Organic Compounds (VOC).
- Asbestos identification and quantification.
- Speciated and banded total petroleum hydrocarbon (TPH).

I2 Analytical undertook the analytical work and the testing results are included in Appendix VI and discussed in Section 4.

Selected samples were submitted to PSL Laboratory where the following geotechnical tests were undertaken:

- Atterberg limits determinations;
- Moisture Content;
- Consolidation Tests;
- Single-stage triaxial tests.

Laboratory analysis sheets are included in Appendix VIII, summarised in Section 3 and discussed in Section 5.

3. GROUND AND GROUNDWATER CONDITIONS

3.1. SUMMARY OF GROUND CONDITIONS

The ground investigation generally confirms the published geology and identifies the strata set out in Table 3.1.

TABLE 3.1 SUMMARY OF STRATA

HOLE	DEPTH TO STRATUM (m bgl)						
	TOPSOIL	MADE GROUND	CLAY	SANDY CLAY	GRAVELLY CLAY	GRAVELLY CLAY (WITH COBBLES AND BOULDERS)	SAND AND GRAVEL
TP101a	–	0.00–1.20	–	–	–	–	–
SA101/ TP101b	0.00–0.20	–	–	–	–	0.20–2.10	–
SA102/ TP102	0.00–0.30	–	–	0.30–1.00	–	1.00–1.70	–
SA103/ TP103	0.00–0.30	–	–	0.30–0.60	–	0.60–1.90	–
TP104	0.00–0.30	–	–	0.30–0.70	–	0.70–2.00	–
TP105	–	0.00–0.70	–	–	–	0.70–2.10	–
TP106	–	0.00–0.20	–	0.20–0.50	–	0.50–2.80	–
TP107	0.00–0.30	–	–	0.30–1.00	–	1.00–2.50	–
TP108	0.00–0.35	–	–	0.35–1.00	–	1.00–2.00	–
TP109	0.00–0.25	–	–	0.25–0.80	–	0.80–2.60	–
TP110	0.00–0.30	–	–	0.30–0.60	–	0.60–2.00	–
TP111	0.00–0.30	–	–	0.30–0.60	–	0.60–2.80	–
TP112	0.00–0.20	–	–	0.20–0.70	–	0.70–2.00	–
TP113	0.00–0.25	–	–	0.25–0.70	0.70–1.20	1.20–2.50	–
TP114	0.00–0.30	–	–	0.30–0.60	–	0.60–2.60	–
TP115	0.00–0.30	–	–	0.30–0.70	–	0.70–2.40	–
WS101	0.00–0.25	–	–	0.25–0.60	–	0.60–4.95	–
WS102	0.00–0.20	–	–	0.20–1.20	–	1.20–3.42	–
WS103	–	0.00–0.20 (Topsoil)	–	0.20–0.80	0.80–2.00	–	–
WS104	0.00–0.35	–	–	0.35–0.80	–	0.80–3.42	–
WS105	0.00–0.30	–	–	0.30–1.00	–	1.00–3.23	–
WS106	0.00–0.30	–	–	0.30–0.70	–	0.70–5.45	–
CP101	–	–	0.00–2.20 9.00–14.00	–	2.20–4.30	6.50–9.00	4.30–6.50

HOLE	DEPTH TO STRATUM (m bgl)						
	TOPSOIL	MADE GROUND	CLAY	SANDY CLAY	GRAVELLY CLAY	GRAVELLY CLAY (WITH COBBLES AND BOULDERS)	SAND AND GRAVEL
CP102	–	–	0.00–1.90 8.90–17.00	–	–	1.90–3.00	3.00–8.90
HP101	0.00–0.15	–	0.35–0.90	0.15–0.35	–	–	–
HP102	0.00–0.15	–	0.15–0.90	–	–	–	–
HP103	0.00–0.15	–	0.15–0.90	–	–	–	–
HP104	0.00–0.15	–	0.15–0.95	–	–	–	–
HP105	0.00–0.15	–	0.15–0.90	–	–	–	–

3.2. TOPSOIL

Natural topsoil was encountered as a dark brown silty sandy CLAY with frequent rootlets across the majority of the site with the exception of TP101a, TP150, TP106, WS103 where Made Ground was identified. Topsoil was encountered to a maximum depth of 0.35m below ground level (bgl).

A depth of Topsoil plan has been included ref: 16-499-007 in appendix III.

3.3. MADE GROUND

Made Ground deposits were encountered within four exploratory hole locations to depths of between 0.20m and 1.20 m bgl to the west of the site, in the area cleared for an access track associated with the school development, adjacent to the western boundary of the site.

Within TP106 and WS103 Made Ground deposits comprised a reworked topsoil, within TP105, brick was encountered within the topsoil and underlying clay to 0.70m bgl and a brick land drain was encountered within TP101a at 1.00m bgl.

A Depth of Made Ground Plan is presented as Drawing 16-499-006 in Appendix III.

3.4. DRIFT DEPOSITS

Drift deposits were encountered within all exploratory locations to a maximum proven depth of 17.00m bgl. The drift deposits generally comprised a greyish brown mottled orange slightly sandy CLAY overlying a very stiff greyish brown sandy gravelly CLAY with occasional cobbles and boulders of mudstone. Gravel also comprised of mudstone.

Granular drift deposits were identified in CP101 and CP102 between, 3.00 and 8.00m bgl and comprised a medium dense to dense greyish brown SAND and GRAVEL. Lenses of clay were encountered with CP102.

Hand pits dug to 0.90m bgl within the bund to the west of the site, confirmed the bund comprised topsoil, overlying a stiff CLAY.

3.5. SOLID GEOLOGY

The solid bedrock geology was not encountered during the site investigation. Additionally, the depth to bedrock is not recorded within any nearby freely available BGS borehole records.

The closest available information relates to a position 2km north of the subject site that identifies broken limestone to 3.00m bgl over Limestone with beds of brown clay to a depth of 35.00m bgl.

3.6. GROUNDWATER

Groundwater was not encountered during the site investigation. The River Ribble is present 2.05km to the west of the site with tributaries present circa 400m south of the subject site.

3.7. VISUAL AND OLFACTORY EVIDENCE OF CONTAMINATION

Visual and olfactory evidence of potential contamination has not been identified during the site investigation.

3.8. SOIL CONSISTENCY

Undrained shear strength values were measured using both field hand shear vane tests and laboratory undrained triaxial tests. Results of the tests are presented in Table 3.2 and Table 3.3, which indicate the clay soils to vary between stiff and very stiff. Strength test data is generally consistent with the field descriptions of the aforementioned soils.

TABLE 3.2 SUMMARY OF HAND SHEAR VANE TESTS

LOCATION	DEPTH	SHEAR STRENGTH (kPA)	CALCULATED ALLOWABLE BEARING PRESSURE (kN/m^2)
SA102/TP102	0.60	66	155
SA103/TP103	0.50	98	230
TP105	0.60	83	195
TP106	0.40	117	275
TP109	0.50	90	212
TP113	0.50	82	193

Notes
ABP Calculated using Stroud and Butler et al 1974.

TABLE 3.3 SUMMARY OF UNDRAINED SHEAR STRENGTH TEST RESULTS

LOCATION	SAMPLE DEPTH (m)	LAB DESCRIPTION	UNDRAINED SHEAR STRENGTH (kN/m^2)	CONSISTENCY
WS105	1.50–2.00	Very stiff brown very gravelly very sandy CLAY	160	Very stiff
WS106	2.50–3.00	Stiff brown gravelly very sandy CLAY.	77	Stiff

Results of the standard penetration tests, including undrained shear strengths derived from SPTs are included in Table 3.4.

3.9. SIDE STABILITY AND EASE OF EXCAVATION

The sides of the exploratory trial pit excavations appeared to be generally stable during excavation.

Excavation through the natural strata was slow through the stiff to very stiff clay present within all exploratory trial pit excavations.

TABLE 3.4 STANDARD/CONE PENETRATION TEST RESULTS

BOREHOLES	DEPTH (m bgl)	MATERIAL FIELD DESCRIPTION	CPT/SPT "N" VALUE	CORRECTED "N" VALUE $(N_1)_{60}$	TERZAGHI & PECK RELATIVE DENSITY (SANDS)	EUROCODE SOIL STRENGTH	CONSISTENCY (BS 5930)	TERZAGHI & PECK APPROXIMATE UNDRAINED SHEAR STRENGTH (kN/m²)	ALLOWABLE BEARING PRESSURE (kN/m²)*
CP101	1.20	CLAY.	10	9.81	N/A	Medium strength	Stiff	49.06	100.87
CP101	2.00	CLAY.	31	28.32	N/A	High strength	Very Stiff	141.60	291.13
CP101	3.00	gravelly CLAY.	30	26.09	N/A	High strength	Very Stiff	130.45	268.20
CP101	4.00	gravelly CLAY.	30	25.35	N/A	High strength	Very Stiff	126.73	260.55
CP101	5.00	SAND and GRAVEL.	35	29.04	Medium Dense	N/A	N/A	N/A	290.37
CP101	6.50	gravelly CLAY.	38	31.02	N/A	Very high strength	Very Stiff	155.11	318.91
CP101	8.00	gravelly CLAY.	37	29.95	N/A	High strength	Very Stiff	149.75	307.89
CP101	9.50	CLAY.	42	33.85	N/A	Very high strength	Very Stiff	169.25	347.97
CP101	11.00	CLAY.	49	37.89	N/A	Very high strength	Very Stiff	189.47	389.56
CP101	12.50	CLAY.	50	36.53	N/A	Very high strength	Very Stiff	182.65	375.53
CP101	14.00	CLAY.	50	34.64	N/A	Very high strength	Very Stiff	173.18	356.06
CP102	1.20	CLAY.	17	16.68	N/A	High strength	Very Stiff	83.41	171.48
CP102	2.20	gravelly CLAY.	50	45.12	N/A	Very high strength	Very Stiff	225.59	463.81
CP102	3.00	SAND and GRAVEL.	27	23.48	Medium Dense	N/A	N/A	N/A	234.81
CP102	4.00	SAND and GRAVEL	34	28.72	Medium Dense	N/A	N/A	N/A	287.25
CP102	5.00	SAND and GRAVEL.	39	32.36	Dense	N/A	N/A	N/A	323.55
CP102	6.50	SAND and GRAVEL.	40	32.66	Dense	N/A	N/A	N/A	326.56
CP102	8.00	SAND and GRAVEL.	40	32.38	Dense	N/A	N/A	N/A	323.79

BOREHOLES	DEPTH (m bgl)	MATERIAL FIELD DESCRIPTION	CPT/SPT "N" VALUE	CORRECTED "N" VALUE $(N_1)_{60}$	TERZAGHI & PECK RELATIVE DENSITY (SANDS)	EUROCODE SOIL STRENGTH	CONSISTENCY (BS 5930)	TERZAGHI & PECK APPROXIMATE UNDRAINED SHEAR STRENGTH (kN/m^2)	ALLOWABLE BEARING PRESSURE (kN/m^2)*
CP102	9.50	CLAY.	47	37.88	N/A	Very high strength	Very Stiff	189.40	389.40
CP102	11.00	CLAY.	48	37.12	N/A	Very high strength	Very Stiff	185.61	381.61
CP102	12.50	CLAY.	49	35.80	N/A	Very high strength	Very Stiff	179.00	368.02
CP102	14.00	CLAY.	47	32.56	N/A	Very high strength	Very Stiff	162.79	334.69
CP102	15.50	CLAY.	50	32.93	N/A	Very high strength	Very Stiff	164.67	338.56
CP102	17.00	CLAY.	50	31.39	N/A	Very high strength	Very Stiff	156.95	322.68
WS101	1.00	sandy gravelly CLAY.	12	12.10	N/A	Medium strength	Stiff	60.49	124.37
WS101	2.00	sandy gravelly CLAY.	13	11.88	N/A	Medium strength	Stiff	59.38	122.09
WS101	3.00	sandy gravelly CLAY.	20	17.39	N/A	High strength	Very Stiff	86.97	178.80
WS101	4.00	sandy gravelly CLAY.	27	22.81	N/A	High strength	Very Stiff	114.05	234.50
WS101	4.40	sandy gravelly CLAY	50	41.90	N/A	Very high strength	Very Stiff	209.48	430.68
WS102	1.00	slightly silty sandy CLAY.	17	17.14	N/A	High strength	Very Stiff	85.69	176.18
WS102	2.00	sandy gravelly CLAY	17	15.53	N/A	High strength	Very Stiff	77.65	159.65
WS102	3.00	sandy gravelly CLAY.	50	43.48	N/A	Very high strength	Very Stiff	217.41	447.00
WS103	1.00	silty gravelly CLAY.	22	22.18	N/A	High strength	Very Stiff	110.90	228.00
WS103	2.00	gravelly CLAY.	22	20.10	N/A	High strength	Very Stiff	100.49	206.61
WS103	3.00	gravelly CLAY.	18	15.65	N/A	High strength	Very Stiff	78.27	160.92
WS103	3.90	gravelly CLAY.	50	42.34	N/A	Very high strength	Very Stiff	211.70	435.26

BOREHOLES	DEPTH (m bgl)	MATERIAL FIELD DESCRIPTION	CPT/SPT "N" VALUE	CORRECTED "N" VALUE $(N_1)_{60}$	TERZAGHI & PECK RELATIVE DENSITY (SANDS)	EUROCODE SOIL STRENGTH	CONSISTENCY (BS 5930)	TERZAGHI & PECK APPROXIMATE UNDRAINED SHEAR STRENGTH (kN/m^2)	ALLOWABLE BEARING PRESSURE (kN/m^2)*
WS104	1.00	sandy gravelly CLAY.	9	9.07	N/A	Medium strength	Stiff	45.37	93.27
WS104	2.00	sandy gravelly CLAY.	18	16.44	N/A	High strength	Very Stiff	82.22	169.04
WS104	3.00	sandy gravelly CLAY.	50	43.48	N/A	Very high strength	Very Stiff	217.41	447.00
WS105	1.00	sandy gravelly CLAY.	18	18.15	N/A	High strength	Very Stiff	90.73	186.55
WS105	2.00	sandy gravelly CLAY.	14	12.79	N/A	Medium strength	Stiff	63.95	131.48
WS105	2.80	sandy gravelly CLAY	50	43.82	N/A	Very high strength	Very Stiff	219.10	450.48
WS106	1.00	sandy gravelly CLAY.	13	13.11	N/A	Medium strength	Stiff	65.53	134.73
WS106	2.00	sandy gravelly CLAY	24	21.92	N/A	High strength	Very Stiff	109.62	225.39
WS106	3.00	sandy gravelly CLAY	27	23.48	N/A	High strength	Very Stiff	117.40	241.38
WS106	4.00	sandy gravelly CLAY	30	25.35	N/A	High strength	Very Stiff	126.73	260.55
WS106	5.00	sandy gravelly CLAY.	26	21.57	N/A	High strength	Very Stiff	107.85	221.74

NOTES
* The Allowable Bearing Pressure (ABP) should be considered indicative.
The interpretation of in situ mass undrained shear strength (cu) data from SPT Blow Count (N) results and the influence of the Plasticity Index (PI) was reported in Standard Penetration Test in Insensitive Clays and Soft Rocks. Stroud (1974). The standard penetration test and the engineering properties of glacial materials subsequently. Stroud and Butler (1975) and (1989).
Allowable bearing pressure on sands. Soil Mechanics in Engineering Practice Terzaghi, K. & Peck, R.B. 1996.

3.10. CONSOLIDATION

One undisturbed samples of Glacial Till was submitted for oedometer analysis. The results are provided in Table 3.5.

