

Miller Homes

Ground Investigation Report

for

Northenden College, Northenden

Jan 2021

REPORT NO: 20MIL039/GI

- *Desk Studies and Site Walkovers*
- *Intrusive Contaminated Land Investigations*
- *Geotechnical Appraisals and Ground Investigations*
- *Landfill Gas Assessments and Remedial Design*
- *Remediation Design and Implementation*
- *Remediation Project Management and Supervision*
- *Site Abnormal Assessments (Foundations and Contaminated Land)*

GEOTECHNICAL - CONTAMINATED LAND- FLOOD RISK

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Prepared by:



K Rodway

Checked by:



B Lewis

Authorised by:



M Fawcett

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CONTENTS

1	EXECUTIVE SUMMARY	6
2	SITE DESCRIPTION	10
2.1	Introduction	
2.1	Site Location	
3	BACKGROUND	12
3.1	Site Description	
3.2	Site History	
3.3	Hydrogeology and Hydrology	
3.4	Geology	
3.5	Geotechnical Data	
3.6	Industrial Data	
3.7	Sensitive Land Uses	
3.8	Desk Study Review by Betts	
4	E3P SITE INVESTIGATION REPORT SUMMARY	19
4.1	General	
4.2	Ground Conditions	
4.3	Contamination Risk Assessment	
4.4	Groundwater Risk Assessment	
4.5	Ground Gas	
4.6	Potable Water Supply	
4.7	Foundations	
4.8	Soakaways	
4.9	Chemical Attack on Concrete	
4.10	Further Works	
4.11	Betts Recommended Additional Works	
5	REMEDIAL STRATEGY BASED ON THE ABOVE SUMMARY OF ENVIRONMENTAL SENSITIVITY	34
6	INITIAL CONTAMINATION CONCEPTUAL MODEL	35
6.3	Geotechnical Constraints	
7	FIELDWORK	38
7.1	Fieldwork Objectives	
7.2	Fieldwork Scope	
7.3	Access Issues	

8	GROUND CONDITIONS	40
8.1	General	
8.2	Ground Conditions Summary	
8.3	Visual and Olfactory Contamination	
8.4	Obstructions	
8.5	Groundwater – Fieldwork	
9	LABORATORY TESTING	42
9.1	General	
10	CONTAMINATION ASSESSMENT	43
10.1	General	
10.2	Soils Contamination Summary	
10.3	Groundwater Contamination	
11	ENVIRONMENTAL RISK ASSESSMENT	45
11.1	General	
11.2	Assessment of Contamination Analytical Results – Betts Geo & e3p datasets	
12	PRELIMINARY GROUND GAS ASSESSMENT	47
12.1	Ground Gas Requirements – Radon	
12.2	Ground Gas Assessment (e3p)	
13	REVISED CONCEPTUAL SITE MODEL	50
13.1	General	
13.2	Final Conceptual Site Model	
14	OUTLINE STRATEGY FOR RISK REDUCTION / REMEDIATION STRATEGY	52
14.1	General	
14.2	Construction / Maintenance Workers	
14.3	Site-End Users	
14.4	Preliminary Ground Gas Protection Measures	
14.6	Ground Water / Aquifer	
14.7	Off-Site Disposal of Soils	
14.8	Piped Drinking Water Supplies	
15	GEOTECHNICAL ASSESSMENT	55
15.1	Introduction	
15.2	Site Preparation and Excavation	
15.3	Control of Groundwater	
15.4	Foundations	

15.5	Ground Floor Construction	
15.6	Heave / Shrinkage Potential	
15.7	Highway	
15.8	Soakaway Testing	
15.9	Protection of Buried Concrete	
16	REFERENCES	58
	APPENDIX A	i
	(i) Site Location Plan	
	APPENDIX B	ii
	(i) Betts Exploratory Hole Location Plan	
	APPENDIX C	iii
	(i) Betts Exploratory Borehole Hole Logs	
	APPENDIX D	iv
	(i) Contamination Test Results	
	APPENDIX E	v
	(i) Geotechnical Test Results	
	APPENDIX F	vi
	(i) Gas Monitoring Data	
	APPENDIX G	vii
	(i) Conceptual Model	
	APPENDIX J	10
	(i) Notes on Ground Gas	
	APPENDIX K	18
	(i) Off-site Disposal of Surplus Soil Guidance Notes	
	APPENDIX L	19
	(i) Validation Report Guidance Notes	
	APPENDIX M	20
	(i) Notes on Limitations	

1 EXECUTIVE SUMMARY

Note – The following summary is not exhaustive and is to be used for guidance purposes only. The full report should be consulted for full details.

1. Site Location

The site is located on The Manchester College, Northenden Campus, Sale Road, Wythenshawe, M23 0DD.

The coordinates on the British National Grid CRS are 381981,390319. The proposed site is approximately 7.37 hectares in total.

2. Site Description On Site

A site walkover was undertaken on 21st October 2019 (REC) and the following description comprises the layout and features based on observations at the time. Selected photographs from the walkover are presented in Appendix IV. Access is gained via Moss Hey Drive via an approximately 7m wide gate with two pedestrian gates located either side.

The site consists of an active college campus with a large building in the north utilised as office and teaching facilities. A residential building with an associated garage is located in the north west with various storage tanks located adjacent. An unidentified brick structure is present in the west by the entrance gate which is likely a utilities box but was not labelled at the time of the walkover. The west of the site is predominantly used as a car park. The surface is made up of asphalt and various landscaping trees of between 4m and 8m in height are located throughout. The south east of the site is used as playing fields bounded by metal fencing. A basketball court is also located in the south east.

Drainage and electricity / gas services are located throughout supplying the buildings and lighting for car parking. All buildings are in good condition and the site is predominantly flat. The site is bounded in all directions by residential properties.

3. Proposed Development

The proposed construction of residential dwellings with associated infrastructure, gardens and public open space.

4. Site History

In 1874 the site was open land with hedgerows. All surrounding land was also open space.

By 1935, the surrounding area had been heavily developed with residential properties. A school had been built in the centre of the site with associated playing fields. The road network began expanding to accommodate this growth around 1938. The school was then expanded with new buildings being constructed in the west of the site by 1956. By this time the school had been labelled as "Yew Tree School".

The school was further developed by 1977 with the addition of extra buildings and a tennis court in the north. The road network has continued to expand, with the road directly east being converted into a dual carriageway.

By 2010 the school and its associated structures had been demolished and replaced with a building in the north east of the site labelled as "College".

5. Published Geology

The BGS map shows the geology beneath the site as the following:

Superficial

Glaciofluvial Sheet Deposits – **SAND & GRAVEL**

Solid

Tarporley Siltstone Formation – **Siltstone**

7. Summary of Previously Undertaken Investigation

The desk study appears largely comprehensive and identifies the possible historic Made Ground associated with the former developments and recommends a limited ground investigation to inspect these areas. It perhaps falls short from recommending more specific locations, such as the two identified substations for PCB testing, as well as making note of a garage with 'Various Storage Tanks' currently on site which would likely be worth investigating further (possible

hydrocarbon contamination associated with the garage as well as the nature of the substances within the storage tanks). Page 29 of the REC report also shows a photo of several storage/shipping containers situated on site which have not been investigated or the potential risk discussed.

Following the E3P Investigation there are several clarifications required to accurately consider risks identified within the conceptual site model namely:

- Further investigation where shallow trial pits were undertaken/trial pits halted due to concrete slabs/low strength soils and deep made ground encountered
- Investigation of the bunds on site which are assumed to be made ground
- Further investigation post demolition
- Further soakaway testing when drainage layout agreed.
- Further chemical and Geotech sampling to fully assess the chemical and geotechnical risks on site
- Update ground gas assessment based on previous and current site conceptual models
- Detailed foundation zoning plan
- Liaison with Regulatory bodies

See full report for individual Betts Comments on prudent sections.

8. Scope of Betts Investigation

- Twelve (12 No) window sample boreholes drilled to 3.00mbgl.
- Three (3 No) hand dug trial pits excavated to depths of up to 0.35mbgl to sample the bund in the east of the site.
- Six (6 No) Infiltration tests
- Chemical analysis (Metals, PAH's, asbestos and TPH's) of fifteen (15 No) samples.
- Collection and analysis of one (1 No) samples for geotechnical analysis.

9. Ground Conditions Encountered

Ground conditions typically comprised sand TOPSOIL (made ground) over granular MADE GROUND deposits of SAND, GRAVEL and SAND & GRAVEL. Made ground was noted to overly natural granular deposits in a number of locations. Natural cohesive strata were only recorded in WS206.

Groundwater was recorded in WS205, WS206 and WS208 from a minimum depth of 2.00mbgl.

MADE GROUND was not bottomed out in WS202, WS204, WS209, WS210 and WS211.

MADE GROUND in WS203 was recorded to a depth of greater than 3.00mbgl.

The full logs should be consulted in conjunction with this summary.

Groundwater Fieldwork

Groundwater was observed from 2m within the Betts investigation

10. Specialist Ground Gas Measures

Area around WS123 and WS124- Amber 1/CS2

Elsewhere on site- Green/CS1

11. Contamination Assessment and Remedial Actions

An exceedance of Benzo(a)pyrene (1.66mg/kg) was observed in WS205 at depth of 0.85mbgl. When compared to the residential threshold of 1.51mg/kg, the exceedance is shown to be minimal.

Statistical analysis of the Benzo(a)pyrene within MADE GROUND strata has shown that the marginal exceedance recorded in WS205 is statistically insignificant and is not representative of the wider site soils. On this basis, the exceedance may be discounted.

Comparison of the Dibenzo(a,h)anthracene exceedances (0.28-0.35mg/kg) from the e3p report, show their maximum concentrations to be below the AtRisk 2017 threshold of 0.838mg/kg. On this basis, these exceedances may also be

discounted.

Despite the above, due to possibility of asbestos being present within MADE GROUND, gardens are to be provided with 600mm growing medium, as per NHBC guidance subject to further investigation where made ground is encountered. Following post demo investigation and finalised layouts/levels, full cover system requirements can be confirmed. PCB testing should be undertaken post demo of potentially affected buildings.

12. Off-Site Disposal of Surplus Soil

No significant changes in site levels are understood to be proposed. However, the area of reworked topsoil/peat is likely to require excavation and offsite disposal.

If there is the need to remove soil / made ground off-site it is recommended that the results of the contamination testing (and possibly further testing) will be assessed by a suitably qualified person. A waste classification report will need to be produced and provided to the receiving landfill to determine whether they will accept the material.

13. Foundations

At the time of investigation, a detailed layout, foundation loadings nor finished floor level plan was available. As such no detailed assessment is possible. A detailed foundation zoning plan is advised when details are available.

Founding strata can generally be described as loose to medium dense SAND.

The following allowable pressures can be assumed on dry natural undisturbed materials described below;

- Loose to medium dense SAND – 75 kN/m²
- Medium dense SAND – 100 kN/m²
- Medium dense SAND & GRAVEL 100 kN/m²

It is important to note that shallow groundwater may reduce bearing capacities by half when found in conjunction with granular soils.

CLAY was observed in one location below the granular deposits. The following allowable pressure can be assumed on dry undisturbed material;

- Soft to firm CLAY – 75 kN/m²

Localised deepening of foundations and/or piled foundations are likely to be required in the vicinity of trees or in the areas of deeper Made Ground/soft clays/silt/peats encountered. A specialist piling contractor should be contacted for appropriate design.

A foundation zoning plan should be undertaken when proposed levels are made available.

Foundations should be excavated wholly on one stratum. Should proposed foundations span different strata, trenching and stepping of foundations and/or nominal reinforcement will be required.

Calculations on the allowable bearing capacity indicate settlements of less than 25mm for a square pad using the above allowable bearing capacity.

14. Concrete Design

The site is recommended for a design class of DS-1, an ACEC class of AC-1.

15. Heave / Shrinkage Potential

Cohesive deposits have been determined to be of low-medium volume change potential .

16. Ground Floor Construction

Shrinkable soils are present at shallow depth across the site and it is therefore recommended that suspended floor construction (e.g. either in-situ RC slabs or block and beam flooring) is adopted in accordance with NHBC guidance.

17. Control of Groundwater

Groundwater / perched water was observed from 1.50mbgl.

Provision of pumping / shuttering could be necessary during all excavations. It is good practice to have such equipment on standby in case of seasonal / abnormal weather conditions.

Should sewers / excavations deeper than the boreholes / trial pits undertaken be required, further SI will be needed.

Soakaway testing carried out at the site has shown that the use of soakaways at the site is unlikely. The results are summarised below;

Location	Infiltration Rate	Likely Drainage Ability / Comments
SA1	NA	Very poor / test unable to start / data taken from below drainage pipe
SA2	1.77×10^{-5}	Poor / 1 test complete
SA3	1.41×10^{-5}	Poor / 1 test complete
SA4	6×10^{-6}	Very poor / Test data extrapolated, 1 test complete
SA5	2.31×10^{-6}	Very poor / Test data extrapolated, 1 test complete

The majority of pits were undertaken in MADE GROUND with wet SAND and / or SAND & GRAVEL below, perched groundwater ingress was therefore present.

A lands drain was noted in SA1, which gave a false impression of infiltration, but it immediately slowed down after passing the land drain. The soakaway results for SA1 was adapted to try and determine infiltration below the pipe but the result should be considered with a level of conservatism applied.

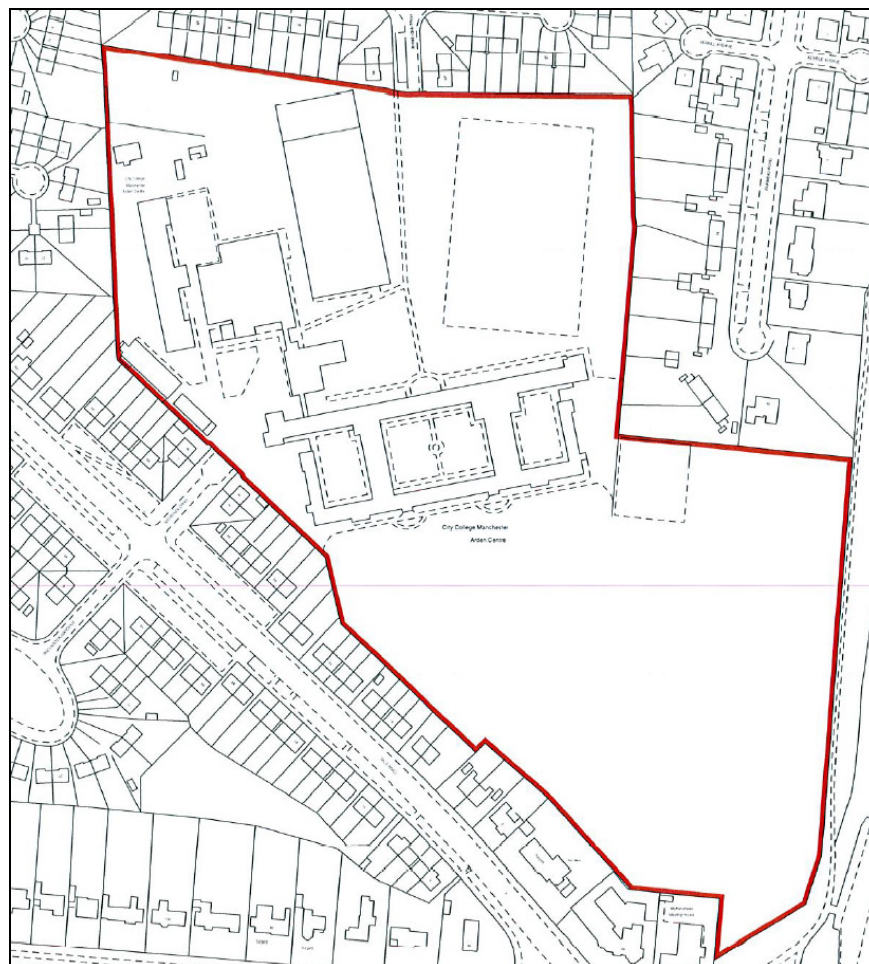
18. Highway

According to the criteria of Highways Agency HD 25/95 Volume 7 Section 2 Part 2 HD 25/94, a CBR value of circa 3-5% on the sands/ made ground is anticipated, however confirming in-situ CBR's should be undertaken once final formation levels are available. Placement of geotextiles within the areas of roads / parking could also be designed to minimise the subgrade thickness.

2 SITE DESCRIPTION

2.1 Introduction

This investigation was carried out on the instruction of Miller Homes. The purpose of the work was to carry out a Ground Investigation to provide additional geotechnical and contamination risk assessment information to inform the due diligence processes for the site. The site boundary can be seen below;



2.1 Site Location

The site is located on The Manchester College, Northenden Campus, Sale Road, Wythenshawe, M23 0DD.

The coordinates on the British National Grid CRS are 381981,390319. The proposed site is approximately 7.37 hectares in total. See Site Location Plan in Appendix A.

1.2 Proposed Development

The proposed development at time of issue comprises the construction of residential dwellings with associated gardens, public open space and other infrastructure.

1.3 Previous Betts Reporting

REC (spectris) have previously undertaken a desk study report the site. This report is as follows;

- Desk Study Report for TMC Northenden Campus, Wythenshawe by REC on Behalf of The Manchester College. Report ref. 108393P1R0 dated October 2019.

e3p have also previously undertaken an intrusive investigation, as referenced below;

- Phase II Geoenvironmental Site Assessment for Northenden College by e3p, on behalf of Cushman and Wakefield / The Manchester College, Report ref.13-969-R1-1, dated July 2020.

Where necessary the above reports have been used throughout this report and referenced accordingly. The following 'Site History Summary', 'Geology' and 'Environmental Data' has been summarised from the desk study report.

Whilst Betts Geo Environmental Ltd cannot be held liable for the third party, client furnished, results/data, it is suggested that it is reasonable to assume that the data provided in these reports have been undertaken with suitable care and due diligence by suitably experience consultants. As such the data is regarded as being of an appropriate standard to utilise within this report.

3 BACKGROUND

3.1 Site Description

A site walkover was undertaken on 21st October 2019 (REC) and the following description comprises the layout and features based on observations at the time. Selected photographs from the walkover are presented in Appendix IV. Access is gained via Moss Hey Drive via an approximately 7m wide gate with two pedestrian gates located either side.

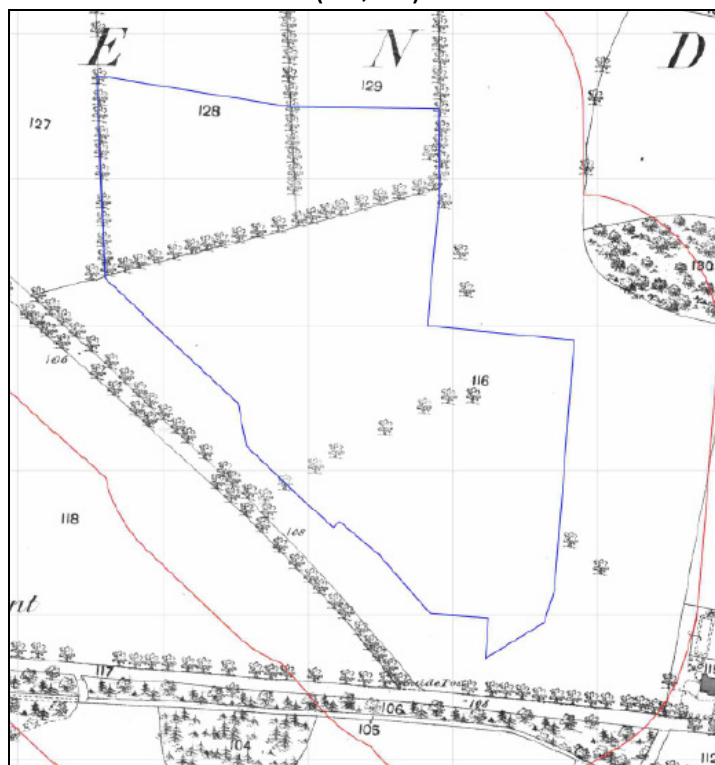
The site consists of an active college campus with a large building in the north utilised as office and teaching facilities. A residential building with an associated garage is located in the north west with various storage tanks located adjacent. An unidentified brick structure is present in the west by the entrance gate which is likely a utilities box but was not labelled at the time of the walkover. The west of the site is predominantly used as a car park. The surface is made up of asphalt and various landscaping trees of between 4m and 8m in height are located throughout. The south east of the site is used as playing fields bounded by metal fencing. A basketball court is also located in the south east.

Drainage and electricity / gas services are located throughout supplying the buildings and lighting for car parking. All buildings are in good condition and the site is predominantly flat. The site is bounded in all directions by residential properties.

3.2 Site History

In 1874 the site was open land with hedgerows. All surrounding land was also open space.