TABLE 3.5 OEDOMETER CONSOLIDATION RESULTS

LOCATION	DEPTH (m)	SAMPLE TYPE	MOISTURE CONTENT (%)	OEDOMETER CONSOLIDATION		
				PRESSURE RANGE (kPa)	Mv (m^2/MN)	Cv (m^2/year)
WS106	2.5	U100	12	0–55	0.523	1.231
				55–110	0.210	1.653
				110–220	0.130	2.212
				220–110	0.014	6.253
				110–55	0.045	2.657

When considered at over-burden pressure with an additional load of 220 kPa the coefficient of volume compressibility (Mv) ranged from 0.014 m^2/MN up to 0.523 m^2/MN. The material is considered to be low to medium compressibility.

The rate at which settlement is likely to occur is determined by the coefficient of consolidation (Cv). As shown in Table 3.5, the coefficient ranges from 1.231 m^2/yr to 6.253 m^2/yr. The rate at which settlement will occur is increased by the presence of sand within the Glacial Till and it is likely that settlement will occur over a period of months to years.

3.11. SOIL DENSITY/MOISTURE CONTENT RELATIONSHIP

Dry density / moisture content relationship analysis has been conducted on soils via utilising proctor compaction tests utilising a 4.5kg rammer. The results of the tests has been summarised in Table 3.6. The full test results can be found in Appendix VIII.

TABLE 3.6 SUMMARY DRY DENSITY AND MOISTURE CONTENT

LOCATION	LABORATORY DESCRIPTION	TOP DEPTH (m)	METHOD OF COMPACTION	INITIAL MOISTURE CONTENT (%)	OPTIMUM MOISTURE CONTENT (%)	MATERIAL RETAINED ON 37.5 mm SIEVE (%)	MAX DRY DENSITY (mg/m^3)	MATERIAL RETAINED ON 20.0 mm TEST SIEVE (%)
CP101	Brown gravelly very sandy CLAY.	0.00	4.5kg	17	11	0	1.97	6

The proctor compaction test has indicated that the material in CP101 is wet of the optimum. It should be noted that if this material is excavated for use in a cut/fill operation careful consideration should be taken in the stabilisation of this material.

Engineering of this type of material will need to be completed during dry weather periods only.

3.12. SOIL INFILTRATION

In-situ BRE 365 Soakaway tests were undertaken within trial pits completed as SA101-SA103.

The results are presented in Table 3.7 below and the test certificates are included within Appendix IX.

TABLE 3.7 BRE365 SOAKAWAY TESTING RESULTS

LOCATION	DEPTH (m)	MATERIAL	TEST NO.	SOIL INFILTRATION RATE (m/s)
SA101/TP101b	2.10	Gravelly CLAY	Test No.1	N/A
SA102/TP102	1.70	Slightly sandy gravelly CLAY	Test No.1	N/A
SA103/TP103	1.90	Sandy gravelly CLAY	Test No.1	N/A

All three tests did not record a sufficient fall in water level to allow reliable calculation of the infiltration rate.

The tests suggest the cohesive drift deposits are unlikely to be suitable for soakaway drainage.

However, the application of soakaway drainage will ultimately be dependent on the specific requirements of the development. All soakaways should be designed in accordance with BRE Special Digest 365 – *Soakaway Design*.

3.13. SOIL PLASTICITY

The Atterberg limits determinations, summarised in Table 3.8, show the clay to be of predominantly low plasticity with discrete areas of moderate plasticity clay.

TABLE 3.8 SUMMARY OF PLASTICITY INDEX TEST RESULTS

LOCATION	DEPTH (m)	NATURAL MOISTURE CONTENT (%)	PLASTIC LIMIT (%)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	PASSING 425 µm SIEVE (%)	MODIFIED PLASTICITY INDEX	NHBC VOLUME CHANGE POTENTIAL
WS104	1.00	13	14	29	15	62	9.3	Low
WS105	1.00	16	15	32	17	64	10.88	Low
WS102	2.00	16	13	27	14	60	8.4	Low
WS101	2.00	14	15	31	16	73	11.68	Low
CP101	5.00	11	13	28	15	64	9.6	Low
CP102	1.20	30	23	47	24	89	21.36	Medium
CP102	3.00	11	13	27	14	65	9.1	Low

The results of the Atterberg limits testing confirmed that the soils would be deemed to be “Low Potential” in accordance with the classification system utilised by the LABC/NHBC industry guidance.

3.14. CALIFORNIA BEARING RATIO

The California bearing ratio (CBR) for the soils were measured using an in-situ TRL probe. The results are summarised in Table 3.9.

The result sheets are included in Appendix X and the locations are shown on Drawing 16-499-005 (Appendix III). CBR results have been averaged from the blow counts across the strata tested and any abnormally high blow counts ignored as these are likely to be from larger granular material and so represent anomalies.

TABLE 3.9 SUMMARY OF DCP RESULTS

LOCATION	DEPTH (m)	STRATA	IN-SITU OR LAB TEST	CBR (%)
DCP101	0.27–0.64	Slightly silty sandy CLAY	In-Situ	7.58
DCP102	0.31–0.55	Slightly silty sandy CLAY	In-Situ	9.73
DCP103	0.31–0.71	Slightly silty sandy CLAY	In-Situ	16.12
DCP104	0.33–0.61	Made Ground	In-Situ	41.45
DCP105	0.30–0.71	Slightly silty sandy CLAY	In-Situ	16.36
DCP106	0.27–0.58	Slightly silty sandy CLAY	In-Situ	10.57

It should be noted that the reported CBR results were obtained from soils in a highly undisturbed state. If, however, the topsoil and surface cover is removed during periods of wetter climatic condition, the formation will soften, reducing the CBR.

3.15. pH AND SULPHATE

Chemical analyses for pH and soluble sulphate content contained in Appendix VI (summarised in Table 3.10), shows that the soils at the site generally meet Class DS-1, Aggressive Chemical Environment for Concrete Classification (ACEC) AC-1s in accordance with BRE *Special Digest 1* (2005).

TABLE 3.10 SUMMARY OF pH AND SULPHATE DATA

LOCATION	DEPTH (m)	SO_4 IN 2:1 WATER/SOIL (g/l)	pH VALUE	CLASSIFICATION
TP101a	1.00	0.03	8.1	DS-1, AC-1s
SA102/TP102	0.80	0.053	7.5	DS-1, AC-1s
SA103/TP103	0.25	0.02	5.8	DS-1, AC-1s
TP104	0.25	0.024	6.0	DS-1, AC-1s
TP105	0.50	0.016	6.4	DS-1, AC-1s
TP106	0.40	0.012	7.0	DS-1, AC-1s
WS103	1.20	0.0056	8.6	DS-1, AC-1s
WS104	0.25	0.014	6.9	DS-1, AC-1s
WS105	1.00	0.036	8.0	DS-1, AC-1s
TP107	1.00	0.0069	8.6	DS-1, AC-1s
TP110	1.80	0.022	7.1	DS-1, AC-1s
TP111	0.20	0.017	6.3	DS-1, AC-1s

LOCATION	DEPTH (m)	SO_4 IN 2:1 WATER/SOIL (g/l)	pH VALUE	CLASSIFICATION
TP112	0.50	0.0083	7.4	DS-1, AC-1s
TP113	0.20	0.019	6.3	DS-1, AC-1s
WS102	1.40	0.011	8.5	DS-1, AC-1s
WS106	2.00	0.028	8.5	DS-1, AC-1s

4. TIER I QUALITATIVE CONTAMINATED LAND RISK ASSESSMENT

E3P has undertaken a Tier 1 qualitative risk assessment to determine if any potential contaminants within the underlying soils and groundwater pose an unacceptable level of risk to the identified receptors.

4.1. HUMAN HEALTH RISK ASSESSMENT

At Tier 1 stage, the long term (chronic) human health toxicity of the soil has been assessed by comparing the on-site concentrations of organic and inorganic compounds with reference values published in LQM/CIEH S4UL (S4UL3267).

Where Tier 1 screening values are not provided by LQM, other screening values have been used and these are referenced in Table 4.1.

The results of this comparison have been summarised within Table 4.1.

TABLE 4.1 SUMMARY OF INORGANIC AND HYDROCARBON TOXICITY ASSESSMENT FOR A RESIDENTIAL END USE

DETERMINANT	UNIT	GAC	N	MC	LOC. OF EX	PATH-WAY	ASSESSMENT
Arsenic	mg/kg	37	21	12	N/A	1	No Further Action
Cadmium	mg/kg	11	21	1.2	N/A	1	No Further Action
Chromium (VI)	mg/kg	6.0	21	3	N/A	1	No Further Action
Lead	mg/kg	200	21	54	N/A	1	No Further Action
Mercury	mg/kg	1.2	21	0.3	N/A	4	No Further Action
Nickel	mg/kg	130	21	43	N/A	1	No Further Action
Selenium	mg/kg	250	21	1.3	N/A	1	No Further Action
Copper	mg/kg	2400	21	28	N/A	1	No Further Action
Zinc	mg/kg	3700	21	130	N/A	1	No Further Action
Cyanide – Total	mg/kg	791	21	1	N/A	1	No Further Action
Phenols – Total	mg/kg	120	21	1	N/A	1	No Further Action
Asbestos	Fibres	NFD	12	NFD	N/A	3	No Further Action
Naphthalene	mg/kg	2.3	21	0.05	N/A	4	No Further Action
Acenaphthylene	mg/kg	170	21	0.05	N/A	2	No Further Action
Acenaphthene	mg/kg	210	21	0.05	N/A	1	No Further Action
Fluorene	mg/kg	170	21	0.05	N/A	1	No Further Action
Phenanthrene	mg/kg	95	21	0.51	N/A	2	No Further Action
Anthracene	mg/kg	2400	21	0.24	N/A	2	No Further Action
Fluoranthene	mg/kg	280	21	1.7	N/A	2	No Further Action
Pyrene	mg/kg	620	21	1.3	N/A	2	No Further Action
Benzo(a)Anthracene	mg/kg	7.2	21	0.65	N/A	2	No Further Action
Chrysene	mg/kg	15	21	0.69	N/A	2	No Further Action
Benzo(b)Fluoranthene	mg/kg	2.6	21	0.69	N/A	2	No Further Action

DETERMINANT	UNIT	GAC	N	MC	LOC. OF EX	PATH-WAY	ASSESSMENT
Benzo(k)Fluoranthene	mg/kg	77	21	0.15	N/A	2	No Further Action
Benzo(a)Pyrene	mg/kg	2.2	21	0.63	N/A	2	No Further Action
Indeno(123-cd)Pyrene	mg/kg	27	21	0.35	N/A	2	No Further Action
Dibenzo(a,h)Anthracene	mg/kg	0.24	21	0.05	N/A	2	No Further Action
Benzo(ghi)Perylene	mg/kg	320	21	0.41	N/A	2	No Further Action
TPH C5-C6 (aliphatic)*	mg/kg	42	21	1	N/A	4	No Further Action
TPH C6-C8 (aliphatic)*	mg/kg	100	21	0.1	N/A	4	No Further Action
TPH C8-C10 (aliphatic)*	mg/kg	27	21	0.1	N/A	4	No Further Action
TPH C10-C12 (aromatic)*	mg/kg	74	21	5.9	N/A	4	No Further Action
TPH C12-C16 (aromatic)*	mg/kg	140	21	11	N/A	4	No Further Action
TPH C16-C21 (aromatic)*	mg/kg	260	21	12	N/A	1	No Further Action
TPH C21-C35 (aromatic)*	mg/kg	1100	21	16	N/A	1	No Further Action

Notes
PL1 = soil ingestion, PL2 = dermal contact and ingestion, PL3 = dust inhalation; PL4 = Vapour/Gas Inhalation; PL5 = Vertical / Lateral Migration; PL6 = Corrosion of concrete; PL7=Tainting of water supply; PL8 = Uptake by plants

Abbreviations: GAC = general assessment criteria, n = number of samples, MC = maximum concentration; Loc of Ex = location of exceedance; NFD = no fibres detected.

* The Tier 1 GAC for the hydrocarbon fraction is derived from the CIEH assessment for petroleum hydrocarbons Criteria Working Group (CWG) for both aliphatic and aromatic compounds. E3P has utilised the Tier 1 values for aliphatic compounds for the volatile and semi volatile fractions (C5-C12) and the Tier 1 values for aromatic compound for the non-volatile fractions (C12-C35). The comparison of a total (aliphatic/aromatic) compounds to an individual fraction is considered to be a conservative approach and satisfactory for the protection of human health.

Referring to Table 4.1, the results of this direct comparison indicate that the data does not exceed the screening criteria for a residential end-use for any of the contaminants of concern analysed.

Asbestos has not been identified in any of the soils submitted for analysis.

Two samples were analysed for volatile organic compound (VOC) and semi-volatile organic compound (SVOC) screening; no elevated VOC or SVOC values were identified from the testing.

Chemical analysis of the natural CLAY drift deposits has identified 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.

A preliminary chemical analysis of the natural topsoil has identified these soils to be acceptable for use within the proposed garden areas; however, further chemical validation samples will be required to confirm this. Where reworked topsoil is present, this material is not deemed to be suitable for use within proposed garden areas.

4.2. CONTROLLED WATERS RISK ASSESSMENT

E3P has undertaken a controlled waters risk assessment for the site based on the consideration of the conceptual site model and the sensitive receptors, which are summarised in Table 4.2.

TABLE 4.2 CONTROLLED WATERS CONCEPTUAL MODEL AND SENSITIVITY PROFILE

DISCUSSION		SENSITIVITY RATING
Contaminant Source		
Made Ground Localised shallow Made Ground is present. Chemical analysis confirms that the soils do not pose a risk to controlled waters.		**Low**
Pathway		
Vertical Migration Due to the majority of the site being underlain by low permeability clay deposits, vertical migration of contaminants is unlikely to occur. Granular deposits were identified in CP101 and CP102 between, 3.00 and 8.00m bgl, however as these higher permeability deposits are overlain by low permeability clay deposits, the risk of vertical migration of potential contaminants is reduced.		**Low**
Lateral migration Lateral migration of contaminants towards the drainage ditch to the north of the site is considered unlikely due to the presence of low permeability drift deposits, inhibiting migration.		**Low**
Receptor		
Aquifer Classification in Superficial Drift Deposits	Secondary Undifferentiated Aquifer	**Medium**
Aquifer Classification in Bedrock	Secondary A Aquifer	**Medium**
Groundwater Source Protection Zone or Drinking Water Safeguard Zone	The site is not affected.	**Low**
Distance to the Closest Groundwater Abstraction Point	1861 m southeast	**Low**
Is the Site Located Within 50 m of a Surface Watercourse?	A drainage ditch is located circa 40m north of the site, that likely flows south westerly towards the Pendleton Brook.	**High**
The ICSM developed within the context of the site setting has viable pollutant pathway, which would be the downward migration of potentially mobile phase-soluble contaminants towards the underlying Secondary A aquifer and the lateral migration of potentially mobile phase-soluble contaminants towards the drainage ditch to the north of the site. The sensitivity is reduced given the absence of any potential source of contamination, the low permeability clay deposits across the majority of the site reducing the potential for vertical and lateral migration and the distance to the closest groundwater abstraction.		

To ensure a robust appraisal of the identified risk to controlled waters, E3P has identified the sources of potential contamination that represent a risk to controlled waters from the initial CSM, we have then assessed the availability of ground investigation data in the form of analysis of the solid phase (soil) and dissolved phase within the perched groundwater or aquifer. The results of this assessment are presented in Table 4.3.