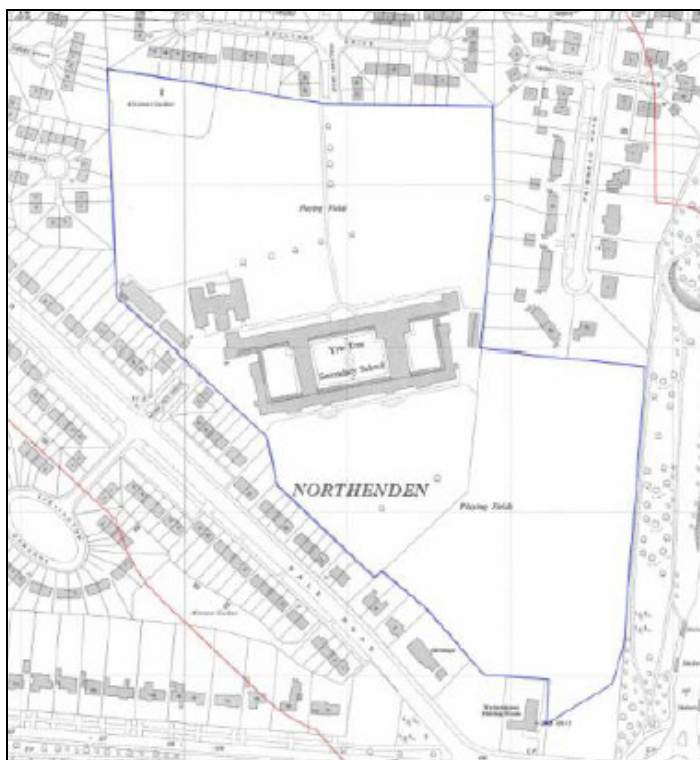
**1874
(1:2,500)**



By 1935, the surrounding area had been heavily developed with residential properties. A school had been built in the centre of the site with associated playing fields. The road network began expanding to accommodate this growth around 1938. The school was then expanded with new buildings being constructed in the west of the site by 1956. By this time the school had been labelled as “Yew Tree School”.

1935 – 1956
(1:2,500) (1:10,560) (1:2,250)





The school was further developed by 1977 with the addition of extra buildings and a tennis court in the north. The road network has continued to expand, with the road directly east being converted into a dual carriageway.

1977 (1:1,250)



By 2010 the school and its associated structures had been demolished and replaced with a building in the

north east of the site labelled as "College".

2010 (1:10,000)



3.3 Hydrogeology and Hydrology

- The superficial deposits are classed as Secondary A Aquifer and a Secondary Undifferentiated Aquifer.
- The bedrock deposits are classed as a Secondary B Aquifer.
- The site does not lie within a Groundwater Source Protection as defined by the Environment Agency.
- There are no licenced water abstractions within 1000m of the site.
- The nearest surface water feature is an inland river located 205m south west. The river itself is not named however its catchment area is the River Mersey.

3.4 Geology

The documented geology of the site is summarised on the British Geological Survey map principally, with further site-specific details detailed below;

Geology	Artificial Ground & Land Slip	Drift	Solid
1:10,000	None recorded*	Glaciofluvial Sheet Deposits – SAND & GRAVEL	Tarporley Siltstone Formation - Siltstone

* Site history suggests made ground will be present

3.5 Geotechnical Data

Hazard	Designation	Comments
Shrink-Swell Clay	Negligible	Ground conditions predominantly non-plastic. No special actions required.
Landslides	Very Low	Slope instability problems are unlikely to be present. No special actions required.
Ground Dissolution	Negligible	Soluble rocks are present, but unlikely to cause problems except under exceptional conditions.
Compressible Ground	Negligible	No indicators for compressible deposits identified. No special actions required.
Collapsible Deposits	Very Low	Deposits with potential to collapse when loaded and saturated are unlikely to be present.
Running Sand	Very Low	Very low potential for running sand problems if water table rises or if sandy strata are exposed to water. No special actions required.

3.5.1 Coal Mining

The site is not located within a Coal Mining Reporting Area as defined by the Coal Authority. No special actions are required in regards to mining and ground workings.

3.5.2 Radon

The site lies within a low-risk area of radon where less than 1% of homes are estimated to be above the action level, therefore **no radon protection measures are required for new dwellings or extensions.**

3.6 Industrial Data

Available records identify the following potentially contaminative current industrial land uses within 200m of the site.

Category	Activity	Distance (m)	Direction
Electrical Features	Electricity Substation	155	E
Repair and Servicing	Vehicle Repair, Testing and Servicing	225	N

The data search report indicates that there are no petrol and fuel sites; high voltage underground electricity transmission cables; or pressure gas transmission pipelines within 500m.

3.7 Sensitive Land Uses

The following sensitive land uses have been identified within 2km:

- 3no. records of Local Nature Reserves; the closest being Wythenshawe Park located 42m south; and
- 4no. records of Green Belt Land, the closest being the Liverpool, Manchester and West Yorks Greenbelt located 153m north.

3.8 Desk Study Review by Betts

The desk study appears largely comprehensive and identifies the possible historic Made Ground associated with the former developments and recommends a limited ground investigation to inspect these areas. It perhaps falls short from recommending more specific locations, such as the two identified substations for PCB testing, as well as making note of a garage with 'Various Storage Tanks' currently on site which would likely be worth investigating further (possible hydrocarbon contamination associated with the garage as well as the nature of the substances within the storage tanks). Page 29 of the REC report also shows a photo of several storage/shipping containers situated on site which have not been investigated or the potential risk discussed.

4 E3P SITE INVESTIGATION REPORT SUMMARY

4.1 General

e3p undertook exploratory fieldwork between 12th May 2020 and 21st May 2020 and comprised;

- 37no. mechanically excavated trial pits.
- 29no. Window sample boreholes
- 24no. Dynamic probe holes
- 6no. Soakaway tests

4.2 Ground Conditions

4.2.1 Topsoil

Topsoil was encountered from ground level to a maximum depth of 0.70mbgl. The topsoil comprised of a black brown slightly gravelly medium SAND with frequent rootlets and gravel of mudstone.

4.2.2 Made Ground

Made Ground underlying the current buildings on site is anticipated to be at a depth > 1.60mbg.

Furthermore, it should be assumed that the paths in the southern sector of the site will be underlain by 0.30m of Made Ground. The bund along the southeastern boundary is assumed to contain Made Ground or reworked natural materials.

Made Ground was encountered to a maximum depth of 2.10mbgl within TP129, however the full depth could not be proven due to inability to progress excavation due to the density of materials. This was also the case in WS122.

Within the northern and central areas of the site TP107, TP108, TP127, TP134, WS119 and WS122 were terminated due to the presence of concrete obstructions, which are considered to be attributed to historical development on the site.

Betts Note: Made Ground has not been bottomed out within TP129 & WS122, proven to depths of 2.10m bgl and 0.95m bgl respectively. Further investigation recommended, particularly within TP129 due to the significant Made Ground depth.

Concrete obstructions were encountered within TP107, TP108, TP127, TP134, WS119 and WS122. Potential from uninvestigated Made Ground below such obstructions of unknown depth and chemical composition.

4.2.3 Drift Superficial

The drift deposits underlying the site generally comprised of a light yellow brown gravelly medium SAND with gravel of mudstone and sandstone underlain by a light grey brown gravelly medium SAND with gravel of mudstone and sandstone. A stiff high strength to very stiff high strength light brown mottled grey gravelly sandy CLAY with gravel of mudstone was subsequently encountered beneath granular deposits.

Within WS107 and WS115, a very soft extremely low strength light brown very sandy gravelly CLAY with gravel of mudstone and sandstone was encountered at 1.90m bgl and 3.20m bgl respectively.

Furthermore, soft CLAY was identified from 3.10-3.40mbgl within SHDP102, SHDP105 at 3.20- 3.30mbgl, 3.00-3.10mbgl within SHDP112, 3.20-3.80mbgl within SHDP116. Laboratory undrained shear strength testing has identified soft clays within wS129 at 3.50-4.00mbgl.

4.2.4 Obstructions and Contamination Observations

Table 6-2 - Summary of Obstructions

Exploratory Hole	Obstruction Depth	Notes
WS6701	0.8	Obstruction unknown
TP7017	0.4 – 0.5	Concrete
TP7034	0.7 – 0.85	Concrete
TP7083	0.9 – 1.0	Concrete
TP7084	0.8 – 0.95	Concrete

Exploratory Hole	Depth of Contamination	Notes
TP7045	0.5 – 1.0	Weathered hydrocarbon odour
TP7094	0.4 – 0.8	Weathered hydrocarbon odour
TP7046	0.4 – 0.8	Sulphur smell
TP7070	0.8 – 1.1	Weathered hydrocarbon odour

Volatile organic compounds were tested in-situ using a PID during the investigations. VOC headspace readings were all low and below 5.0ppm with the exception of the following two locations during the ESG (2016) investigation:

- WS6603 at 1.0m bgl (20.1ppm)
- WS6604 at 0.5m bgl (18.2ppm)

No obvious sources of contamination are noted within the logs with the exception of asphalt gravel within some of the Made Ground horizons.

4.2.5 Soil Consistency

The tables below are taken from the e3p report and summarise the soils shear strengths.

TABLE 4.3 SUMMARY OF HAND SHEAR VANE TESTS

LOCATION	DEPTH	SHEAR STRENGTH (kPA)	CALCULATED ALLOWABLE BEARING PRESSURE (kN/m ²)
TP111	0.50	61	143.35

TABLE 4.4 SUMMARY OF UNDRAINED SHEAR STRENGTH TEST RESULTS

LOCATION	SAMPLE DEPTH (m)	LAB DESCRIPTION	UNDRAINED SHEAR STRENGTH (kN/m ²)	CONSISTENCY
WS101	3.50-4.00	Soft brown slightly gravelly sandy CLAY	28	Soft
WS108	3.50-4.00	Firm brown slightly gravelly very sandy CLAY	62	Firm
WS118	3.50-4.00	Firm brown slightly gravelly very sandy CLAY	53	Firm
WS129	3.50-4.00	Soft brown slightly gravelly CLAY	39	Soft

4.2.6 Soil Compressibility

The results have determined that the clay soil is of medium compressibility under a loading of 75-150kN/m². It should be noted that if this material is excavated for use in a cut/fill operation, then careful consideration should be taken in the stabilisation of this material as it would appear that at depth, the cohesive deposits are wetter than the optimum.

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

4.2.7 Soil Infiltration

Soil infiltration was taken over the wetted area from between 75% and 25% of the effective depth. All tests showed granular drift deposits to have good to moderate soakage potential. A soil infiltration rate could not be calculated within TP104/SA104.

Therefore, considering the significant volumes of permeable SANDs on the site, it is considered that soakaway drainage may be suitable for the proposed development within areas of gravelly SAND.

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.

4.2.8 Soil Plasticity

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

The areas of medium volume change potential CLAY was located within shallow cohesive deposits in the south-west of the site. We have further found this shallow CLAY band at WS107 and therefore the sample at TP111 may be indicative of clay at this shallow depth rather than materials at a greater depth below granular stratum.

4.2.9 pH and Sulphate

Chemical analyses for pH and soluble sulphate content, 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).

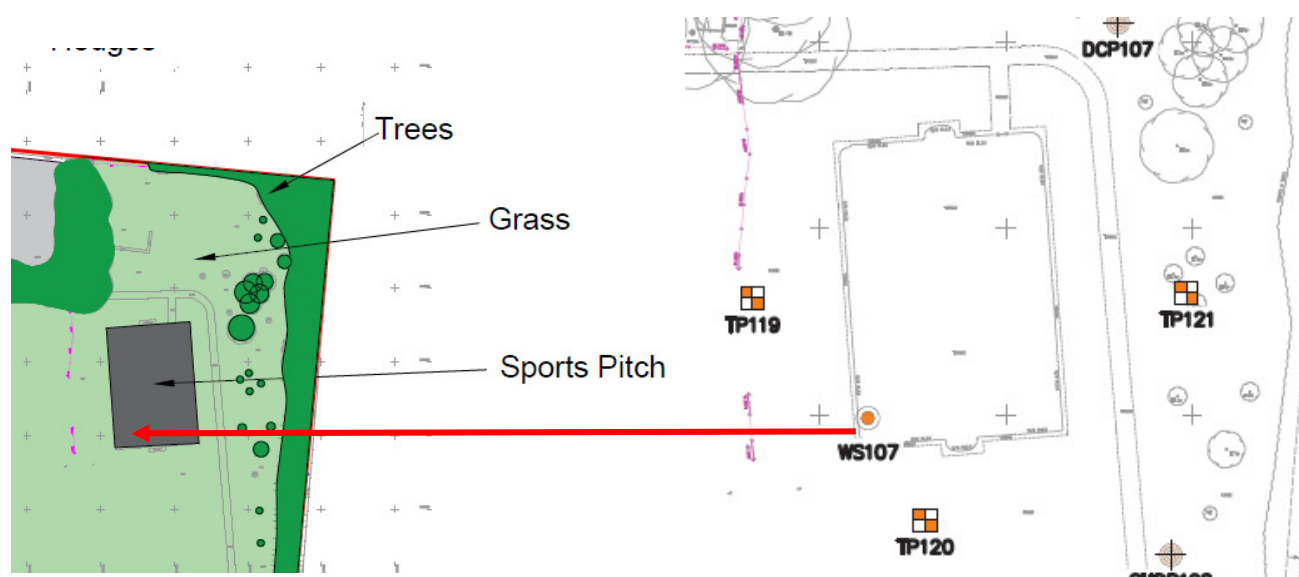
4.2.10 Groundwater

During the ground investigation, groundwater strikes were recorded a seepage at depths between 1.50m and 3.00m bgl within the Superficial deposits. Post investigation groundwater monitoring was undertaken on three occasions between June and July 2020 and show groundwater levels between 1.65m and 2.88m bgl, suggesting a shallow groundwater regime. Given the time of year when ground gas monitoring was undertaken, this is likely to fluctuate during times of rainfall/autumn and winter.

4.3 Contamination Risk Assessment

One exceedance for Arsenic was recorded, taken from a thin veneer of Made Ground with WS107 (recorded between 0.50m and 0.60m bgl) which was placed below a sports pitch.

Betts Note: It is anticipated that this exceedance is likely related to a subbase type material used for the sports pitch, and is as such likely to be localised to beneath the sports pitch area (no Made Ground was encountered in TP119-121 positioned around the pitch). The area is marked for housing/gardens, and as such due to the shallow nature is likely to be removed anyway. Further testing may be required of the impacted Made Ground material for waste disposal, and to confirm contaminant levels across the volume of the material.



Five exceedances for Dibenzo(a,h)Anthracene were noted during the investigation, which according to the report restricts the materials potential reuse as topsoil for future use on-site, as below;

Dibenzo(a,h)Anthracene	mg/kg	0.24	15	0.32 0.29 0.35 0.28 0.31	WS111 (0.20m) WS118 (0.30m) TP110 (0.20m) TP128 (0.80m) TP129 (0.20m)	2	Further Action
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Betts Note: The concentrations reports are well below screening criteria used by Betts (AtRisk 20017 Residential Home Grown at 1% SOM), which reports exceedances for Dibenzo(a,h)Anthracene above 0.838mg/kg (0.24mg/kg used as a screening value by e3p). As such it is the opinion of Betts that the reported results do not constitute exceedances, and from the samples provided the material may be suitable for reuse.

One sample reported a positive ID for asbestos, quantified at 0.02% sample weight within WS118

Betts Note: The Made ground horizon the sample was taken from extended from 0.20m to 0.40m bgl and is within an area planned for housing. As such it will likely be removed during construction and may be considered a Hot Spot. The quantity reported is marginally above background concentrations for asbestos and is not considered a risk to human health. A watching brief or similar may be required to remove the impacted material to ensure no ACM is present, and potentially for validation testing to ensure the impacted material is removed. Further testing on the material may be required to quantify the extent of the asbestos contamination. The material may then potentially be placed on-site and referenced within an agreed materials management plan or disposed of off-site.

No PCB testing has been undertaken, though it is difficult to discern the age of the substations (not marked

on historical maps), and subsequently is PBC contamination is a possibility.

Only 9 samples have been taken, which on a partial brownfield site is not enough to adequately qualify the risk of contamination on-site, especially given the depths of made ground, relic structures and ashy material encountered. Further chemical assessment is required to assess contamination risk and to allow for re-use/disposal of material on site

4.4 Groundwater Risk Assessment

Relatively low-level exceedances for three relatively 'exotic' SVOCs noted and argued away (exceedances noted against a Limit of Detection screening criteria).

- ☛ Isophorone (WS102 – 8.0 µg/l; WS117 – 2.9 µg/l);
- ☛ Diethyl phthalate (WS102 – 2.5 µg/l; WS117 – 1.5 µg/l; WS123 – 0.92 µg/l); and,
- ☛ Dibutyl phthalate (WS102 – 0.29 µg/l; WS117 – 1.0 µg/l; WS123 – 0.81 µg/l).

Soil analysis across the site has not identified elevated concentrations of SVOCs above the LOD other than PAHs identified within the human health risk assessment. Historical land uses on site do not indicate a significant potential source of these determinants. However Isophorone is a solvent within coatings, paints and printing which may be present within the Made Ground. Phthalates are associated with plastics; plastic has been noted within Made Ground deposits on-site and therefore the concentrations identified may be attributed to degradation of these materials.

Overall there is not considered to be a primary source on-site, however it is recommended further groundwater and soil sampling is completed within these locations.

Given that the site is underlain by low-permeability, predominantly cohesive glacial till deposits beneath granular deposits, these will afford protection to the underlying Secondary B Aquifer, furthermore, there are no groundwater abstraction points within close proximity of the site. Therefore, it is considered the site poses a low risk to controlled waters and the wider environ as no complete pollutant linkage can be determined.

It is considered that based on the above, there is a low level of risk to the controlled water receptors.

Betts Note: No groundwater risks were noted within phase 1, and no volatiles were tested for within the made ground. The rationale for testing groundwater is unknown.

The above seems contradictory, as it both advocates that there is a low risk to controlled waters, but also that further testing should be undertaken. It is considered that no further testing is required and that the report is correct stating the low risk.

4.5 Ground Gas

Preliminary ground gas monitoring suggests that the site can be predominantly classified as Green / CS1, and in these areas it is considered that ground gas protection measures will not be required.

However, localised areas of the site have been assessed as being Amber 1 / CS2 and properties within this area will likely require specialist protection measures as detailed herein.

However, should properties be constructed within a sub-floor void, NHBC guidance can be followed, which would mean properties within the vicinity of WS123 and WS124 would be classified as Green and would not require ground gas protection measures as the calculated GSV is <0.76l/hr. However, ground gas protection measures will be required in the vicinity of WS128 due to the presence of elevated carbon dioxide concentrations.

The site may be zoned however agreement with the local authority will be required.

The final ground gas regime will be confirmed following completion of the ground gas monitoring programme.

Betts Note: No deep Made Ground around this area, though possibly within TP108 which was concluded at ~0.85m due to a concrete obstruction. No other sources noted. There is no flow over time given (presumed peak flow given?), flow values given are representative of diffusive flow in the amber locations (recorded between 0.26-2.73l/h, with one result of 7.41l/h which appears anomalous compared to the rest of the data set), and there's only one location with CO2 concentrations over 5%. Shallow groundwater pumping could also affect ground gas levels in these boreholes given the depth of response zones.

4.6 Potable Water Supply

Based on the assessment of current site conditions it is likely that PE pipe will be suitable, however an allowance barrier pipeline may be required at the proposed development dependent upon imported materials.

4.7 Foundations

The below allowable bearing capacities were stated from the site;

GRANULAR SOILS			
Description	Depth (Range m bgl)	Relative Density	Allowable Bearing Pressure (kN/m ²)
Gravelly SAND	1.00-3.00	Loose	52-95
Gravelly SAND	1.00-3.00	Medium Dense	100-274
Gravelly SAND	1.00	Dense	332-342
COHESIVE SOILS			
Description	Depth (range m bgl)	Undrained Shear Strength (Cu) (kN/m ²)	Allowable Bearing Pressure (kN/m ²)
Very soft sandy CLAY	2.00-3.00	8-9	17-18
Firm sandy CLAY	2.00-3.00	26-36	53-75
Description	Depth (range m bgl)	Undrained Shear Strength (Cu) (kN/m ²)	Allowable Bearing Pressure (kN/m ²)
Stiff sandy CLAY	1.00-5.00	41-71	84-147
Very stiff sandy CLAY	3.00-5.00	76-207	156-426

Following which the below foundation solutions/comments are recommended;

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 medium dense to dense gravelly SAND at circa 1 m bgl;
- ✦ Trench fill to support reinforced strip foundations in areas of variable ground and/or potential tree influence;
- ✦ Vibro stone columns in the vicinity of deep Made Ground or loose SANDs; and,
- ✦ Driven piled foundation solution.