TABLE 4.3 QUALITATIVE RISK TO CONTROLLED WATERS FROM SOIL ANALYTICAL RESULTS

CONTAMINANT	ASSESSMENT RATING	DISCUSSION
BTEX > 1 mg/kg **Total VOC > 1 mg/kg**	All concentrations are below the laboratory LOD.	None
Total SVOC > 1 mg/kg	All concentrations are below the laboratory LOD.	None
C5-C10 > 5 mg/kg	All concentrations are below the laboratory LOD.	None
C10-C12 > 10 mg/kg	All concentrations are below or slightly exceeding the laboratory LOD.	None
C12-C16 > 50 mg/kg	All concentrations are below or slightly exceeding the laboratory LOD.	None
Phenols > 2 mg/kg	All concentrations are below the laboratory LOD.	None
Naphthalene > 2 mg/kg	All concentrations are below the laboratory LOD.	None
Total PAH > 10 mg/kg	No concentrations of low-solubility PAH compounds above 10 mg/kg have been detected on site.	None
PCB > 1 mg/kg	No potential sources of PCB have been identified	None
Heavy metals > 500 mg/kg	Concentrations of heavy metals above 500 mg/kg have not been identified.	None

The Tier I assessment has included a comparison of leachate analysis from samples of the Made Ground and groundwater samples to drinking water standards (DWS) and environmental quality standards (EQS), due to presence of a Secondary A bedrock Aquifer underlying the site and the drainage ditch located circa 40m north of the site. The tables below include data from water samples collected in January 2023.

During the initial return monitoring visit, as well groundwater samples a surface water sample was obtained from the drainage ditch located circa 40m north of the site.

These are presented in Table 4.4 and Table 4.5.

TABLE 4.4 COMPARISON OF GROUNDWATER AND LEACHATE ANALYSIS WITH TIER 1 SCREENING LEVELS

DETERMINAND	UNIT	EQS [1,2] AA	DWS [3,4]	NO. OF GW SAMPLES	MAX CONC. IN GROUNDWATER	LOCATION OF EXCEEDANCE	NO. OF LEACHATE SAMPLES	MAX CONC. IN LEACHATE	LOCATION OF EXCEEDANCE	ASSESSMENT
Arsenic	µg/l	50	10	4	0.36	N/A	2	1.6	N/A	No Further Action
Cadmium	µg/l	0.08-0.25	5	4	0.12	N/A	2	<0.08	N/A	No Further Action
Chromium (VI)	µg/l	3.4	–	4	<5.0	N/A	2	<5.0	N/A	No Further Action
Chromium (III)	µg/l	4.7	50	4	0.4	N/A	2	6.5	TP105 0.50m (EQS)	**Further Action**
Copper	µg/l	1	2000	4	2.7	WS102 (EQS) WS103 (EQS) WS105 (EQS) WS106 (EQS)	2	12	TP101a 1.00m (EQS) TP105 0.50m (EQS)	**Further Action**
Total Cyanide	µg/l	1	50	4	<1.0	N/A	2	<1.0	N/A	No Further Action
Lead	µg/l	1.2	10	4	<0.2	N/A	2	5.4	TP101a 1.00m (EQS) TP105 0.50m (EQS)	**Further Action**
Mercury	µg/l	–	1.0	4	<0.05	N/A	2	<0.5	N/A	No Further Action
Nickel	µg/l	4	20	4	2.1	N/A	2	7	TP105 0.50m (EQS)	**Further Action**
Selenium	µg/l	–	10	4	12	WS102 (DWS)	2	<4.0	N/A	**Further Action**
Zinc	µg/l	10.9	–	4	7.1	N/A	2	35	TP105 0.50m (EQS)	**Further Action**
pH	6–9			4	7.3–7.5	N/A	2	7.8–8.1	N/A	No Further Action

DETERMINAND	UNIT	EQS [1,2] AA	DWS [3,4]	NO. OF GW SAMPLES	MAX CONC. IN GROUNDWATER	LOCATION OF EXCEEDANCE	NO. OF LEACHATE SAMPLES	MAX CONC. IN LEACHATE	LOCATION OF EXCEEDANCE	ASSESSMENT
Polycyclic Aromatic Hydrocarbons										
Naphthalene	µg/l	2	10*	4	<0.01	N/A	2	<0.01	N/A	No Further Action
Anthracene	µg/l	0.1	10*	4	<0.01	N/A	2	<0.01	N/A	No Further Action
Benzo[b]fluoranthene	µg/l	0.00017*	10*	4	<0.01	N/A	2	<0.01	N/A	No Further Action
Benzo[k]fluoranthene	µg/l	0.00017*	10*	4	<0.01	N/A	2	<0.01	N/A	No Further Action
Benzo(a)pyrene	µg/l	0.00017*	10*	4	<0.01	N/A	2	<0.01	N/A	No Further Action
Indeno(123-cd)pyrene	µg/l	0.00017*	10*	4	<0.01	N/A	2	<0.01	N/A	No Further Action
Fluoranthene	µg/l	0.0063	10*	4	<0.01	N/A	2	<0.01	N/A	No Further Action
Benzo(ghi)perylene	µg/l	1.7–4	10*	4	<0.01	N/A	2	<0.01	N/A	No Further Action
Aromatic Hydrocarbon										
TPH C5-C7 (benzene)	µg/l	10	1	4	<1.0	N/A	2	<1.0	N/A	No Further Action
TPH C7-C8 (toluene)	µg/l	74	700	4	<1.0	N/A	2	<1.0	N/A	No Further Action
TPH C8-C10 (xylene)	µg/l	30	300	4	<1.0	N/A	2	<1.0	N/A	No Further Action
TPH C10-C12 (naphthalene)	µg/l	2	90	4	<10	N/A	2	<10	N/A	No Further Action
TPH C12-C16	µg/l	–	90	4	<10	N/A	2	<10	N/A	No Further Action
TPH C16-C35	µg/l	–	90	4	<10	N/A	2	<10	N/A	No Further Action
Aliphatic Hydrocarbon										
TPH C5-C6	µg/l	–	1000[5]	4	<1.0	N/A	2	<1.0	N/A	No Further Action
TPH C6-C8	µg/l	–	1000[5]	4	<1.0	N/A	2	<1.0	N/A	No Further Action
TPH C8-C10	µg/l	–	300	4	<1.0	N/A	2	<1.0	N/A	No Further Action

DETERMINAND	UNIT	EQS [1, 2] AA	DWS [3,4]	NO. OF GW SAMPLES	MAX CONC. IN GROUNDWATER	LOCATION OF EXCEEDANCE	NO. OF LEACHATE SAMPLES	MAX CONC. IN LEACHATE	LOCATION OF EXCEEDANCE	ASSESSMENT
TPH C10-C12	µg/l	–	300	4	<10	N/A	2	<10	N/A	No Further Action
TPH C12-C16	µg/l	–	300	4	<10	N/A	2	<10	N/A	No Further Action
TPH C16-C21	µg/l	–	300**	4	<10	N/A	2	<10	N/A	No Further Action
TPH C21-C35	µg/l	–	300**	4	<10	N/A	2	<10	N/A	No Further Action
Volatile Organic Compounds										
Tetrachloroethylene	µg/l	0.4	10	4	<1.0	N/A	-	-	N/A	No Further Action
Trichloroethylene	µg/l	10	10	4	<1.0	N/A	-	-	N/A	No Further Action
Trichlorobenzene	µg/l	0.4	–	4	<1.0	N/A	-	-	N/A	No Further Action
Trichloromethane	µg/l	2.5	–	4	<1.0	N/A	-	-	N/A	No Further Action
Dichloromethane	µg/l	20	200	4	<1.0	N/A	-	-	N/A	No Further Action
Carbon Tetrachloride	µg/l	12	3	4	<1.0	N/A	-	-	N/A	No Further Action
Vinyl Chloride	µg/l	–	0.3	4	<1.0	N/A	-	-	N/A	No Further Action

Notes

Solubility <0.01µg/l
AA – Annual Average
* Polyaromatic hydrocarbons (PAH) - Benzo(a)pyrene (BaP), Benzo(b)fluoranthene, Benzo(k)fluoranthene, Benzo(g,h,i)-perylene and Indeno(1,2,3-cd)-pyrene. Benzo(a)pyrene can be considered as a marker for the other PAHs, hence only benzo(a)pyrene needs to be monitored for comparison with the biota EQS or the corresponding AA-EQS in water
** There are no WHO Guideline Values for aliphatic fractions C16-C21 and C21-C35, therefore the guideline value for aliphatic fractions inclusive of C8-C16 (300µg/l) has been applied.

1. The Water Framework Directive (Standards and Classification) Directions (England and Wales) 2015 (legislation.gov.uk)
2. The Water Supply (Water Quality) Regulations 2018 (legislation.gov.uk)
3. Guidelines for drinking-water quality, 4th edition, incorporating the 1st addendum (who.int)
4. CL:AIRE publishes Petroleum Hydrocarbons in Groundwater guidance (claire.co.uk)
5. A total TPH criteria of 1000 mg/kg will act as a surrogate criterion for remaining aliphatic and aromatic TPH fractions.

TABLE 4.5 COMPARISON OF SURFACE ANALYSIS WITH TIER 1 SCREENING LEVELS

DETERMINAND	UNIT	EQS [1, 2, 3] AA	DWS [3,4,5]	NO. OF SAMPLES	MAXIMUM CONCENTRATION IN SURFACE WATER 06/01/2023	LOCATION OF EXCEEDANCE	ASSESSMENT
Arsenic	µg/l	50	10	1	0.70	N/A	No Further Action
Cadmium	µg/l	0.08-0.25	5	1	<0.02	N/A	No Further Action
Chromium (VI)	µg/l	3.4	–	1	<5.0	N/A	No Further Action
Chromium (III)	µg/l	4.7	50	1	2.5	N/A	No Further Action
Copper	µg/l	1	2000	1	4.8	Drainage Ditch	Further Action
Total Cyanide	µg/l	1	50	1	1.8	Drainage Ditch	Further Action
Lead	µg/l	1.2	10	1	<0.2	N/A	No Further Action
Mercury	µg/l	–	1.0	1	<0.05	N/A	No Further Action
Nickel	µg/l	4	20	1	2.6	N/A	No Further Action
Selenium	µg/l	–	10	1	2.7	N/A	No Further Action
Zinc	µg/l	10.9	–	1	7.9	N/A	No Further Action
pH	6–9			2	8.1	N/A	No Further Action
Naphthalene	µg/l	2	10*	1	<0.01	N/A	No Further Action
Anthracene	µg/l	0.1	10*	1	<0.01	N/A	No Further Action
Benzo[b]fluoranthene	µg/l	0.00017*	10*	1	<0.01	N/A	No Further Action
Benzo[k]fluoranthene	µg/l	0.00017*	10*	1	<0.01	N/A	No Further Action
Benzo(a)pyrene	µg/l	0.00017*	10*	1	<0.01	N/A	No Further Action
Indeno(123-cd)pyrene	µg/l	0.00017*	10*	1	<0.01	N/A	No Further Action
Fluoranthene	µg/l	0.0063	10*	1	<0.01	N/A	No Further Action
Benzo(ghi)perylene	µg/l	1.7–4	10*	1	<0.01	N/A	No Further Action

DETERMINAND	UNIT	EQS [1, 2, 3] AA	DWS [3,4,5]	NO. OF SAMPLES	MAXIMUM CONCENTRATION IN SURFACE WATER 06/01/2023	LOCATION OF EXCEEDANCE	ASSESSMENT
Aromatic Hydrocarbon [5]							
TPH C5-C6 (benzene)	µg/l	10	1	1	<1.0	N/A	No Further Action
TPH C6-C8 (toluene)	µg/l	74	700	1	<1.0	N/A	No Further Action
TPH C8-C10 (ethyl benzene)	µg/l	20	300	1	<1.0	N/A	No Further Action
TPH C10-C12 (xylene)	µg/l	30	500	1	<10	N/A	No Further Action
TPH C12-C16	µg/l	2	90[5]	1	<10	N/A	No Further Action
TPH C16-C35	µg/l	50#	90[5]	1	<10	N/A	No Further Action
Aliphatic Hydrocarbon [5]							
TPH C5-C6	µg/l	–	15000	1	<1.0	N/A	No Further Action
TPH C6-C8	µg/l	–	15000	1	<1.0	N/A	No Further Action
TPH C8-C10	µg/l	–	300	1	<1.0	N/A	No Further Action
TPH C10-C12	µg/l	–	300	1	<10	N/A	No Further Action
TPH C12-C16	µg/l	–	300	1	<10	N/A	No Further Action
TPH C16 – C21	µg/l	–	300**	1	<10	N/A	No Further Action
TPH C21-C35	µg/l	–	300**	1	<10	N/A	No Further Action
Volatile Organic Compounds							
Tetrachloroethylene	µg/l	0.4	10	1	<1.0	N/A	No Further Action
Trichloroethylene	µg/l	10	10	1	<1.0	N/A	No Further Action
Trichlorobenzene	µg/l	0.4	–	1	<1.0	N/A	No Further Action
Trichloromethane	µg/l	2.5	–	1	<1.0	N/A	No Further Action
Dichloromethane	µg/l	20	200	1	<1.0	N/A	No Further Action

DETERMINAND	UNIT	EQS [1, 2, 3] AA	DWS [3,4,5]	NO. OF SAMPLES	MAXIMUM CONCENTRATION IN SURFACE WATER 06/01/2023	LOCATION OF EXCEEDANCE	ASSESSMENT
Carbon Tetrachloride	µg/l	12	3	1	<1.0	N/A	No Further Action
Vinyl Chloride	µg/l	–	0.3	1	<1.0	N/A	No Further Action

Notes

Solubility <0.01µg/l
AA – Annual Average
* Polyaromatic hydrocarbons (PAH) - Benzo(a)pyrene (BaP), Benzo(b)fluoranthene, Benzo(k)fluoranthene, Benzo(g,h,i)-perylene and Indeno(1,2,3-cd)-pyrene. Benzo(a)pyrene can be considered as a marker for the other PAHs, hence only benzo(a)pyrene needs to be monitored for comparison with the biota EQS or the corresponding AA-EQS in water
** There are no WHO Guideline Values for aliphatic fractions C16-C21 and C21-C35, therefore the guideline value for aliphatic fractions inclusive of C8-C16 (300µg/l) has been applied.

1. The Water Framework Directive (Standards and Classification) Directions (England and Wales) 2015 (legislation.gov.uk)
2. The Water Supply (Water Quality) Regulations 2018 (legislation.gov.uk)
3. Guidelines for drinking-water quality, 4th edition, incorporating the 1st addendum (who.int)
4. CL:AIRE publishes Petroleum Hydrocarbons in Groundwater guidance (claire.co.uk)
5. A total TPH criteria of 1000 mg/kg will act as a surrogate criterion for remaining aliphatic and aromatic TPH fractions.

4.2.1. CONTROLLED WATER RISK ASSESSMENT AND MITIGATION

During the intrusive site investigation, two leachate samples were taken of the Made Ground soils within TP101a at 1.00m and TP105 at 0.50m bgl. Leachate analysis identified minor heavy metal exceedances of chromium (III), copper, lead, nickel and zinc when compared to Environmental Quality Standards (EQS). No exceedances of Drinking Water Standards (DWS) were identified.

Four groundwater samples were collected from the monitoring wells. Within all four groundwater samples, copper was identified above the EQS screening levels between 1.70 ug/l and 2.70 µg/l. Additionally, Selenium was identified above the DWS screening values in WS102.

A surface water sample was collected from the drainage ditch located circa 40m north of the site. Copper and Total Cyanide concentrations were noted to be elevated against the EQS screening values. No exceedances of the DWS screening values were noted.

4.2.2. DISCUSSION OF CONTROLLED WATERS RISK ASSESSMENT

Where leachate analysis has been undertaken, this can overstate the risk and is not wholly representative of the site characterisation, as the contaminants present in the soils are required to be mobilised by water in order to cause a potential risk to the aquifer. Therefore, reliance should be on groundwater or surface water samples.

The presence of cohesive deposits across the site will provide some protection to the underlying aquifer, and given the absence of a groundwater abstraction point within 1 km of the site there is not considered to be a complete pollutant linkage on-site which could cause a detrimental effect to the underlying aquifer.