LOCATION	ANTICIPATED FOUNDING STRATA DEPTH (m bgl)	GROUND WATER (m bgl)	TARGET STRATUM	TREES	FOUNDATION TYPE	TYPE OF CONCRETE
WS101	0.75	2.50	MD SAND	Y	Shallow Strip	DS-1, AC-1s
WS102	>2.50	-	Stiff CLAY	Y	Engineered solution	-
WS103	0.75	2.30	MD SAND	N	Shallow Strip	-
WS104	0.75	-	MD SAND	N	Shallow Strip	DS-1, AC-1s
WS105	0.75	2.00	D SAND	Y	Shallow Strip	-
WS106	0.75	-	MD SAND	N	Shallow Strip	-
WS107	>2.50	2.00	Stiff CLAY	Y	Engineered solution	DS-1, AC-1s
WS108	1.05	2.00	MD SAND	Y	Shallow Strip	-
WS109	>2.50	1.50	Stiff CLAY	Y	Engineered solution	-
WS110	0.75	-	MD SAND	N	Shallow Strip	DS-1, AC-1s
WS111	0.75	2.20	MD SAND	N	Shallow Strip	-
WS112	1.15	-	MD SAND	Y	Shallow Strip	DS-1, AC-1s
WS113	1.45	2.00	MD SAND	Y	Shallow Strip	-
WS114	0.75	2.00	MD SAND	Y	Shallow Strip	-
WS115	1.75	2.00	MD SAND	Y	Mass Trench / VSC	-
WS116	2.35	2.50	MD SAND	Y	Mass Trench / VSC	-
WS117	1.25	3.00	MD SAND	Y	Shallow Strip	-
WS118	1.25	2.00	MD SAND	Y	Shallow Strip	-
WS120	0.85	2.00	D SAND	Y	Shallow Strip	-
WS121	>2.50	1.50	Stiff CLAY	Y	Engineered solution	-
WS123	1.25	2.00	MD SAND	Y	Shallow Strip	-
WS124	1.15	2.00	MD SAND	Y	Shallow Strip	-
WS125	>2.50	-	-	Y	VSC	-
WS126	>2.50	-	Stiff CLAY	Y	Engineered solution	-
WS127	>2.50	-	-	N	VSC	-
WS128	0.75	-	MD SAND	N	Shallow Strip	-
WS129	0.75	-	MD SAND	Y	Shallow Strip	-
TP101	0.75	-	MD SAND	Y	Shallow Strip	-

TP102	0.75	-	MD SAND	Y	Shallow Strip	-
TP103	>2.50	-	MD SAND	Y	Engineered Solution	-
TP104	0.75	-	MD SAND	Y	Shallow Strip	-
TP105	1.45	-	MD SAND	Y	Shallow Strip	-
TP106	0.75	-	MD SAND	Y	Shallow Strip	-
TP109	0.75	-	MD SAND	N	Shallow Strip	-
TP110	>2.50	1.50	Stiff CLAY	Y	Engineered solution	-
TP111	>2.50	1.50	Stiff CLAY	Y	Engineered solution	-
TP112	>2.50	1.50	Stiff CLAY	Y	Engineered solution	-
TP113	0.95	-	MD SAND	N	Shallow Strip	-
TP114	0.75	-	MD SAND	N	Shallow Strip	DS-1, AC-1s
TP115	0.75	-	MD SAND	Y	Shallow Strip	-
TP116	0.75	-	MD sand	N	Shallow Strip	-
TP117	0.75	-	MD SAND	N	Shallow Strip	-
TP118	0.75	-	MD SAND	N	Shallow Strip	-
TP119	>2.50	-	-	N	Engineered solution	-
TP120	0.75	-	MD SAND	N	Shallow Strip	-
TP121	>2.50	-	-	N	Engineered solution	-
TP122	1.05	-	MD SAND	Y	Shallow Strip	-
TP123	1.15	-	MD SAND	Y	Shallow Strip	-
TP124	1.15	-	MD SAND	Y	Shallow Strip	-
TP125	1.45	-	MD SAND	Y	Shallow Strip	DS-1, AC-1s
TP129	>2.50	-	-	N	Engineered solution	-
TP130	1.45	-	MD SAND	Y	Shallow Strip	-
TP131	2.35	-	MD SAND	Y	VSC	-
TP132	2.35	2.50	MD SAND	Y	Mass Trench / VSC	-
TP133	1.25	2.00	MD SAND	Y	Shallow Strip	-
TP135	0.85	-	MD SAND	Y	Shallow Strip	-
TP136	0.95	-	MD SAND	Y	Shallow Strip	-
TP137	0.75	-	MD SAND	Y	Shallow Strip	-

Very loose or loose SAND deposits and very soft CLAY deposits have been identified across the site, in addition to saturated sand strata within window sample probe holes where groundwater has been encountered. The deeper soil profiles are saturated by the natural groundwater body that results in the reduction in the calculated safe ABP by 50% as is demonstrated by the significant decrease in the calculated SPT N Value at depth. Within the areas of loose SANDs the use of vibro stone columns (VSC) is advised. However, where soft CLAYs have been identified with an ABP <30kN/m², either driven piled foundations are required, or soft clays should be removed and replaced with granular material to allow the use of VSC. Within areas of saturated strata the VSC should be completed via the use of a bottom feed. At WS107, the natural clay drift deposits have been assessed as being very soft extremely low strength with a

net allowable bearing pressure (ABP) of 18 kN/m² at a depth of 2.00m bgl. Within WS115 a calculated ABP of 17 kN/m² has been encountered at 3.00m bgl. Laboratory undrained shear strength testing of WS101 and WS129 identified soft clays with undrained shear strengths of 28 kN/m² and 39 kN/m² respectively. The use of VSC will be limited where ABP is <30 kN/m².

SHDPs have identified loose granular deposits within both shallow and deep granular horizons. Consideration of the bulb of pressure on the underlying loose sands at depth should be taken and will require an engineered design.

Furthermore, following the demolition of the current buildings on site, there will likely be in excess of 1.50m of Made Ground, therefore it would be considered necessary to remediate the ground to enable the use of VSC.

Where Made Ground has been identified to be depths >1.45mbgl. dependent on development levels, for plots in these areas it may be more economic to consider the use of VSC in areas outside of tree influence in the event cohesive materials subject to volumetric instability are encountered.

Consideration must be given to the aforementioned soft clay deposits that are isolated on site. Where cohesive deposits are present in influencing distance of trees consideration must be given to the viability as the foundation will still require locally deepening or the clays that are subject to volumetric instability.

Materials could be removed and replaced with site won natural sands during the enabling works to accommodate for this solution.

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.

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 medium dense to dense gravelly SAND at circa 1 m bgl;
- ✿ Trench fill to support reinforced strip foundations in areas of variable ground and/or potential tree influence;
- ✿ Vibro stone columns in the vicinity of deep Made Ground or loose SANDs; and,
- ✿ Driven piled foundation solution.

As the majority of the underlying 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). However where medium volume change potential clays have been identified within the shallow CLAY strata on site, heave precautions will be required.

Betts Note: The foundation depth/solution table appears contradictory and confusing. E.g. TP132 completed at 2.3m, however, the foundation depths is given as 2.35m it's not clear where these depths have come from. The adjacent WS116 showed loose sands from 0.8m similar to those shown in the trial pit log, therefore a shallower foundation depth would be possible. A full foundation assessment plan is required.

The loose-medium dense sands above the soft strata encountered may be sufficient for foundations based on the trial pitting logs and photos. Agree that generally, a strip/trench foundation solution subject to proposed finished floor levels is likely to be required over the majority of the site. Driven piles/VSC to be considered in areas of deep made ground or soft cohesive deposits. Foundation Assessment Plan and further investigation required. Given the variability of the glacial drift a reinforced footing should be assumed for areas of conventional footings.

4.7.1 Floor Slabs

Due to the frequent depths of Made Ground exceeding 600mm, variable stratum and clay soils within influencing distance to trees, suspended floor slabs are recommended.

Betts Note: Where Made Ground exceeding 600mm the use of suspended slab with underfloor void is likely to be required. NHBC also prefer this method.

4.7.2 Road & Pavements

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.
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Betts Note- The impact of the soft ground on proposed highways needs delineating so appropriate testing can be undertaken to allow for re-use on site in POS or removal off-site. An earthworks strategy will be required. Increased CBR may be possible on granular soils, however, testing will be required to confirm.

4.8 Soakaways

Soakaway Drainage	The BRE365 soakaways tests completed across the site have calculated permeability coefficients of between 3.65 E-05 and 9.33 E-05. The design and viability of soakaways on site should be designed by a suitably qualified drainage engineer.
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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.

Furthermore, permeability tests showed granular drift deposits to have a good soakage potential.

Therefore, considering the significant volumes of permeable SAND on the site, it is considered that soakaway drainage may be suitable for the proposed development. 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.

Betts Note- 6 soakaway tests were undertaken on a >7ha site, it is likely the LLFA will require additional testing where infiltration is proposed to be used as a surface water drainage option. One soakaway test SA104 did not successfully infiltrate.

It is also noted that groundwater was encountered during fieldwork and during post fieldwork monitoring at 1.5-2.5mbgl. Seasonal variations in groundwater levels may affect the infiltration rates within sand strata.

4.9 Chemical Attack on Concrete

Samples of Made Ground and the Superficial sand deposits were tested for water-soluble sulphate concentration and pH.

LOCATION	DEPTH (m)	SO ₄ IN 2:1 WATER/SOIL (g/l)	pH VALUE	CLASSIFICATION
WS101	0.10	0.0075	5.3	DS-1, AC-1s
WS104	1.60	0.0047	8.4	DS-1, AC-1s
WS107	0.55	0.048	8.3	DS-1, AC-1s
WS110	0.80	0.0045	8.3	DS-1, AC-1s
WS112	0.40	0.037	7.1	DS-1, AC-1s
TP125	1.00	0.010	6.9	DS-1, AC-1s
TP128	0.80	0.024	7.7	DS-1, AC-1s
TP133	0.50	0.35	7.8	DS-1, AC-1s

In accordance with guidance presented in BRE Special Digest 1 [9], a Design Sulphate Class of DS-1 and Aggressive Chemical Environment for Concrete class of AC-1 is considered appropriate for the Made Ground and Superficial sand deposits tested for preliminary design.

Betts Note – Small sample size for the size of the site (three samples for Natural strata and five samples for the Made Ground, however, there is not much to suggest an aggressive chemical attack on concrete would occur from the site investigation.

4.10 Further Works

4.10.1 Geotechnical

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

- ✿ Post-demolition site investigation beneath current buildings and in the vicinity of the electricity substation;
- ✿ Plot-specific foundation schedule (upon receipt of the final development levels);
- ✿ Arboricultural survey;
- ✿ Materials management plan;

- ✿ Geotechnical earthworks strategy (infrastructure);
- ✿ Remediation and enabling works strategy; and,
- ✿ Full three-dimensional earthworks cut/fill model.

Betts Note – Deep MG needs bottoming out & below concrete obstructions need to be investigated. Areas where soft strata were encountered also require investigating further. Chemical and Geotech assessment required to adequately assess volume change potential and concrete specification within the soils.

4.10.2 Geo-Environmental

Asbestos, in the form of chrysotile loose fibres, has also been identified within one localised areas in shallow Made Ground deposits at WS118 at 0.30m bgl. Asbestos quantification was undertaken to further assess where these soils may be placed which identified 0.002% asbestos by volume/weight. No visual signs of asbestos-containing material (ACM) were encountered during the ground investigation, therefore it is likely only trace fibres are present within these localised soils and a process of hotspot excavation with placement of impacted soils in accordance with the E3P Asbestos CSM should be undertaken within an area of low sensitivity.

Betts Note – This is likely from the demolition of the former school in this locality. Further assessment will be required

Chemical analysis of the natural SAND and CLAY drift deposits have 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.

Betts Note – 9 samples taken over the site, therefore additional sampling will be required to qualify contamination risk and assess for re-use/cart off-site.

There are potential suitable sources of topsoil available on the site, however isolated occurrences of exceedances of dibenzo(a,h)anthracene have been identified within natural topsoil deposits. Analysis of exceedances against human health remediation targets for residential end use at an SOM of 2.5% for dibenzo(a,h)anthracene of 0.28mg/kg show that the two natural topsoil samples which have exceeded the GAC at 1% SOM are still noted to be exceeding.