Based on the lack of groundwater across the majority of the site and no noted contributing contamination to the adjacent surface water feature, it is considered there is unlikely to be any degree of unacceptable risk to the controlled water receptors and the wider environment.

It is recommended further analysis of the surface water in the drainage ditch should be undertaken as groundworks progress, to ensure no future mobilisation of contaminants is caused, which may pose a risk to the watercourse.

4.3. GROUND GAS RISK ASSESSMENT METHODOLOGY

The potential impact on the development from ground gases has been assessed with reference to standards and guidelines published in:

- CIRIA Report 665 – Assessing risks posed by hazardous ground gases to buildings (2007)
- BS8485:2015+A1:2019 – Code of Practice for the design of protective measures for methane and carbon dioxide ground gases for new buildings

BS8485 provides guidance on the level of gas protection requirements based upon the characteristic situation (CS) and the proposed development based on building type.

Therefore, in accordance with BS8485, based on the measured flow rates and hazardous gas concentrations, individual hazardous gas flow rates (Q_{hg}) shall be derived for each monitoring point, from which the site characteristic hazardous gas flow rate (Q_{hgs}), and then the Characteristic Situation (CS) can be determined.

The following equation should be utilised:

$$Q_{hg} = q\left(\frac{C_{hg}}{100}\right)$$

Where:
q is the measured flow rate (in litres per hour) of combined gases from the monitoring standpipe
C_{hg} is the measured hazardous gas concentration (in percentage volume/volume).

The subsequent derived gas screening value (GSV) should be the maximum Q_{hg} (flow rate x concentration as a percentage volume) for all the monitoring events.

A 'worst case check' may be carried out using the maximum recorded flow in any hole with the maximum concentration in any hole to present the plausible worst case conditions. Adoption of the worst case Q_{hg} requires thorough justification and reference to the CSM.

The final derived GSV can then be used to characterise the site as summarised in Table 4.6.

TABLE 4.6 SITE CHARACTERISATION BY GSV (BS8485:2015)

CS	HAZARD POTENTIAL	GSV (l/hr) FOR METHANE AND CARBON DIOXIDE	ADDITIONAL FACTORS
CS1	Very Low	< 0.07	Typically <1% methane concentration and <5% carbon dioxide concentration (otherwise consider an increase to CS2)
CS2	Low	< 0.70	Typical measured flow rate <70 l/h (otherwise consider an increase to CS3)
CS3	Moderate	< 3.5	N/A
CS4	Moderate to High	< 15	N/A
CS5	High	< 70	N/A
CS6	Very High	> 70	N/A

Notes
1. The CS is equivalent to the characteristic GSV in CIRIA C665.
2. The worst-case ground gas regime identified on the site, either methane or carbon dioxide, at the worst-case temporal conditions that the site may be expected to encounter should be considered.
3. Gas Screening Value is the Borehole Gas Volume Flow Rate, in litres per hour, multiplied by the concentration in the air stream of the particular gas being considered.
4. The Gas Screening Value thresholds should not generally be exceeded without the completion of a detailed ground gas risk assessment taking into account site-specific conditions.

4.4. MONITORING METHODOLOGY

Concentrations of methane (CH_4), carbon dioxide (CO_2) and oxygen (O_2) (hydrogen sulphide) were measured using a calibrated infrared gas analyser (GFM435) with gas flow rates measured using an integrated flow meter.

Gas measurements were recorded for a minimum of 500 seconds at each location, at which point the maximum concentration of CH_4 and CO_2, together with the lowest concentration of O_2 were recorded.

The results of the ground gas monitoring are presented in Table 4.7.

In addition to the raw data, the results for each individual standpipe have been assessed with reference to guidance provided in BS8485:2015. Based on the initial peak measured flow rates and hazardous gas concentrations, individual hazardous gas flow rates (Q_{hg}) have been derived for each monitoring point, from which an individual Characteristic Situation (CS) can ultimately be determined.

TABLE 4.7 SUMMARY OF GROUND GAS MONITORING RESULTS

WELL	STRATA	DATE	CH_4 PEAK (%V/V)	CH_4 STEADY (%V/V)	CH_4 Q_{hg} (l/hr)	CO_2 PEAK (%V/V)	CO_2 STEADY (%V/V)	CO_2 Q_{hg} (l/hr)	O_2 (%V/V)	ATMOS (mb)	ATMOS. DYNAMIC	PEAK FLOW (l/hr)	STEADY FLOW (l/hr)	RESPONSE ZONE (m bgl)	DEPTH TO BASE (m bgl)	DEPTH TO WATER (m bgl)
WS102	CLAY	06/01/2023	0.1	0.1	0.0001	0.1	0.1	0.0001	20.1	993	Falling	0.1	0.1	1.00-3.00	2.75	0.90
		16/01/2023	0.1	0.1	0.0001	0.1	0.1	0.0001	20.1	993	Rising	0.1	0.1		2.75	0.90
		08/02/2023	0.1	0.1	0.0001	2.4	2.2	0.0024	17.6	1015	Steady	0.1	0.1		2.77	1.86
		23/02/2023	0.1	0.1	0.0001	0.3	0.3	0.0003	19.9	1008	Falling	0.1	0.1		2.77	1.90
		02/03/2023	0.1	0.1	0.0001	0.1	0.1	0.0001	19.4	1015	Steady	0.1	0.1		2.78	2.35
		13/03/2023	0.1	0.1	0.0001	0.1	0.1	0.0001	19.6	966	Falling	0.1	0.1		2.78	2.11
WS103	CLAY	06/01/2023	0.1	0.1	0.0001	0.1	0.1	0.0001	20.2	993	Falling	0.1	0.1	1.00-4.00	3.80	1.20
		16/01/2023	0.1	0.1	0.0001	0.1	0.1	0.0001	20.2	993	Rising	0.1	0.1		3.80	1.20
		08/02/2023	0.1	0.1	0.0001	2.3	2.2	0.0023	18.2	993	Steady	0.1	0.1		3.84	1.79
		23/02/2023	0.1	0.1	0.0001	0.2	0.2	0.0002	20.3	993	Falling	0.1	0.1		3.85	1.38
		02/03/2023	0.1	0.1	0.0001	0.1	0.1	0.0001	19.4	993	Steady	0.1	0.1		3.81	2.37
		13/03/2023	0.1	0.1	0.0001	0.1	0.1	0.0001	19.6	993	Falling	0.1	0.1		3.79	2.13
WS105	CLAY	06/01/2023	0.1	0.1	0.0001	0.1	0.1	0.0001	20.1	994	Falling	0.1	0.1	1.00-3.00	3.25	0.85
		16/01/2023	0.1	0.1	0.0001	0.1	0.1	0.0001	20.1	994	Rising	0.1	0.1		3.25	0.85
		08/02/2023	0.1	0.1	0.0001	2.3	2.2	0.0023	18	1015	Steady	0.1	0.1		2.88	1.80
		23/02/2023	0.1	0.1	0.0001	0.1	0.1	0.0001	20.2	1008	Falling	0.1	0.1		2.88	1.95
		02/03/2023	0.1	0.1	0.0001	0.1	0.1	0.0001	19.4	1015	Steady	0.1	0.1		2.88	1.99
		13/03/2023	0.1	0.1	0.0001	0.1	0.1	0.0001	19.6	965	Falling	0.1	0.1		2.88	2.10
WS106	CLAY	06/01/2023	0.1	0.1	0.0001	0.1	0.1	0.0001	20.1	993	Falling	0.1	0.1	1.00-5.00	4.75	1.10
		16/01/2023	0.1	0.1	0.0001	0.1	0.1	0.0001	20.1	993	Rising	0.1	0.1		4.75	1.10
		08/02/2023	0.1	0.1	0.0001	2.3	2.2	0.0023	17.8	1015	Steady	0.1	0.1		4.77	1.99

WELL	STRATA	DATE	CH_4 PEAK (%V/V)	CH_4 STEADY (%V/V)	CH_4 Q_{hg} (l/hr)	CO_2 PEAK (%V/V)	CO_2 STEADY (%V/V)	CO_2 Q_{hg} (l/hr)	O_2 (%V/V)	ATMOS (mb)	ATMOS. DYNAMIC	PEAK FLOW (l/hr)	STEADY FLOW (l/hr)	RESPONSE ZONE (m bgl)	DEPTH TO BASE (m bgl)	DEPTH TO WATER (m bgl)
		23/02/2023	0.1	0.1	0.0001	0.5	0.5	0.0005	19.9	1009	Falling	0.1	0.1		4.77	1.15
		02/03/2023	0.1	0.1	0.0001	0.1	0.1	0.0001	19.4	1015	Steady	0.1	0.1		4.77	2.18
		13/03/2023	0.1	0.1	0.0001	0.1	0.1	0.0001	19.6	966	Falling	0.1	0.1		4.74	1.90

Notes

CIRIA Characteristic Situation	Q_{hg}		
CS1	<0.07	Typical Max CO2 <5 % Typical Max CH4 <1 %	Values in **BOLD** exceed CS1 Thresholds
CS2	<0.7	Flow rate not to exceed 70 l/hr otherwise consider increase to CS3	Values in BLUE denote water above level of response zone (flooded)
CS3	<3.5		
CS4	<15	Quantitative Risk Assessment required to evaluate scope of protective measures	

4.5. SUMMARY OF MONITORING RESULTS

4.5.1. GROUNDWATER

During the first two visits, the water level within two of the monitoring wells (WS102 and WS105) was recorded to be above the top of the response zone (flooded). However, during the remaing four visits no wells recorded as flooded, suugesting the flooding was a result of high rainfall prior to monitoring.

Within the remaining monitoring wells, the groundwater level was recorded between 1.10m and 2.37m bgl, with groundwater levels generally decreasing over the monitoring period.

4.5.2. BAROMETRIC PRESSURE

Visit 1 and visit 6 were undertaken during periods of relatively low/falling pressure, with pressure recorded to be 993 and 966 mbar, respectively. Visit 4 was also undertaken during a period of falling pressure.

Visit 2 was undertaken during a period of relatively low/rising pressure and visit 5 was undertaken during a period of relatively high/steady pressure.

It is therefore considered that the visits have been undertaken over representative conditions.

4.5.3. GAS FLOW

Throughout the monitoring period, flow rates were recorded to be <0.1 l/hr (limit of detection of the analyser).

4.5.4. GAS CONCENTRATIONS

The maximum methane value recorded within the monitoring wells was 0.1% v/v (limit of detection of the analyser).

The maximum carbon dioxide value recorded within the monitoring wells was 2.4% v/v (WS102).

4.6. CONCLUSION

The determined Characteristic Situation for each standpipe for each visit is presented in Table 4.8. This indicates that based on the peak flow rates the majority of the monitoring visits classify as Characteristic Situation (CS)1 – Very Low Gas Risk.

TABLE 4.8 GAS RISK PROFILE AND LOCATION

WELL	DATE	DEPTH TO WATER (m bgl)	MAX FLOW (l/hr)	MAX CH_4 (%V/V)	MAX CH_4 Q_{hg} (l/hr)	MAX CO_2 (%V/V)	MAX CO_2 Q_{hg} (l/hr)	CHARACTERISTIC SITUATION	NHBC TRAFFIC LIGHT
WS102	06/01/23	0.90	0.1	0.1	0.0001	0.1	0.0001	CS1	Green
	16/01/23	0.90	0.1	0.1	0.0001	0.1	0.0001	CS1	Green
	08/02/23	1.86	0.1	0.1	0.0001	2.4	0.0024	CS1	Green
	23/02/23	1.90	0.1	0.1	0.0001	0.3	0.0003	CS1	Green
	02/03/23	2.35	0.1	0.1	0.0001	0.1	0.0001	CS1	Green
	13/03/23	2.11	0.1	0.1	0.0001	0.1	0.0001	CS1	Green
WS103	06/01/23	1.20	0.1	0.1	0.0001	0.1	0.0001	CS1	Green
	16/01/23	1.20	0.1	0.1	0.0001	0.1	0.0001	CS1	Green
	08/02/23	1.79	0.1	0.1	0.0001	2.3	0.0023	CS1	Green
	23/02/23	1.38	0.1	0.1	0.0001	0.2	0.0002	CS1	Green
	02/03/23	2.37	0.1	0.1	0.0001	0.1	0.0001	CS1	Green
	13/03/23	2.13	0.1	0.1	0.0001	0.1	0.0001	CS1	Green
WS105	06/01/23	0.85	0.1	0.1	0.0001	0.1	0.0001	CS1	Green
	16/01/23	0.85	0.1	0.1	0.0001	0.1	0.0001	CS1	Green
	08/02/23	1.80	0.1	0.1	0.0001	2.3	0.0023	CS1	Green
	23/02/23	1.95	0.1	0.1	0.0001	0.1	0.0001	CS1	Green
	02/03/23	1.99	0.1	0.1	0.0001	0.1	0.0001	CS1	Green
	13/03/23	2.10	0.1	0.1	0.0001	0.1	0.0001	CS1	Green
WS106	06/01/23	1.10	0.1	0.1	0.0001	0.1	0.0001	CS1	Green
	16/01/23	1.10	0.1	0.1	0.0001	0.1	0.0001	CS1	Green
	08/02/23	1.99	0.1	0.1	0.0001	2.3	0.0023	CS1	Green
	23/02/23	1.15	0.1	0.1	0.0001	0.5	0.0005	CS1	Green
	02/03/23	2.18	0.1	0.1	0.0001	0.1	0.0001	CS1	Green
	13/03/23	1.90	0.1	0.1	0.0001	0.1	0.0001	CS1	Green

E3P has assessed the previous variables and come to the following conclusions:

- The site is predominantly glacial till of CLAY at depths of 0.15m to 17.00m bgl.
- Made Ground has been encountered in two locations at a maximum depth of 1.20m bgl.
- With due consideration to the Conceptual Site Model and the absence of any persistent gas source and gas generation potential, it is considered by E3P that the site can be classified as CS1/Green, suggesting no gas protection measures will be required.

It is recommended that the full ground gas assessment and recommended protection measures (if applicable) are agreed with the local authority prior to their adoption on site. Furthermore, all protection measures adopted should be validated by a suitably qualified engineer.

4.7. POTABLE WATER SUPPLY

This section provides a summary of the site investigation data with reference to the selection of potable water supply pipework. The assessment is made with reference to the UK Water Industry Research (UKWIR) publication "*Guidance on the selection of Water Supply Pipes to be used in Brownfield Sites*"

TABLE 4.9 PIPELINE SELECTION PE THRESHOLD CONCENTRATIONS

Contaminant Group	PE-threshold (mg/kg)	Concentrations at Current pipeline depth (mg/kg)
Total VOC	0.5	<LOD
Total BTEX And MTBE	0.1	N/A
Total SVOCs (Excluding PAH and those substances marked with an *)	2	<LOD
EC5-EC10 Aliphatic and Aromatic Hydrocarbons	2	<1.2
EC10-EC16- Aliphatic and Aromatic Hydrocarbons	10	16.9 (WS105 1.00m)
EC16-EC40 Aliphatic and Aromatic Hydrocarbons	500	<34
Phenols (From SVOC Analysis)*	2	N/A
Cresols and Chlorinated Phenols (From SVOC Analysis)	2	NA
Ethers*	0.5	NA
Nitrobenzene*	0.5	NA
Ketones*	0.5	NA
Aldehydes*	0.5	NA
Amines	Fail	NA
Other Consideration		
Are there any exceedances of the PE threshold outside of the pipeline depth?	None identified.	
Is free product present in soil and groundwater?	None identified.	
Could hydrocarbon impact at greater depth than current pipeline depth be mobilised by rising groundwater levels?	No hydrocarbon impact has been identified across the site.	
Will soils impacted with above determinands likely be utilised elsewhere on site?	N/A	
Will soils be imported to site as part of any future earth works	Currently unknown, however it is unlikely soils will be required to be imported to site. The importation of materials may affect the WIR Risk Assessment which should be updated after completion.	

Notes - Pipe line depth normally between 0.75m–1.35m

Based on the assessment of current site conditions it is likely that PE pipe will be suitable at the proposed development.

4.8. CONCEPTUAL SITE MODEL

Following the completion of the intrusive site investigation, chemical analysis and risk assessment, the conceptual model shown in Table 4.10 has been prepared for the site.

TABLE 4.10 CONCEPTUAL MODEL

POLLUTANT LINKAGE	CONTAMINANT (SOURCE)	PATHWAY	RECEPTOR	PROBABILITY	CURRENT RISK	RESIDUAL RISK AFTER MITIGATION
PL1 PL2	Heavy Metals, non-volatile PAH (Made Ground)	Dermal contact. Dermal contact and ingestion.	Future site users. Off-site receptors.	Low Likelihood	Low	LOW
Discussion: No exceedances have been identified on site. **Recommendation:** A 300 mm clean growing medium will be required in areas where Made Ground remains. Excavation can cease where the natural drift deposits are identified.						
PL3	Methane, carbon dioxide (Localised Made Ground)	Inhalation of gas. Migration through permeable strata and preferential pathways. Explosion in confined spaces.	Future site users. Buildings. Off-site land users.	Low likelihood	Low	LOW
Assessment: No significant sources have been identified. Localised Made Ground is a potential source within areas of infilled field boundaries across the site. **Recommendation:** A completed phase of ground gas monitoring confirms that the site should be classified as CS1/Green.						

POLLUTANT LINKAGE	CONTAMINANT (SOURCE)	PATHWAY	RECEPTOR	PROBABILITY	CURRENT RISK	RESIDUAL RISK AFTER MITIGATION
PL4	Sulphate (potential ash within Made Ground)	Sulphate attack on concrete.	Building structure.	Low Likelihood	Low	**Low**
Assessment: The soils at the site meet class DS-1, AC-1s. **Recommendation:** Concrete should be designed in accordance with the chemical testing results.						
PL5	Organic contaminants such as hydrocarbons, solvents (imported soils)	Ingestion of tainted water supply.	Future site users. Water pipes.	Low Likelihood	Low	**Low**
Assessment: No elevated concentrations of TPHs have been identified at the proposed pipeline depth (0.75 m – 1.35 m). **Recommendation:** Based on the assessment of current site conditions, it is likely that PE pipe will be suitable for the proposed development. This will need to be confirmed with a UKWIR risk assessment post remediation and enabling works.						
PL6	Phytotoxic contaminants (Made Ground)	Direct Contact (plant uptake).	Flora.	Low likelihood	Low	**LOW**
Assessment: No phytotoxic contaminants have been identified. **Recommendation:** A growing medium should be installed in areas of proposed planting/soft landscaping to promote healthy plant growth.						

Main exposure pathways:
PL1 = soil ingestion, PL2 = dermal contact and ingestion, PL3 = Vapour/Gas Inhalation; PL4 = Corrosion of concrete; PL5=Tainting of water supply; PL6 = Uptake by plants

5. GEOTECHNICAL ASSESSMENT

5.1. PROPOSED DEVELOPMENT

Eric Wright Construction Ltd intends to construct a new care facility.

Drawing 16-499-002 (Appendix III) identifies the proposed development layout.

5.2. SUMMARY OF GROUND CONDITIONS

- Natural topsoil was encountered as a dark brown silty sandy CLAY with frequent rootlets across the majority of the site. Topsoil was encountered to a maximum depth of 0.35m below ground level (bgl).
- Made Ground deposits were encountered within four exploratory hole locations to depths of between 0.20m and 1.20 m bgl to the west of the site, in the area cleared for an access track associated with the school development, adjacent to the western boundary of the site. Within TP106 and WS103 Made Ground deposits comprised a reworked topsoil, within TP105, brick was encountered within the topsoil and underlying clay to 0.70m bgl and a brick land drain was encountered within TP101a at 1.00m bgl.
- Drift deposits were encountered within all exploratory locations to a maximum proven depth of 17.00m bgl. The drift deposits generally comprised a greyish brown mottled orange slightly sandy CLAY overlying a very stiff greyish brown sandy gravelly CLAY with occasional cobbles and boulders of mudstone. Gravel also comprised of mudstone. Granular drift deposits were identified in CP101 and CP102 between, 3.00 and 8.00m bgl and comprised a medium dense to dense greyish brown SAND and GRAVEL. Lenses of clay were encountered with CP102. Hand pits dug to 0.90m bgl within the bund to the west of the site, confirmed the bund comprised topsoil, overlying a stiff CLAY.
- The solid bedrock geology was not encountered during the site investigation. Additionally, the depth to bedrock is not recorded within any nearby freely available BGS borehole records.
- Groundwater was not encountered during the site investigation.

5.3. SITE PREPARATION

The site should be cleared and any vegetation below areas of proposed development stripped in accordance with Series 200 of the *Manual of Contract Documents for Highway Works (MCHW)*. This should include the following:

- Roots present below the footprint of proposed structures and infrastructure should be grubbed out and the resulting void infilled with suitable compacted engineered fill.
- Demolition of all existing buildings and removal of all concrete hardstanding.
- Redundant services should be sealed off and grubbed out and replaced with suitable compacted engineered fill.
- Buried structures and old foundations have been encountered on site. These should be excavated from below the proposed development footprint with the resulting void backfilled.

5.4. FOUNDATION CONDITIONS AND ASSESSMENT OF POTENTIAL BEARING CAPACITIES

In due consideration of the identified ground conditions, in-situ and laboratory geotechnical testing, E3P has undertaken an assessment of the net safe allowable bearing pressure (ABP) within the underlying natural stratum to assist in the detailed design of foundations and infrastructure and determine the target founding stratum. The results of this assessment are summarised in Table 5.1.

TABLE 5.1 SUMMARY OF ABP

GRANULAR SOILS			
Description	**Depth (Range m bgl)**	**Relative Density**	**Allowable Bearing Pressure (kN/m^2)**
SAND and GRAVEL	3.00-5.45	Medium Dense	235-290
SAND and GRAVEL	5.00-8.45	Dense	324-327
COHESIVE SOILS			
Description	**Depth (range m bgl)**	**Undrained Shear Strength (Cu) (kN/m^2)**	**Allowable Bearing Pressure (kN/m^2)**
Stiff CLAY (CP101)	1.00-2.45	45-66	93-135
Very stiff CLAY	1.00-2.45	78-226	160-464
Very stiff CLAY	3.00-5.45	78-219	161-450
Very stiff gravelly CLAY	6.50-17.00	150-189	308-390

Based on the assessment of the relative undrained shear strength, relative in-situ densities and corresponding safe net allowable bearing pressure, the suitable target founding stratum has been identified as the underlying stiff to very stiff glacial clays.

To determine if VSC is viable at the subject site, E3P has completed a Ground Improvement Design Risk Matrix that is summarised in Table 5.2.

TABLE 5.2 GROUND IMPROVEMENT DESIGN RISK MATRIX

RISK ITEM	COMMENT	PASS/FAIL
Soft clays with an undrained shear strength of less than 30 kN/m^2	CLAY soils are generally stiff to very with Cu > 49 kN.	**PASS**
Ground with peat layers close to foundation level or the base of the stone column, or where intermediate layers of peat are thicker than 200 mm, either as a single layer or the sum of the thicknesses of individual layers throughout the length of the stone column	None identified.	**PASS**
Voided filled ground, e.g. old water tanks, pottery, glass bottles, concrete rubble or brick fill of unsuitable grading	None identified.	**PASS**

RISK ITEM	COMMENT	PASS/FAIL
Loose or non-engineered fill not previously subject to rising or fluctuating water levels saturation	None identified.	**PASS**
Filled ground still settling or expected to settle under its own weight or due to the effects of surcharging/upfilling where there is a high organic content or where decay is continuing	None identified.	**PASS**
Fill, containing degradable material where organic material forms more than 15% of fill by volume	None identified.	**PASS**
Clays with a plasticity index greater than 40%	None identified.	**PASS**
Highly sensitive soils liable to collapse or remoulding	None identified.	**PASS**
Cohesive soils with trees in influencing distance	Plots where tree influence has been modelled and will either be subject to a piled or mass trench-fill solution.	**PASS**
Overall Risk Rating and Suitability for Vibratory Ground Improvement		**PASS**

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.

It is recommended that at working drawing stage a foundation schedule is prepared for the development, taking account of the physical change of natural clay soils and the current/proposed locations of trees.

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, based on our extensive experience of similar sites, we would anticipate that the final foundation solution would be a combination of the following:

- Shallow strip foundations bearing on stiff to very stiff gravelly CLAY at circa 1 m bgl; and
- Trench fill to support reinforced strip foundations in areas of variable ground and/or potential tree influence.

A summary of anticipated foundations is presented in Table 5.3.

TABLE 5.3 ANTICIPATED FOUNDATIONS

LOCATION	ANTICIPATED FOUNDING STRATA DEPTH (m bgl)	TARGET STRATUM	TREES	FOUNDATION TYPE	TYPE OF CONCRETE
WS101	1.05	Stiff CLAY	Y	Mass Trench	–
WS102	0.90	V Stiff CLAY	N	Strip	DS-1, AC-1s
WS103	0.90	V Stiff CLAY	N	Strip	–
WS104	1.25	V Stiff CLAY	N	Strip	–

LOCATION	ANTICIPATED FOUNDING STRATA DEPTH (m bgl)	TARGET STRATUM	TREES	FOUNDATION TYPE	TYPE OF CONCRETE
WS105	1.45	V Stiff CLAY	N	Strip	–
WS106	1.05	Stiff CLAY	N	Strip	DS-1, AC-1s
TP101a	TBC	TBC	N	Strip	DS-1, AC-1s
SA101/TP101b	0.90	V Stiff CLAY	Y	Mass Trench	–
SA102/TP102	0.90	Firm CLAY	N	Strip	DS-1, AC-1s
SA103/TP103	0.90	V Stiff CLAY	N	Strip	DS-1, AC-1s
TP104	1.15	V Stiff CLAY	N	Strip	DS-1, AC-1s
TP105	1.05	V Stiff CLAY	N	Strip	DS-1, AC-1s
TP106	0.95	Firm to Stiff CLAY	Y	Mass Trench	DS-1, AC-1s
TP107	0.90	V Stiff CLAY	N	Strip	DS-1, AC-1s
TP108	0.90	Stiff CLAY	N	Strip	–
TP109	0.90	V Stiff CLAY	N	Strip	–
TP110	1.05	Stiff CLAY	N	Strip	DS-1, AC-1s
TP111	1.05	V Stiff CLAY	N	Strip	DS-1, AC-1s
TP112	0.90	V Stiff CLAY	N	Strip	DS-1, AC-1s
TP113	1.15	V Stiff CLAY	N	Strip	DS-1, AC-1s
TP114	1.05	Stiff CLAY	N	Strip	–
TP115	1.15	V Stiff CLAY	Y	Mass Trench	–
CP101	0.90	Stiff CLAY	N	Strip	–
CP102	0.90	V Stiff CLAY	N	Strip	–

5.5. GROUND FLOOR SLABS

Current building control regulations require that where infilled ground is present to depths in excess of 600 mm, or where the substratum is variable in terms of the structure and settlement potential, or where clay soils are present within the influence of existing or proposed trees, a suspended floor slab is required.

In this instance, it is considered that for the majority of substructures, the underlying stratum would have in excess of 600 mm of infill and, as such, a suspended floor slab will be required.

Where a cast in-situ suspended slab is utilised with no subfloor void, appropriate compressible material (heave precautions) will be required in the construction of the substructure.

5.6. HEAVE PRECAUTIONS

The site has been proven to be underlain by clay soils, which are susceptible to volumetric instability due to fluctuations in moisture content, particularly within influencing distance of trees as per the NHBC/LABC conjectured zones of influence.

As the clay is deemed to be low plasticity, heave precautions are not required to the internal face of the external load-bearing walls (outside or within tree influence).

If a ground beam is to be constructed within the zone of tree influence, heave precautions are required to the underside of this and edge beams.

If the ground floor slab is to be constructed with a beam and block floor, a minimum subfloor void of 200 mm is required within any structures located in the zone of conjectured tree influence.

If the ground floor slab is constructed with a cast in-situ suspended floor slab, then heave precautions that can tolerate 50 mm of clay swelling are required within any part of the floor slab to be located within the zone of influence of a tree.

A summary of heave precautions is presented in Table 5.4.

TABLE 5.4 SUMMARY OF HEAVE PRECAUTIONS

		MINIMUM VOID DIMENSION FOR FOUNDATIONS, GROUND BEAMS AND SUSPENDED IN-SITU CONCRETE GROUND FLOORS		MINIMUM VOID DIMENSIONS UNDER PRECAST CONCRETE AND SUSPENDED TIMBER FLOORS
Plasticity Index of Soil	**Required Foundation Depth (m)**	**Thickness of Void Former Against Side of Foundation or Ground Beam (mm)**	**Thickness of Void Former on Underside of Edge Beam and Floor Slab (mm)**	**Void Dimension (mm)**
High Plasticity (> 40)	> 2.5	Engineer Design		Engineer Design
	2.0–2.5	35	150	300
	1.5–2.0	25	75	
Moderate Plasticity (20–40)	> 2.5	Engineer Design		Engineer Design
	2.0–2.5	25	100	250
	1.5–2.0	25	50	
Low Plasticity (< 20)	2.0–2.5	N/A	50	200
	> 2.0	No Special Precautions		

5.7. HIGHWAYS CONSTRUCTION

A programme of remediation and enabling works will be required to remediate the proposed road subgrade in accordance with the requirements of the Manual of Contract Documents for Highway Works Volume 1 Specification For Highway Works (Series 600-Earthworks) for a method compaction.

It is considered that the material can be re-engineered using method compaction to achieve a CBR in excess of 5% if works are completed in favourable climatic conditions.

5.8. DRAINAGE

The presence of substantial depths of Made Ground across some areas of the site may result in settlement. It is therefore recommended that drain runs are designed using steeper gradients and flexible joints to allow for some differential settlement.

If soakaway drainage is to be considered, full BRE 365 testing must be completed to inform the detailed design.

5.9. 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).

5.10. EXCAVATIONS

Trial pits were generally stable in both granular Made Ground and natural strata; as such, it is considered that near-surface excavations will be feasible.

Site observations indicated that excavations should be feasible in the near surface with normal plant. 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, 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 5.5 CIVIL ENGINEERING EXCAVATION RISK MATRIX

RISK ITEM	PRESENT	COMMENT
Running Sands	No	No running sand has been identified.
Minor Water Ingress	No	Minor 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	Yes	No shallow bedrock has been identified.

5.11. 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).

5.12. GEOTECHNICAL RISK REGISTER

POTENTIAL ABNORMAL CONSTRAINT	LOCATION ON SITE	ESTIMATED AREA OF SITE AT RISK (%)	ASSESSMENT AND MITIGATION
Remediation of contaminated soils	On site	0	No contaminant exceedances were identified during the site investigation.
Bedrock	N/A	N/A	Shallow bedrock has not been identified.
Mature trees	North	TBC	Arboriculture survey required to determine areas of potential tree influence.
Volume change potential clay	All	100	The clay soils are of low volume change potential, therefore heave precautions may not be required.
Peat	N/A	N/A	Peat has not been identified within the site investigation.
Running sands	N/A	N/A	Data searches indicate very low risk.
Ground dissolution	N/A	N/A	Data searches indicate very low risk.
Concrete design	TBC	100	The concrete design has been determined to be AC-1s, DC-1.
Low-permeability ground	All	100	In-situ BRE 365 Soakaway tests were undertaken within trial pits completed as SA101-SA103. All three tests did not record a sufficient fall in water level to allow reliable calculation of the infiltration rate. The site is predominantly low permeability cohesive deposits, therefore soakaways are unlikely to be effective.
Services/sensitive structures	-	-	A review of online services has not identified any services within the site boundary.
Abnormal foundation solutions	TBC	TBC	It is assumed that a piled foundation will be required due to the development load.
Surface water features	N/A	N/A	A drainage ditch is located circa 40m north of the site, that likely flows south westerly towards the Pendleton Brook.