During the enabling works these soils should be segregated, and further chemical analysis undertaken of the remaining natural topsoil deposits to ensure suitability for use within the proposed development and confirm the identified elevated concentrations are indeed hotspots and not representative of the topsoil as a whole. Excavated impacted topsoil materials not suitable for use within the garden cover system cannot be placed at a depth greater than 1.00 m with gardens and must be 2.00 m off-set from plots.

Betts Note – No exceedances noted from our chemical screening criteria, thus the topsoil is likely suitable with no segregation required. Further testing is likely required due to volumetric sampling requirements.

Anthropogenic topsoil is likely to be impacted across the site and therefore will not be suitable for use within the proposed development. During enabling works these soils should be segregated and disposed off-site at a licensed waste facility.

Betts Note – Testing has been conducted on 7 samples of Made Ground Topsoil (TP127-129, TP134 & 135, WS125 & 126) which shows no exceedances (notwithstanding the Dibenzo(a,h)anthracene, which are previously discussed is not considered to be true exceedances by Betts screening standards). The gravel of brick has been noted within the logs for the MG/TS, and as such it is recommended that the soil could be reused on-site subject to the removal of the brick and further chemical testing. Such Made Ground Topsoil should be kept separate from the Natural topsoil found on site.

Further post-demolition investigations are required beneath current buildings on site and areas in which access has been prohibited due to utility infrastructure, to confirm the findings of this initial assessment as and when full and unrestricted access is available.

Betts Note – This will likely be required

4.11 Betts Recommended Additional Works

- Further investigation where shallow trial pits were undertaken/trial pits halted due to concrete slabs/low strength soils and deep made ground encountered
- Investigation of the bunds on site which are assumed to be made ground
- Further investigation post demolition
- Further soakaway testing when drainage layout agreed.
- Further chemical and Geotech sampling to fully assess the chemical and geotechnical risks on site
- Update ground gas assessment based on previous and current site conceptual models
- Detailed foundation zoning plan
- Liaison with Regulatory bodies

5 REMEDIATION STRATEGY BASED ON THE ABOVE SUMMARY OF ENVIRONMENTAL SENSITIVITY

The following section is a review of the environmental sensitivity of the site as discussed in Sections 2 - 5. Significant potential risks are discussed in the following subsections and will then be evaluated as part of the Site Conceptual Model in Section 7. Sources are defined as where pollution comes from, pathways are a route in which the pollution travels and receptors are anything affected by a pollutant. Further details on Source-Pathway-Receptor methodology can be found in Appendix I.

The table in section 6.1 focuses on significant site-specific sources, pathways and receptors. More 'generic' pathways and receptors (such as site end uses) will be covered as part of the full Site Conceptual Model in Section 7.

5.1 Sources

Source	Distance/ Direction	Details	Significant Risk
Current Site Use – School	Onsite	No significant widespread contamination anticipated from current site use. Contaminants associated with current site use include fuel oils, and heavy metals.	Possible (Localised)
Historic Site Use – School / Agriculture	Onsite	No significant widespread contamination anticipated from historic site use, localised hotspots may occur from demolition. Contaminants associated with current site use include fuel oils, and heavy metals.	Possible (Localised)

5.2 Pathways and Receptors

Pathways and Receptors	Distance/ Direction	Details	Significant Risk
Aquifers	Below Site	Site is predicted to be covered by non-cohesive superficial deposits. Superficial deposits are classed as Secondary A Aquifer, and bedrock is classed as a Secondary B Aquifer. No significant site wide sources of contamination anticipated on site other than localised Made Ground. Site does not lie within Source Protection Zone.	Unlikely
Site End Users	On Site	No significant widespread contamination anticipated onsite, however if found, a clean cover system may be required to protect end users against any near surface contamination.	Possible
Construction Workers	On Site	Risk assessments / PPE used for construction / contaminated material handling techniques / appropriate welfare provision / toolbox talks / enforcement of personal hygiene practices.	Low

6 INITIAL CONTAMINATION CONCEPTUAL MODEL

For details on how the conceptual model is evaluated please refer to Appendix I.

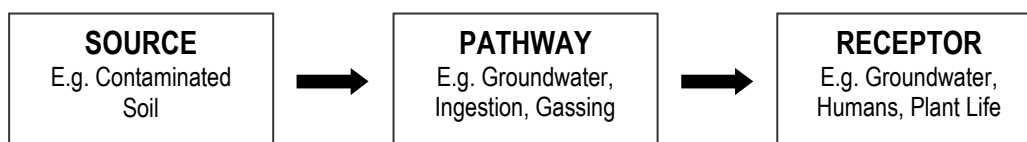
This section of the report aims to identify land which could potentially be affected by contamination, such that it could affect the value or re-use of the land, or such that mitigation would be required for certain proposed end uses of the land.

Potential contamination sources and environmentally sensitive receptors have been discussed in Section 6. Potentially significant risks are evaluated as part of the subsequent sub-sections.

6.1 Source-Pathway-Receptor-Linkages

The risk assessment uses a 'Source-Pathway-Receptor' methodology for assessing whether a source of contamination could potentially lead to harmful consequences. This means that there needs to be a pollutant linkage from source to a receptor for harm to be caused, this linkage consisting of; a source of pollution; a pathway for the pollutant to move along; a receptor that is affected by the pollutant.

The current potential risks to site arising from various Source-Pathway-Receptor linkages are assessed below. A risk may be considered significant if all three of the stages are present and therefore providing a pollution linkage. The various sources, pathways and receptors are considered separately. The assessment is based on future use, which is understood to be residential.



Type of Contamination	Potential Sources	Potential Pathway	Potential Receptors	Pollution Linkage	Comment	Estimated Level of Risk
Ground Gas	Infilled Ponds On Site and in Immediate Area	Inhalation of Vapours	Construction/ Maintenance Workers	Potentially Active	Potential for biogenic ground gas from MADE GROUND. Ground gas monitoring to be completed by e3p. PPE to protect construction workers.	Low
	Coal Mining Under Site	Vapours Penetrating Unprotected Buildings	Future Site Users	Potentially Active++	Potential for biogenic ground gas from MADE GROUND. Ground gas monitoring to be completed by e3p. PPE to protect construction workers.	Low/Moderate
Surface and Near Surface Contaminants Within Soils	Electricity Pylons On Site Infilled Ponds On Site and in Immediate Area	Ingestion, Inhalation, Dermal Contact	Current Site Users	Potentially Active	Localised hotspots of contamination present on sit, further exceedances may be present below existing buildings. Migration of contamination from offsite sources unlikely.	Low – Moderate (Localised)
			Construction Workers	Potentially Active	Localised hotspots of contamination present on sit, further exceedances may be present below existing buildings. Migration of contamination from offsite sources unlikely.	Low – Moderate (Localised)
			Future Site Users	Potentially Active	Localised hotspots of contamination present on sit, further exceedances may be present below existing buildings. Migration of contamination from offsite sources unlikely.	Low – Moderate (Localised)
			Adjacent Land Users	Potentially Active	Localised hotspots of contamination present on sit, further exceedances may be present below existing buildings. Migration of contamination from offsite sources unlikely.	Low – Moderate
		Direct Contact	Structures	Potentially Active	Localised hotspots of contamination present on sit, further exceedances may be present below existing buildings. Migration of contamination from offsite sources unlikely.	Low – Moderate (Localised)
		Absorption in Root Zone	Plants	Potentially Active	Localised hotspots of contamination present on sit, further exceedances may be present below existing buildings. Migration of contamination from offsite sources unlikely.	Low – Moderate (Localised)
Mobile Contaminants, Leachables e.g. from Pollution Sources Adjacent to Site/On Site	Electricity Pylons On Site	Leaching into Groundwater	Groundwater	Potentially Active	Permeability designation of the bedrock geology is Secondary B. Site superficial geology is Secondary A Aquifer. No significant site wide contamination anticipated.	Low
	Infilled Ponds On Site and in Immediate Area	Off-site Migration in Groundwater	Abstractions	Potentially Active	Limited contamination observed. There are no groundwater abstractions within close proximity. Site does not lie within Groundwater Source Protection Zone.	Low
			Controlled Waters	Potentially Active	Limited contamination observed. Superficial geology anticipated to be both cohesive and non-cohesive.	Low
Organic and Inorganic Contaminants Within Soils / Groundwater	Electricity Pylons On Site Infilled Ponds On Site and in Immediate Area	Potable Water Supply Pipes	Utilities Workers	Potentially Active	Localised hotspots of contamination may be present on site from infilled features and electricity pylons Migration of contamination from offsite sources unlikely. Requirement for UU Assessment required.	Low – Moderate (Localised)

6.2 Contamination Summary

In this qualitative risk assessment, a generally **Low – Moderate (Localised)** risk for contamination and ground gas exists onsite. SI was required to confirm the risk potential and design remedial actions where necessary.

6.3 Geotechnical Constraints

- Variable drift deposits and bearing capacities.
- Possible service easements – liaison with utility providers advised.
- Potential Made ground.
- Possible shallow groundwater on site.
- Existing former foundations/floor slabs in place

7 FIELDWORK

7.1 Fieldwork Objectives

The objectives of the intrusive ground investigation will be to:

- Clarify the 'Initial Contamination Conceptual Model'.
- Clarify the Initial Risk Assessment.
- Benchmark the contamination status of the site.
- Provide data for the design of any remedial works that may be required.
- Provide a geotechnical appraisal for the site.

7.2 Fieldwork Scope

The fieldwork was carried out between the 16-17th December 2020 and 18th/19th January and comprised:

- Twelve (12 No) window sample boreholes drilled to 3.00mbgl.
- Three (3 No) hand dug trial pits excavated to depths of up to 0.35mbgl to sample the bund in the east of the site.
- Six (6 No) Infiltration tests
- Chemical analysis (Metals, PAH's, asbestos and TPH's) of fifteen (15 No) samples.
- Collection and analysis of one (1 No) samples for geotechnical analysis.

The exploratory hole positions were selected and set out by Betts Geo Environmental Ltd (BGE) as shown on the Exploratory Hole Location Plan in Appendix B.