5.13. FURTHER WORKS

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

- Arboricultural survey.
- Settlement Analysis for earthworks design.
- Geotechnical earthworks strategy (infrastructure).
- Remediation and enabling works strategy.

6. CONCLUSIONS AND RECOMMENDATIONS

6.1. CONTAMINATED LAND ASSESSMENT

Human Health	A Tier I human health risk assessment has been undertaken using the chemical analysis results of 21no soil samples and comparing to the relevant Tier I criteria - residential end use with plant uptake. This assessment has not identified any Tier 1 screening value exceedances on the sampling undertaken to date. Asbestos has not been identified in any of the soils submitted for analysis. Two samples were sent for volatile organic compound (VOC) and semi-volatile organic compound (SVOC) screening; no elevated VOC or SVOC values were identified from the testing. Chemical analysis of the natural CLAY drift deposits has identified 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. A preliminary chemical analysis of the natural topsoil has identified these soils to be acceptable for use within the proposed garden areas; however, further chemical validation samples will be required to confirm this. Where reworked topsoil is present, this material is not deemed to be suitable for use within proposed garden areas.
Controlled Waters	Low risk to controlled waters.
Ground Gas	Ground gas monitoring confirms the site can is classified as Characteristic Situation 1/Green.
Potable Water	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. Current chemical analysis of soils at the site suggests the polyethylene (PE) pipeline will be suitable for the development.

6.2. GEOTECHNICAL ASSESSMENT

Based on the assessment of the relative undrained shear strength, relative in-situ densities and corresponding safe net allowable bearing pressure, the suitable target founding stratum has been identified as the underlying stiff medium strength to very stiff very high strength CLAY.

Dependent on development levels, it is considered that the optimum foundation solution would be a combination of the following:

- Strip/trench foundations bearing into competent stiff to very stiff (medium to very high strength) CLAY
- Trench fill to support reinforced strip foundations in areas of variable ground and/or potential tree influence.

Foundation depths within the conjectured influence of former, existing or proposed trees will need to be deepened to ensure that structural loading bears within the underlying target founding stratum, which cannot be subject to volumetric instability associated with fluctuation in moisture content.

During a phase of cut-and-fill enabling works to create a developable platform, all below-ground obstructions will require grubbing out to the base of the Made Ground to enable the construction of the proposed plot.

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.

9. E3P cannot be held responsible for any use of the report or its contents for any purpose other than that for which it was prepared. The copyright in this report and other plans and documents prepared by E3P is owned by them and no such plans or documents may be reproduced, published or adapted without written consent. Complete copies of this may, however, be made and distributed by the client as is expected in dealing with matters related to its commission. Should the client pass copies of the report to other parties for information, the whole report should be copied, but no professional liability or warranties shall be extended to other parties by E3P in this connection without their explicit written agreement there to by E3P.

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

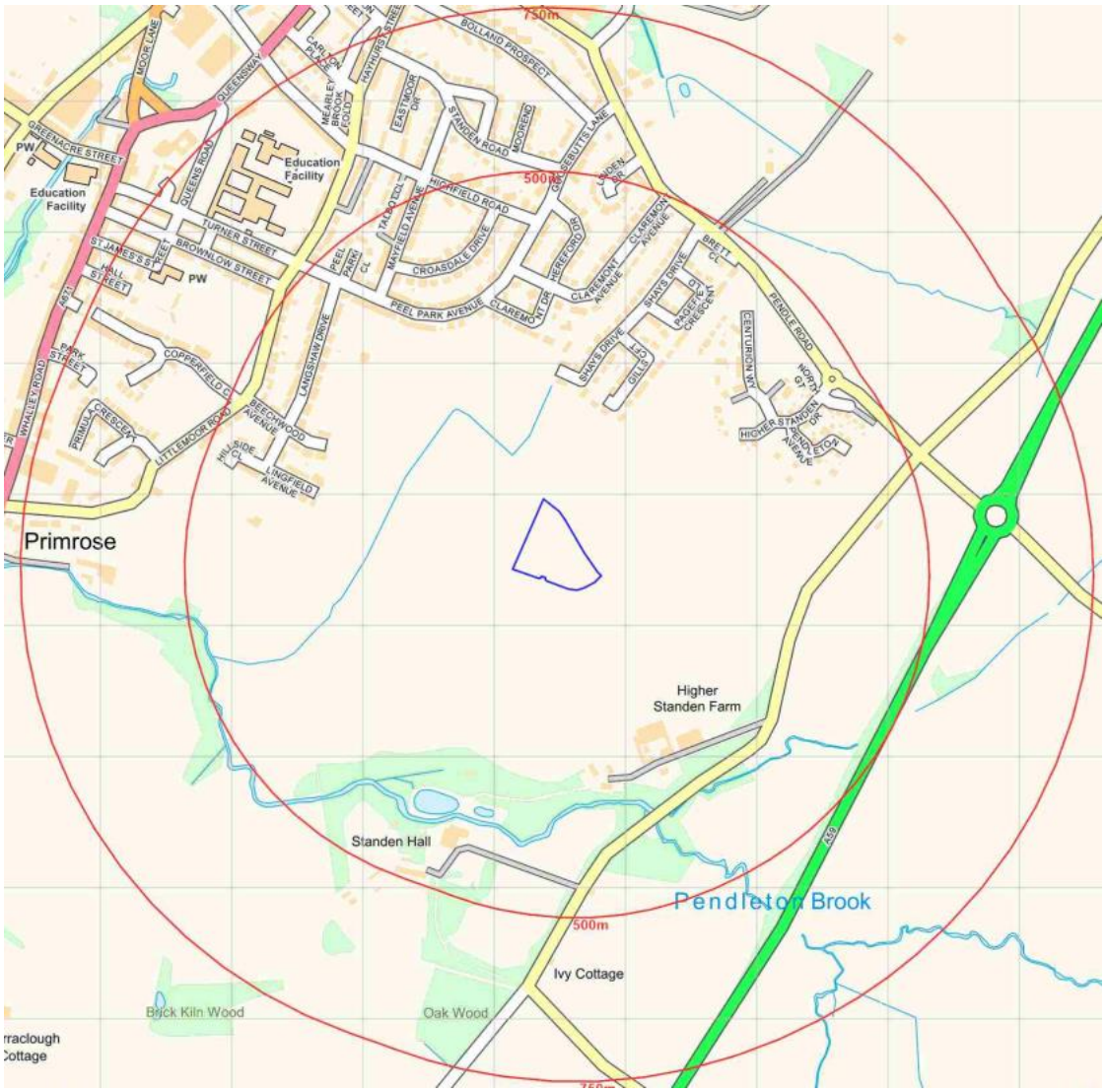
TERMS

ACM	Asbestos-containing material	**MMP**	Materials management plan
ADS	Acoustic design statement	**ND**	Not detected
AST	Above-ground storage tank	**NDP**	Nuclear density probe
BGS	British Geological Survey	**NMP**	Noise management plan
BSI	British Standards Institute	**NPSE**	Noise policy statement for England
BTEX	Benzene, toluene, ethylbenzene, xylenes	**NR**	Not recorded
CA	Coal Authority	**PAH**	Polycyclic aromatic hydrocarbon
CBR	California bearing ratio	**PCB**	Polychlorinated biphenyl
CIEH	Chartered Institute of Environmental Health	**PI**	Plasticity index
CIRIA	Construction Industry Research Association	**PID**	Photo ionisation detector
CLEA	Contaminated land exposure assessment	**POS**	Public open space
CML	Council of Mortgage Lenders	**PPE**	Personnel protective equipment
CoC	Contaminants of concern	**ProPG**	Professional practice guidance
CSM	Conceptual site model	**QA**	Quality assurance
DNAPL	Dense non-aqueous phase liquid (chlorinated solvents, PCB)	**SGV**	Soil guideline value
DWS	Drinking water standard	**SPH**	Separate-phase hydrocarbon
EA	Environment Agency	**SPT**	Standard penetration test
EQS	Environmental quality standard	**SVOC**	Semi-volatile organic compound
FFL	Finished floor level	**TPH**	Total and speciated petroleum hydrocarbon
GAC	General assessment criteria	**TPH CWG**	Total Petroleum Hydrocarbon (Criteria Working Group)
GL	Ground level	**UKWIR**	United Kingdom Water Infrastructure Risk
GSV	Gas screening value	**UST**	Underground storage tank
HCV	Health criteria value	**VCC**	Vibro-concrete column
ICSM	Initial conceptual site model	**VOC**	Volatile organic compound
LEL	Lower explosive limit	**VRSC**	Vibro-replacement stone columns
LMRL	Lower method reporting limit	**VSC**	Vibro-stone columns
LNAPL	Light non-aqueous phase liquid (petrol, diesel, kerosene)	**WHO**	World Health Organisation
MCV	Moisture condition value	**WRAP**	Waste and Resources Action Programme
MIBK	Methyl isobutyl ketone	**WTE**	Water table elevation

m	Metres	**ppm**	Parts per million
km	Kilometres	**mg/m^3**	Milligram per metre cubed
% v/v	Percent volume in air	**m bgl bgl**	Metres below ground level
mb	Millibars (atmospheric pressure)	**m bcl**	Metre below cover level
l/hr	Litres per hour	**mAOD**	Metres above ordnance datum (sea level)
µg/l	Micrograms per litre (parts per billion)	**kN/m^2**	Kilonewtons per metre squared
ppb	Parts per billion	**µm**	Micrometre
mg/kg	Milligrams per kilogram (parts per million)	**SSRT**	Site Specific Remediation Target
PSD	Particle Size Distribution	**DD**	Dry Density
CL:AIRE	Contaminated Land: Applications in Real Environments	**Mc**	Moisture Content
ρ	Bulk Density	**GPR**	Ground Penetrating Radar
NDP	Nuclear Density Probe	**FFL**	Finished Floor Level
LEL	Lower Explosive Limit	**UKWIR**	UK Water Industry Research
CIRIA	Construction Industry Research and Information Association	**LOD**	Limit of Detection

APPENDIX III
DRAWINGS

DRAWING 16-499-001 – SITE LOCATION PLAN



P1	REVA	09.02.2023	OW	EC
Phase	Issue	Date	Drawn	Checked

Notes:

Client: Eric Wright

Job No: 16-499

Date: 09.02.2023

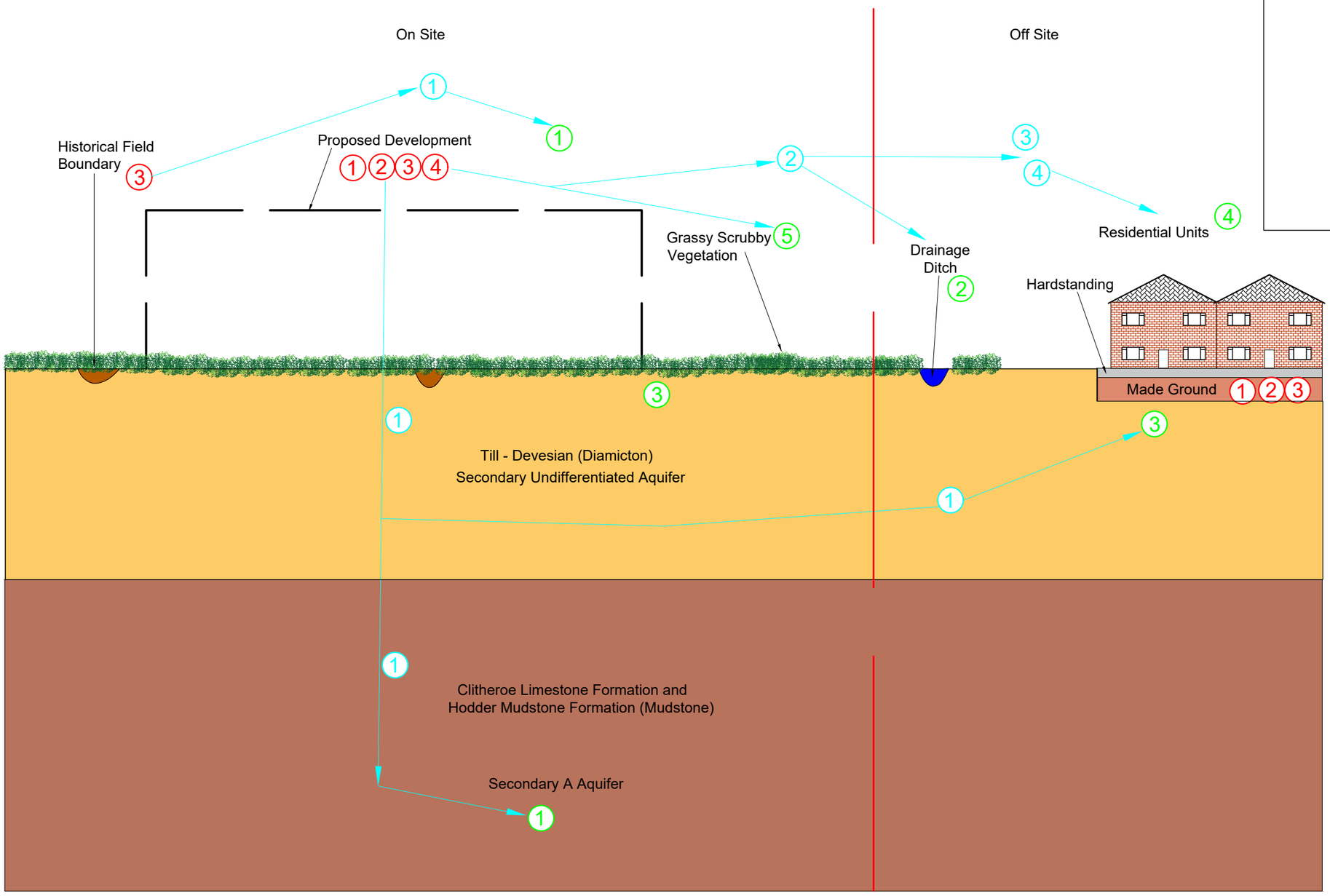
Drawing No: 002

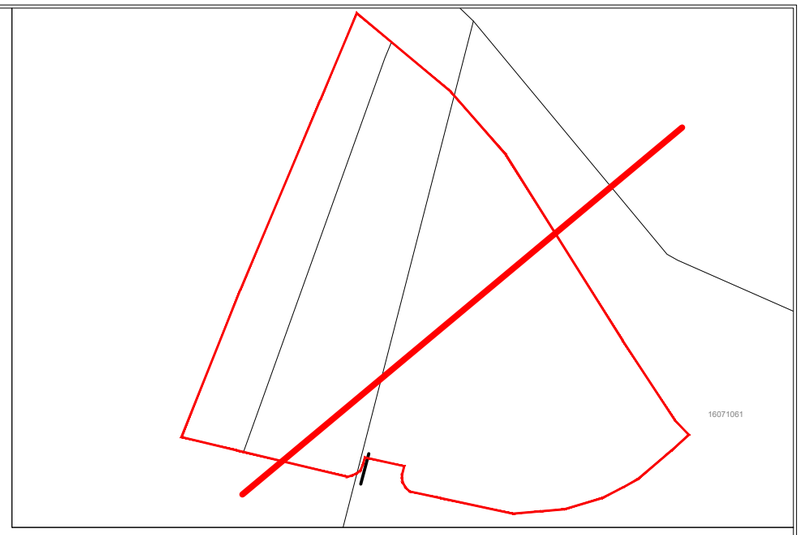
Scale: 1:1000 @ A3

Job Title: Standen Central

Drawing Title: Proposed Development Plan

e3p
Environmental Engineering Partnership Ltd
Taylor Road, Trafford Park
Urmston, Manchester, M41 7JQ
Tel: 0161 707 9612
E-mail: info@e3p.co.uk
Website: www.e3p.co.uk