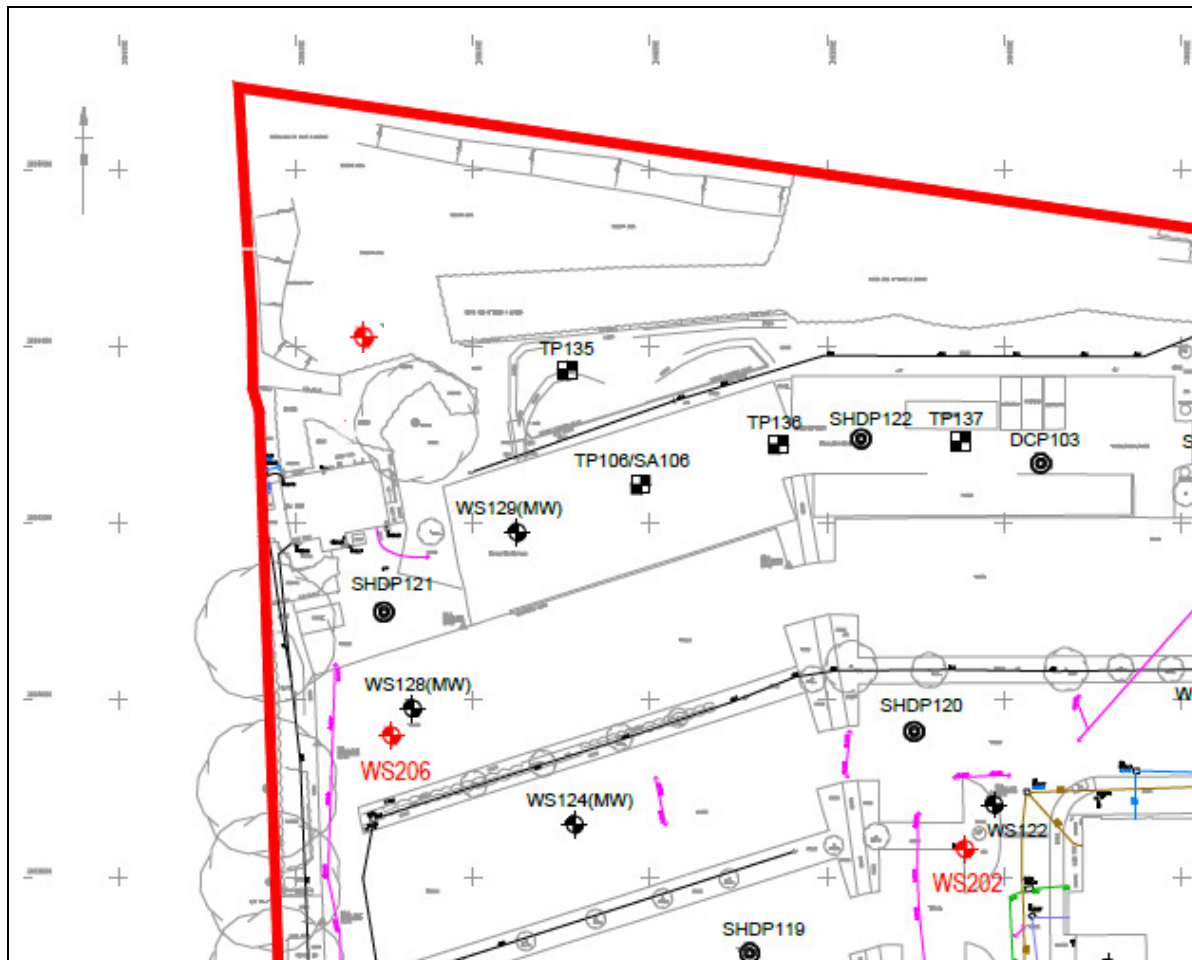
Services are present on-site and are known to cross areas of planned investigation, exploratory hole positions were located to avoid any known services. Prior to any intrusive works, each location was checked for services using a cable avoidance tool (CAT) and review of statutory service plans.

Exploratory holes were positioned to investigate identified potentially contaminated areas identified during the Phase 1 Desk Study and intrusive investigation undertaken for the site by REC and e3p, as well as provide a baseline contamination assessment as part of a due diligence exercise for the site. Note that this does not replace the need for post demo investigation.

7.3 Access Issues

WS207 was aborted due to the presence of a possible service at 1.10mbgl.

The northern most location could not be accessed due to vegetation, as shown on the sketch below;



8 GROUND CONDITIONS

8.1 General

The exploratory holes were logged by an Engineer in general in accordance with the recommendations of BS5930:2015. Detailed descriptions, together with relevant comments, are given in the Exploratory Hole Logs included in Appendix C.

8.2 Ground Conditions Summary

Ground conditions typically comprised sand TOPSOIL (made ground) over granular MADE GROUND deposits of SAND, GRAVEL and SAND & GRAVEL. Made ground was noted to overly natural granular deposits in a number of locations. Natural cohesive strata were only recorded in WS206.

Groundwater was recorded in WS205, WS206 and WS208 from a minimum depth of 2.00mbgl.

MADE GROUND was not bottomed out in WS202, WS204, WS209, WS210 and WS211.

MADE GROUND in WS203 was recorded to a depth of greater than 3.00mbgl.

The full logs should be consulted in conjunction with this summary.

8.2.1 Topsoil (Made Ground)

Topsoil was observed in most exploratory locations to depths of between 0.10mbgl and 0.15mbgl. Topsoil was generally described as *'Brown slightly clayey slightly gravelly fine to coarse SAND. Gravel is fine to coarse angular to subangular of brick and concrete'*.

All topsoil was determined to be made ground due to anthropogenic components.

8.2.2 Made Ground

Made Ground was observed in all locations. The base of MADE GROUND was not observed in WS202, WS203, WS204, WS209, WS210 and WS211.

Where MADE GROUND was bottomed out, it was observed to depths of between 0.70-1.40mbgl.

Made Ground was heterogenous, and commonly granular in nature, and it is anticipated to have been created during previous phases of demolition or imported materials used to raise levels.

Typically, MADE GROUND was described as *'Medium dense brown and grey gravelly fine to coarse SAND with rare cobbles. Gravel and cobbles are fine to coarse subangular to angular of brick and concrete'*.

Cohesive MADE GROUND was generally described as *'Firm black gravelly CLAY. Gravel is fine to medium of ash, brick and concrete'*.

8.2.3 Glaciofluvial Deposits – Granular

Granular deposits were observed as either SAND or SAND & GRAVEL and were recorded below made ground strata from 0.70-1.40mbgl.

Generally, the shallower SAND strata were described as '*Medium dense yellow slightly very gravelly clayey SAND. Gravel is fine medium subrounded to subangular of mixed lithology*'. The deeper material was described as '*Medium dense grey slightly very gravelly clayey SAND. Gravel is fine medium subrounded to subangular of mixed lithology*'.

SPT 'N' Values in GRANULAR strata ranged from 5 (WS205) and 27 (WS201). SILT was recorded in TP8 only as was recorded as soft to firm grey vary sandy clayey SILT at 1.60-1.85mbgl.

8.2.4 Glaciofluvial Deposits – Cohesive

Cohesive deposits were only encountered in WS206 from 2.50-3.00mbgl and was described as '*Soft to firm reddish brown sandy silty CLAY*'.

8.3 Visual and Olfactory Contamination

Other than MADE GROUND, no visual or olfactory evidence of contamination was noted within the holes.

8.4 Obstructions

Obstructions were noted in the following locations;

Exploratory Hole	Depth (mbgl)	Notes
WS201	0.90	Concrete obstruction
WS202	0.80	Concrete obstruction
WS204	0.85	Brick or concrete obstruction
WS207	1.10	Hollow sounding obstruction, possible service
WS210	0.75	Possible wall / footing
WS211	1.00	Possible wall / footing

8.5 Groundwater – Fieldwork

The following exploratory holes encountered groundwater during the site investigation:

Exploratory Hole	Depth (m bgl)	Strata	Remark
WS205	2.95	SAND	Wet
WS206	2.00	SAND	Rising to 1.55mbgl
WS208	2.00	SAND	Wet

9 LABORATORY TESTING

9.1 General

An assessment of potential determinants associated with the current/former site uses has been undertaken. Determinants originating from the current/former site uses may include metals, polycyclic aromatic hydrocarbons (PAHs), total petroleum hydrocarbons (TPHs) and asbestos. A general suite of testing should detect most potential contaminants.

Test	No. of Tests	Description
pH Values	16	Determination of pH (using Cyberscan pH meter).
Sulphate - Soluble 2:1 Extract	16	Dionex.
Arsenic, Cadmium, Chromium VI, Chromium III, Total Chromium, Lead, Mercury, Selenium, Copper, Nickel, Complex and Free Cyanide and Zinc.	15	Soil samples were analysed in accordance with UKAS/MCERTS standards Inductively coupled plasma atomic emission spectroscopy (ICP-OES)
Speciated Polycyclic Aromatic Hydrocarbons (PAH),	15	Determination of Polycyclic Aromatic Hydrocarbons by GC-MS. End/end extraction using DCM on as received sample. In house method modified USEPA 8270. Include coronene if required.
TPH CWG	15	TPH CWG (Aliphatics C5-6,>6-8,>8-10,>10-12,>12-16,>16-21,>2-35) (aromatics >C5-7,>7-8,>8-10,>10-12,>12-16,>16-21,>21-35) C5-8 fractions by Headspace GC-MS (003S). C8-35 fractions on as received sample extracted with hexane/acetone, aliphatic/aromatic splits run by GC-FID (005S), banded as listed above.
GRO/BTEX/MTBE by GC-FID (C5-10; C10-C12)	15	Determination of Gasoline Range Hydrocarbons (GRO) and BTEX (MTBE) compounds by Headspace GC-FID (C4-C12).
Organic Matter	15	Determination of Organic Matter by combustion.
Asbestos Screen	15	Visual Screening for Fibres.
4pt Atterburg Test	1	

10 CONTAMINATION ASSESSMENT

10.1 General

Contaminants of concern recorded at concentrations above relevant screening values are summarised below. For ease of description, the identification of contaminant sources and possible re-use of material, Topsoil, Made Ground, Natural Strata and Groundwater will be dealt with in separate sub-headings in this section of the report where required.

Our assessment is based on the following assumptions:

- The proposed site end use is of a high-risk rating (residential housing with gardens). For analysis purposes, 'residential with home grown produce' is deemed most appropriate end use.
- The superficial deposits are classed as Secondary A Aquifer (Moderate permeability).
- The bedrock deposits are classed as a Secondary B Aquifer (Low permeability).
- It is deemed that some statistical analysis is appropriate. Where sample data numbers are low and/or targeted, each determinant result is reviewed further as an individual result as opposed to an average across the site.
- Site history has indicated a **Low to Low-Moderate** risk of contamination.
- Statistical analysis of the chemical test results has been undertaken in general accordance with Environment Agency 2009 SGV Guidance and AtRisk 2017 using the combined assessment criterion given by CLEA (Note: all SSVs for EA derivation are for a SOM of 6%, in line with Environment Agency Report SC050021/SR4 – this figure is deemed representative as an average value for a sandy loam soil). AtRisk 2017 are used to the nearest SOM percentage deemed appropriate.
- No free product was noted within the exploratory holes.
- Following the withdrawal of CLR 7-10 Guidance documents by the Environment Agency, statistical analysis has been undertaken in accordance with the CIEH/CL:AIRE 'Guidance on Comparing Soil Contamination Data with a Critical Concentration' (May 2008). As such, the use of the mean value test alone is not considered.

A full risk assessment is detailed within Section 14 of this report.