Geology Key

- Made Ground
- Hardstanding
- Drainage Ditch
- Till Devisian (Diamicton)
- Clitheroe Limestone Formation

Sources

1. Heavy Metals, heavy end hydrocarbons and non volatile polycyclic hydrocarbons (PAHs)
2. Volatile organic compounds (VOCs) & TPHs
3. Hazardous Ground Gases (CO_2 / CH_4)
4. PH & Sulphate

Pathways

1. River
2. Shallow Groundwater
3. Potential Future Residents / Industrial Employees
4. Buildings

Receptors

1. Secondary A aquifer
2. Surface Water Courses
3. Foundations / Concrete
4. Residential End Users
5. Flora & Fauna

Notes:

Phase	Issue	Date	Drawn	Checked
P1	REVA	16.11.2022	LM	MD

Client: Eric Wright

Job No: 16-499

Date: 16.11.2022

Drawing No: 010

Scale: NTS

Job Title: Standen Central

Drawing Title: Conceptual Site Model

Environmental Engineering Partnership Ltd
Taylor Road, Trafford Park
Urmston, Manchester, M41 7JQ
Tel: 0161 707 9612
E-mail: info@e3p.co.uk
Website: www.e3p.co.uk

Historical Features

Field Boundary

Notes:

Client:
Eric Wright

Job No:
16-499

Date:
16.11.2022

Drawing No:
003

Scale:
1:1000 @ A3

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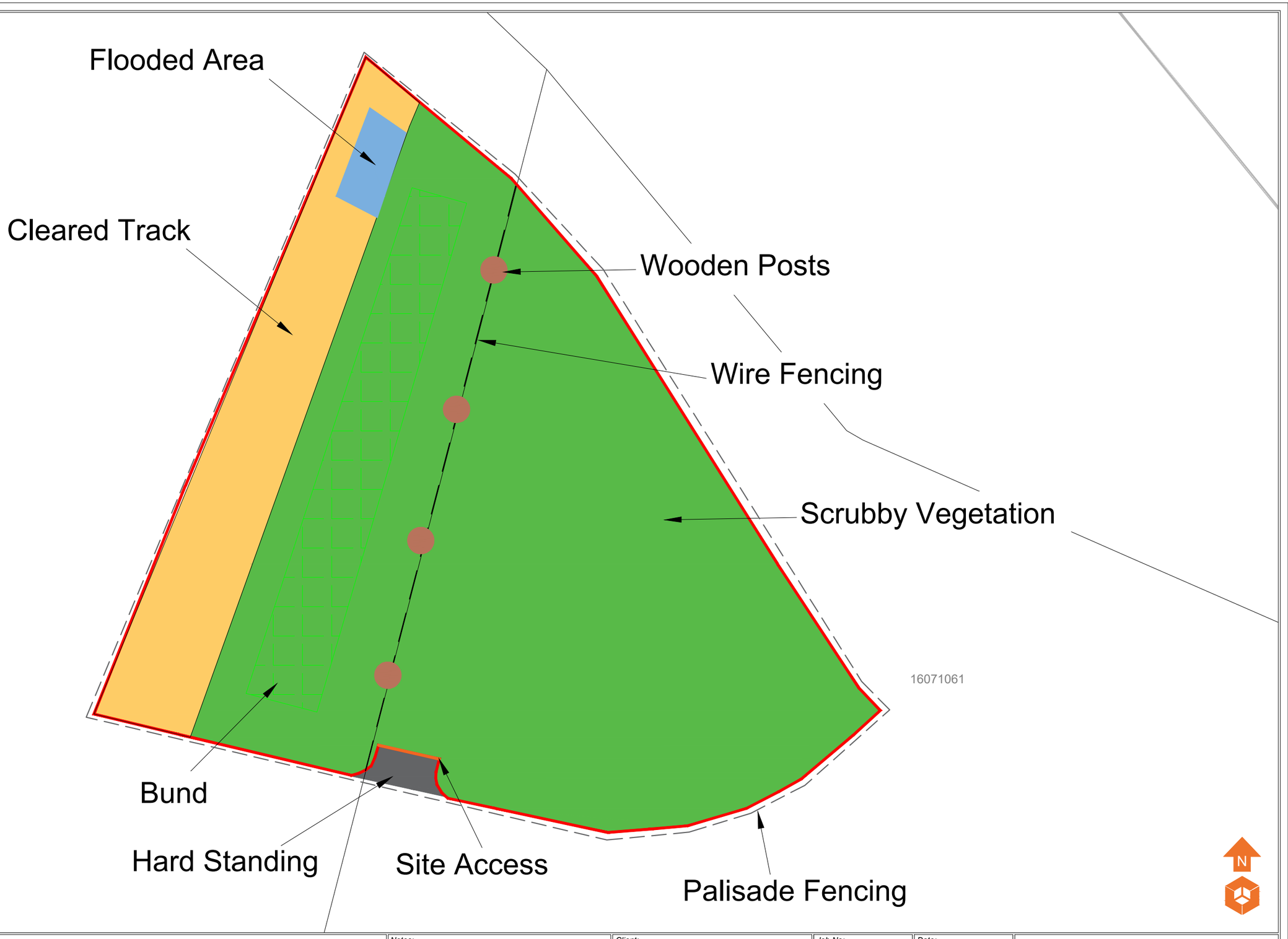
Taylor Road, Trafford Park
Urmston, Manchester, M41 7JQ
Tel: 0161 707 9612
E-mail: info@e3p.co.uk
Website: www.e3p.co.uk

Phase	Issue	Date	Drawn	Checked
P1	REVA	16.11.2022	LM	MD

Job Title:
Standen Central

Drawing Title:
Historical Features Plan



Site Features

- Scrubby Vegetation
- Cleared Track
- Site Access
- Bund
- Hardstanding
- Palisade Fencing
- Flooded Area

Notes:

Phase	Issue	Date	Drawn	Checked
P1	REVB	09.02.2023	OW	EC
P1	REVA	16.11.2022	LM	MD

Client: Eric Wright

Job No: 16-499

Date: 09.02.2023

Drawing No: 004

Scale: 1:1000 @ A3

Job Title: Standen Central

Drawing Title: Site Features Plan

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Environmental Engineering Partnership Ltd
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Urmston, Manchester, M41 7JQ
Tel: 0161 707 9612
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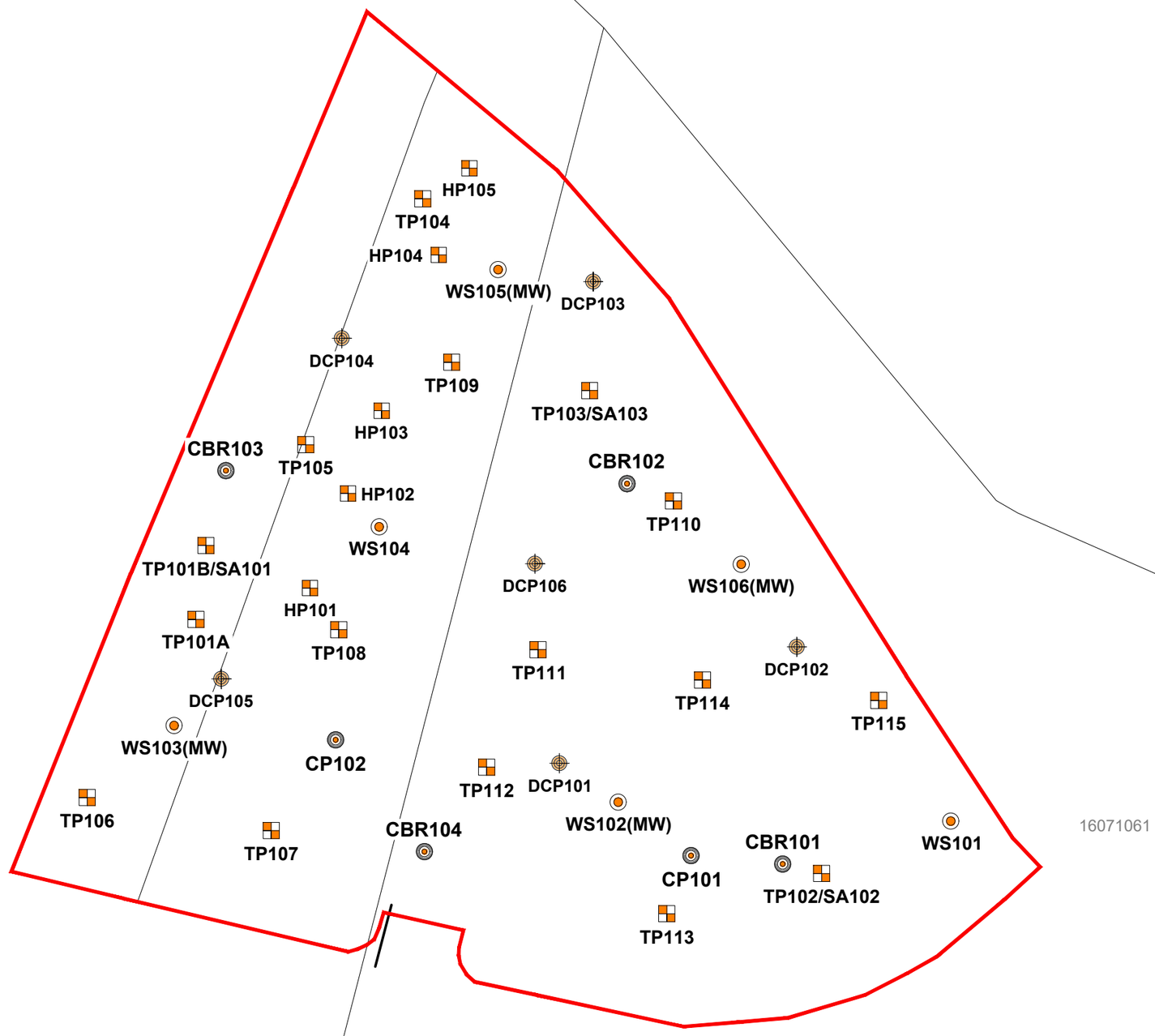
Website: www.e3p.co.uk



Location Symbols

- Approximate Window Sample Probehole Location
- Approximate Trial Pit Location
- Approximate Cable Percussive Borehole Location
- Approximate Soakaway Test Location
- Approximate Hand Dug Pit Location
- Approximate California Bearing Ratio Test Location
- Approximate Dynamic Cone Penetrometer Test Location

Notes:

Phase	Issue	Date	Drawn	Checked
P1	REVB	06.02.2023	OW	EC
P1	REVA	16.12.2022	OW	EC

Client: Eric Wright

Job No: 16-499

Date: 06.02.2023

Drawing No: 005

Scale: NTS @ A3

Job Title: Standen Central

Drawing Title: Exploratory Hole Location Plan

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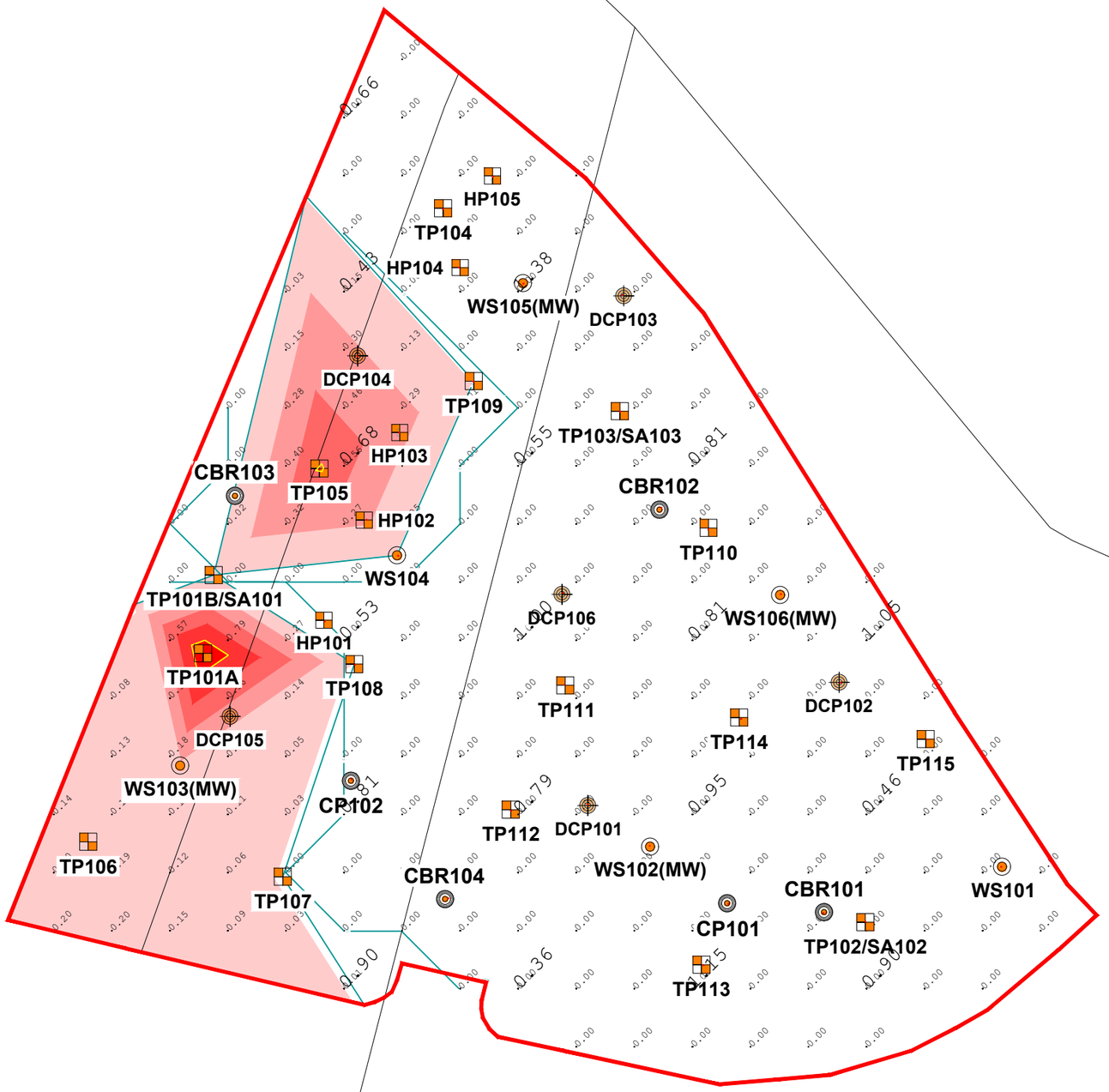
Environmental Engineering Partnership Ltd
Taylor Road, Trafford Park
Urmston, Manchester, M41 7JQ
Tel: 0161 707 9612
E-mail: info@e3p.co.uk
Website: www.e3p.co.uk



16071061

Location Symbols

- Approximate Window Sample Probehole Location
- Approximate Trial Pit Location
- Approximate Cable Percussive Borehole Location
- Approximate Soakaway Test Location

Made Ground Depth (m)

- Depth of Made Ground 0.00 - 0.24m
- Depth of Made Ground 0.25 - 0.49m
- Depth of Made Ground 0.50 - 0.74m
- Depth of Made Ground 0.75 - 0.99m
- Depth of Made Ground >1.00m

Notes:

Phase	Issue	Date	Drawn	Checked
P1	REVA	06.01.2023	EB	EC

Client: Eric Wright

Job No: 16-499

Date: 06.01.2023

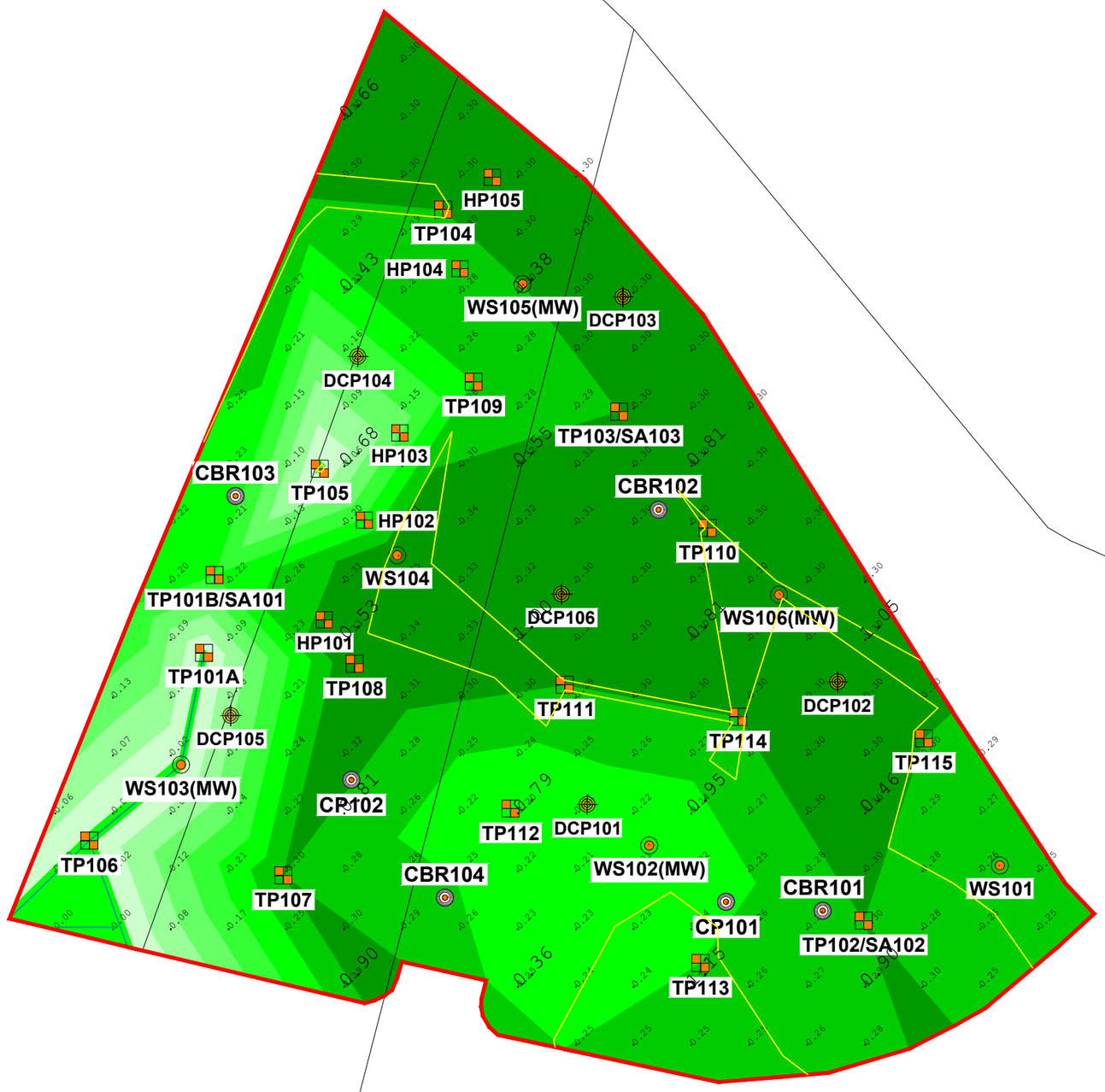
Drawing No: 006

Scale: NTS @ A3

Job Title: Standen Central

Drawing Title: Depth of Made Ground Plan

e3p
Environmental Engineering Partnership Ltd
Taylor Road, Trafford Park
Urmston, Manchester, M41 7JQ
Tel: 0161 707 9612
E-mail: info@e3p.co.uk
Website: www.e3p.co.uk



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Location Symbols

- Approximate Window Sample Probehole Location
- Approximate Trial Pit Location
- Approximate Cable Percussive Borehole Location
- Approximate Soakaway Test Location

Topsoil Depth (m)

- Depth of Topsoil 0.01 - 0.04m
- Depth of Topsoil 0.05 - 0.09m
- Depth of Topsoil 0.10 - 0.14m
- Depth of Topsoil 0.15 - 0.19m
- Depth of Topsoil 0.20 - 0.24m
- Depth of Topsoil 0.25 - 0.29m
- Depth of Topsoil >0.30m

Notes:

P1	REVA	06.01.2023	EB	EC
Phase	Issue	Date	Drawn	Checked

Client: Eric Wright

Job No: 16-499

Date: 06.01.2023

Drawing No: 007

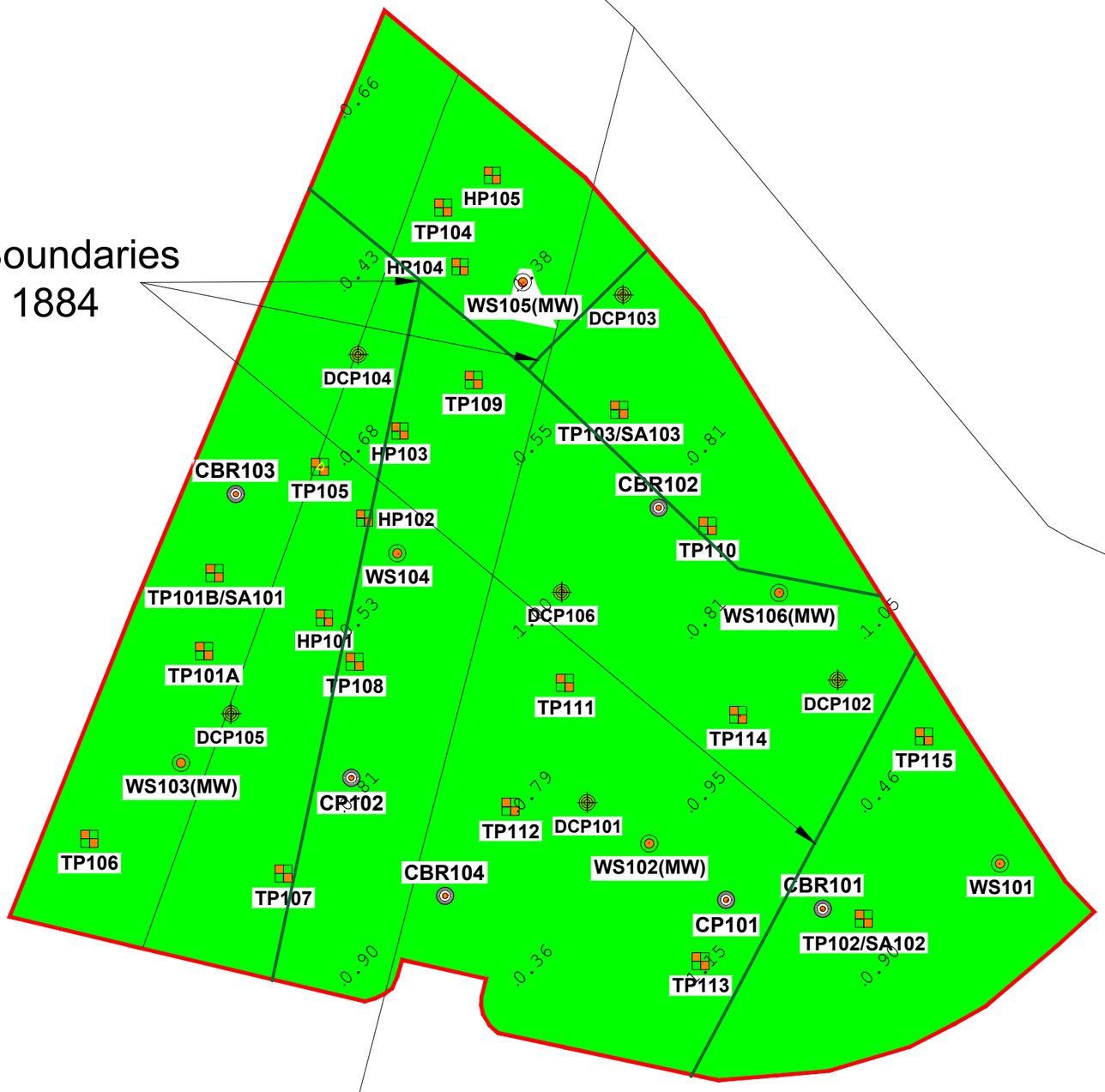
Scale: NTS @ A3

Job Title: Standen Central

Drawing Title: Depth of Topsoil Plan

e3p
Environmental Engineering Partnership Ltd
Taylor Road, Trafford Park
Urmston, Manchester, M41 7JQ
Tel: 0161 707 9612
E-mail: info@e3p.co.uk
Website: www.e3p.co.uk

Former Field Boundaries
Pre 1847 - Pre 1884



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N

Location Symbols

- Approximate Window Sample Probehole Location
- Approximate Trial Pit Location
- Approximate Cable Percussive Borehole Location
- Approximate Soakaway Test Location
- Former Field Boundaries

Shallow Spread Footings

- Depth to Founding Strata 0.00 - 1.24m
- Depth to Founding Strata 1.25 - 1.49m

Mass Trench Fill Footings

- Depth to Founding Strata 1.50 - 1.74m
- Depth to Founding Strata 1.75 - 1.99m
- Depth to Founding Strata 2.00 - 2.24m

Engineered Footings

- Depth to Founding Strata 2.25 - 2.49m
- Depth to Founding Strata >2.50m

Notes:

Phase	Issue	Date	Drawn	Checked
P1	REVB	14.02.2023	EB	RJW
P1	REVA	09.02.2023	OW	EC

Client: Eric Wright

Job No: 16-499

Date: 14.02.2023

Drawing No: 008

Scale: NTS @ A3

Job Title: Standen Central

Drawing Title: Depth of Founding Strata

e3p
Environmental Engineering Partnership Ltd
Taylor Road, Trafford Park
Urmston, Manchester, M41 7JQ
Tel: 0161 707 9612
E-mail: info@e3p.co.uk
Website: www.e3p.co.uk

APPENDIX IV
PHOTOGRAPHS

PLATE 1 BUND THAT RUNS NORTH TO SOUTH ACROSS THE WESTERN SECTOR OF THE SITE

PLATE 2 FORMER FIELD BOUNDARY

PLATE 3 VIEW OF SITE FACING SOUTH

PLATE 4 FLOODED AREA TO THE NORTH OF THE SITE

PLATE 5 TP105 EXCAVATION

PLATE 6 TP105 ARISINGS

PLATE 7 TP111 EXCAVATION

PLATE 8 TP111 ARISINGS

PLATE 9 WS103 ARISINGS AND MONITORING WELL

APPENDIX V
E3P EXPLORATORY HOLE LOGS

Trial Pit Log

			TrialPit No TP101a Sheet 1 of 1
Project Name: Standen Central	Project No. 16499	Co-ords: 374847.00 - 440713.00 Level:	Date 19/12/2022
Location: Clitheroe		Dimensions (m): Depth 1.20 (1.90 × 0.70)	Scale 1:30
Client: Eric Wright			Logged E. Canham

Water Strike	Samples & In Situ Testing: Depth	Type	Results	Depth (m)	Level (m)	Legend	Stratum Description
				0.20			MADE GROUND: Brown sandy gravelly reworked clay with occasional rootlets. Gravel is fine to coarse subangular to subrounded of mudstone and brick.
	1.00	ES					MADE GROUND: Very stiff brown sandy gravelly clay with occasional cobbles and boulders. Gravel is fine to coarse subangular to subrounded of mudstone. Cobbles and boulders are subrounded mudstone. (Brick land drain encountered at 1.00m bgl)
				1.20			End of Pit at 1.20m

1
2
3
4

Trial Pit Photographs

Trial Pit 101a

Trial Pit 101 Spoil

Remarks: 1. Terminated at 1.20m bgl- land drain encountered with water ingress

Stability: Stable.

Trial Pit Log

TrialPit No SA101/ TP101b
Sheet 1 of 1

Project Name: Standen Central	Project No. 16499	Co-ords: 374848.00 - 440718.00 Level:	Date 19/12/2022
Location: Clitheroe		Dimensions (m): 1.90 × 0.70 Depth 2.10	Scale 1:30
Client: Eric Wright			Logged E. Canham

Water Strike	Samples & In Situ Testing: Depth	Type	Results	Depth (m)	Level (m)	Legend	Stratum Description
				0.20			Brown sandy CLAY with occasional rootlets. (Topsoil)
				2.10			Very stiff greyish brown mottled orange sandy gravelly CLAY with frequent cobbles and occasional boulders. Gravel is fine to coarse subangular to subrounded of mudstone. Cobbles and boulders are subrounded mudstone. End of Pit at 2.10m

1
2
3
4

Trial Pit Photographs

Soakaway 101/ Trial Pit 101b

Soakaway 101/ Trial Pit 101b Spoil

Remarks: 1. Complete 2. Soakaway test completed

Stability: Stable.

Trial Pit Log

TrialPit No SA102/ TP102
Sheet 1 of 1

Project Name: Standen Central	Project No. 16499	Co-ords: 374927.00 - 440675.00 Level:	Date 19/12/2022
Location: Clitheroe		Dimensions (m): Depth 1.70 (1.90 × 0.70)	Scale 1:30
Client: Eric Wright			Logged E. Canham

Water Strike	Samples & In Situ Testing: Depth	Type	Results	Depth (m)	Level (m)	Legend	Stratum Description
				0.30			Dark brown silty sandy CLAY with occasional rootlets. (Topsoil)
	0.60	HVP	66				Firm light brown slightly silty slightly sandy CLAY with occasional rootlets.
	0.80	ES		1.00			Firm to stiff dark greyish brown slightly sandy gravelly CLAY with frequent cobbles and occasional boulders. Gravel is fine to coarse subangular to subrounded of mudstone. Cobbles and boulders are subrounded mudstone.
				1.70			End of Pit at 1.70m

Trial Pit Photographs

Soakaway 102/ Trial Pit 102

Trial Pit 102/ Soakaway 102 Spoil

Remarks: 1. Complete 2. Soakaway test completed

Stability: Stable.

Trial Pit Log

TrialPit No SA103/ TP103
Sheet 1 of 1

Project Name: Standen Central	Project No. 16499	Co-ords: 374901.00 - 440746.00 Level:	Date 19/12/2022
Location: Clitheroe		Dimensions (m): 1.90 x 0.70 Depth 1.90	Scale 1:30
Client: Eric Wright			Logged E. Canham

Water Strike	Samples & In Situ Testing: Depth	Type	Results	Depth (m)	Level (m)	Legend	Stratum Description
	0.25	ES		0.30			Dark brown silty sandy CLAY with occasional rootlets. (Topsoil)
	0.50	HVP	98	0.60			Firm to stiff greyish brown mottled orange slightly silty sandy CLAY with occasional rootlets.
				1.90			Very stiff greyish brown sandy gravelly CLAY with frequent cobbles and occasional large boulders. Gravel is fine to coarse subrounded to rounded of mudstone. Cobbles and boulders are subrounded of mudstone.
							End of Pit at 1.90m

1
2
3
4

Trial Pit Photographs

Trial Pit 103/ Soakaway 103

Soakaway 103/ Trial Pit 103 Spoil

Remarks: 1. Complete 2. Soakaway test completed

Stability: Stable.