10.2 Soils Contamination Summary

10.2.1 Topsoil (Made Ground)

Topsoil recorded no elevated concentrations above residential with home grown produce thresholds.

10.2.2 Made Ground

Three exceedances above residential thresholds were observed within MADE GROUND strata. These are detailed below;

Location	Depth (mbgl)	Determinant	Observed concentration (mg/kg)	AtRisk 2017 Threshold (mg/kg)	DEFRA C4SL Threshold (mg/kg)
WS205	0.85	Benzo(a)pyrene	1.66	1.51	2.05
WS211	0.80	Asbestos (Chrysotile)	<0.001	<0.001	<0.001
B3	0.35				

10.2.3 Natural Strata

Natural strata recorded no elevated concentrations above residential with home grown produce thresholds.

10.3 Groundwater Contamination

Based on site history and limited contamination observed within the site soils, the risk to controlled waters is considered to be negligible.

11 ENVIRONMENTAL RISK ASSESSMENT

11.1 General

This section assesses likely risks to the identified receptors, arising from potential contamination sources. It provides a final qualitative assessment of the risks involved, indicating whether (where appropriate) any immediate action is required to mitigate certain risks.

In assessing the risk qualitatively, it is appropriate to use the methods outlined in the CIRIA document C552, "Contaminated Land Risk Assessment a Guide to Good Practice". It uses a classification of risk based on the magnitude of the potential consequence or severity of risk occurring, compared with the magnitude of the probability or likelihood of the risk occurring. These are indicated on the attached tables in Appendix I.

The superficial deposits are classed as Secondary A Aquifer (Moderate Permeability) and the Bedrock deposits are classed as a Secondary B Aquifer (Low Permeability).

With respect to human health, the proposed end use (residential with home grown produce) is of high sensitivity. Therefore, the site's environmental setting is considered to be of a **Moderate to High** environmental sensitivity. Transient risks to construction workers can be addressed by the adoption of appropriate health and safety measures, therefore, the primary residual risks that require assessment are Site End Users. The following sections are split into soils and groundwater for clarity.

11.2 Assessment of Contamination Analytical Results – Betts Geo & e3p datasets

Soils

An exceedance of Benzo(a)pyrene (1.66mg/kg) was observed in WS205 at depth of 0.85mbgl. When compared to the residential threshold of 1.51mg/kg, the exceedance is shown to be minimal.

Statistical analysis of the Benzo(a)pyrene within MADE GROUND strata has shown that the marginal exceedance recorded in WS205 is statistically insignificant and is not representative of the wider site soils. On this basis, the exceedance may be discounted.

Comparison of the Dibenzo(a,h)anthracene exceedances (0.28-0.35mg/kg) from the e3p report, show their maximum concentrations to be below the AtRisk 2017 threshold of 0.838mg/kg. On this basis, these exceedances may also be discounted.

The remaining exceedances across the site, from both investigations are detailed below;

Location	Depth (mbgl)	Determinant	Observed concentration (mg/kg)	AtRisk 2017 Threshold (mg/kg)	DEFRA C4SL Threshold (mg/kg)
Betts Investigation					
WS211	0.80	Asbestos (Chrysotile)	<0.001	<0.001	<0.001
B3	0.35				
E3p Investigation					
WS107	0.55	Arsenic	68	32	37
WS118	0.30	Asbestos (Chrysotile)	0.002	<0.001	<0.001

Despite the above, due to possibility of asbestos being present within MADE GROUND, gardens are to be provided with 600mm growing medium, as per NHBC guidance subject to further investigation where made ground is encountered. Following post demo investigation and finalised layouts/levels, full cover system requirements can be confirmed. PCB testing should be undertaken post demo of potentially affected buildings.

Groundwater and Aquifer Risk

Risk to controlled waters is deemed minimal due to the lack of significant contamination observed onsite.

12 PRELIMINARY GROUND GAS ASSESSMENT

12.1 Ground Gas Requirements – Radon

The site is in a low-risk area where <1% of the homes are above the action level.

12.1.1 Guidance

Three recent publications are used for ground gas risk assessment:

- 'Guidance on Evaluation of Development Proposals on Sites Where Methane and Carbon Dioxide are Present', Report Edition No.04 March 2007 NHBC – designed for use with low rise residential properties.
- CIRIA C665 'Assessing risks posed by hazardous ground gases for buildings' 2007 - for high rise residential / flats.
- BS8485:2015 'Code of practice for the design of protective measures for methane and carbon dioxide ground gases for new buildings'.

Further details / accompanying notes for the following gas risk assessment are enclosed in Appendix L. The proposed development at the site is Residential.

12.2 Ground Gas Assessment (e3p)

The ground gas assessment has been carried out by e3p and is summarised below, their report should be read in conjunction with this summary. It should also be noted that Betts Geo has not been provided with the full gas monitoring data set.

The GSV has been compared to the criteria outlined with CIRIA C665 to determine the level of risk to the proposed development and to ensure the appropriate remedial options are incorporated into any future building design in this area.

Preliminary ground gas monitoring suggests that the site can be predominantly classified as Green / CS1, and in these areas it is considered that ground gas protection measures will not be required.

However, localised areas of the site have been assessed as being Amber 1 / CS2 and properties within this area will likely require specialist protection measures as detailed herein. However, should properties be constructed within a sub-floor void, NHBC guidance can be followed, which would mean properties within the vicinity of WS123 and WS124 would be classified as Green and would not require ground gas protection measures as the calculated GSV is <0.76l/hr. However, ground gas protection measures will be required in the vicinity of WS128 due to the presence of elevated carbon dioxide concentrations.

LOCATION	MAX CO ₂ (% v/v)	GSV (l/hr)	MAX CH ₄ (% v/v)	GSV (l/hr)	CLASSIFICATION
WS102	1.40	0.00676	0.10	0.00052	Green/CS1
WS103	1.80	0.03582	0.10	0.00199	Green/CS1
WS105	0.90	-0.00351	0.10	-0.00039	Green/CS1
WS106	2.30	-0.01092	0.10	-0.00052	Green/CS1
WS109	2.00	0.0104	0.10	0.00052	Green/CS1
WS110	0.90	-0.00234	0.10	-0.00026	Green/CS1
WS111	0.70	-0.00364	0.10	-0.00052	Green/CS1
WS113	2.70	0.01404	0.10	0.00052	Green/CS1
WS115	1.30	0.01196	0.10	0.00092	Green/CS1
WS117	3.70	-0.00676	0.10	-0.00052	Green/CS1
WS121	0.80	0.00156	0.10	0.0001	Green/CS1
WS123	2.20	0.16302	0.10	0.00741	Amber 1/CS2
WS124	3.30	0.09009	0.10	0.00273	Amber 1/CS2
WS125	1.90	0.00936	0.10	0.00052	Green/CS1
WS127	2.20	-0.01144	0.10	-0.00052	Green/CS1
WS128	5.40	-0.04266	0.10	-0.00079	Amber 1/CS2
WS129	3.70	-0.01716	0.10	-0.00052	Green/CS1

12.2.1 Ground Gas Summary – Preliminary

Review of the data provided by e3p thus far shows only two areas WS123 and WS124, where there are elevated GSVs;

No deep Made Ground was recorded these areas, though there is some potential within TP108, which was concluded at ~0.85m due to a concrete obstruction, no other sources noted.

There is limited flow rate (presumed peak flow used by e3p?), flow values given are representative of diffusive flow in the amber locations (recorded between 0.26-2.73l/h, with one result of 7.41l/h which appears anomalous compared to the rest of the data set), and there's only one location with CO₂ concentrations over 5%. Shallow groundwater pumping could also affect ground gas levels in these boreholes given the depth of response zones. The anticipated source is MADE GROUND from the previous site development. MADE GROUND such as this will be arrested during development as part of excavation works. The ongoing risk is therefore deemed negligible.

With local authority agreement, zoning of the site should be possible. The preliminary ground gas assessment is below;

Site Area	Site Classification	Recommended Ground Gas Protection Measures
Area around WS123 and WS124	Amber 1 / CS2	Low-level ground gas protection measures are required, using a gas resistant membrane and ventilated sub-floor void that creates a permeability contrast to limit the ingress of gas into buildings. Gas protection measures are to be installed as prescribed in BRE 414. Ventilation of the sub-floor void should be designed to provide a minimum of one complete volume change per 24 hours.

Rest of Site	Green / CS1	No specialist ground gas protection is anticipated with regards to ground gas production.
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13 REVISED CONCEPTUAL SITE MODEL

13.1 General

The Initial Conceptual Site Model has been amended in light of data obtained during the ground investigation.

13.2 Final Conceptual Site Model

This section reassesses likely risks to the identified receptors, arising from potential contamination sources. It provides a final qualitative assessment of the risks involved, indicating whether (where appropriate) any immediate action is required to mitigate certain risks. It also discusses (where appropriate) what longer term measures or remedial works may be required in the future if the site were to be developed. It is considered that the site has not been assessed by the Local Authority as a contaminated site under the terms of the Environmental Protection Act 1990 Part IIa.

Target (Receptor)	Potential Source-Pathway Linkage	Remedial Action Required (where appropriate)	Est. Degree of Risk to Target Following Remedial Action Where Necessary
Site End Users	Inhalation of soil gases, odours or dust.	Amber 1 / CS2 – vicinity of WS123 and WS124. Remainder of site – Green.	Low
Site End Users	Ingestion of, and skin contact with, contaminated soil.	600mm clean and inert capping required where made ground encountered subject to finalised layout and levels, zonation may be possible, as per NHBC guidance.	Low
Site End Users	Ingestion of contaminants in vegetables etc. or in soils adhering to vegetables, etc	600mm clean and inert capping required, as per NHBC guidance.	Low
Construction/ Maintenance Workers	Inhalation of soil gases, odours or dust.	PPE (gas monitoring data suggests ground gas will not affect construction workers)	Low (assumed basic PPE is used)
Construction/ Maintenance Workers	Ingestion of, and skin contact with, contaminated soil	PPE and appropriate handwashing facilities to be provided to ground workers	Low (assumed basic PPE is used)
Plants	Adverse effects on growth caused by presence of phytotoxic contaminants in soil	600mm clean and inert capping required, as per NHBC guidance.	Low
Buildings and Structures	Flow of ground gas into buildings. Asphyxiation, toxicity, explosion and fire hazards	Amber 1 / CS2 – vicinity of WS123 and WS124. Remainder of site – Green.	Low
Foundations	Sulphate attack of foundations	Foundations to be designed as per section 16.4.	Low
Water Supplies	Hydrocarbons penetrating plastic water supply pipes.	United Utilities pipeline risk assessment required. Protect-A-line not anticipated due to lack of contamination observed.	Low
Groundwater	Migration of soluble contaminants into groundwater on or off site	Risk is anticipated to be negligible due to lack of contamination.	Low

Surface Water	Migration of soluble contaminants and/or direct run-off of contaminants	Risk is anticipated to be negligible due to lack of contamination.	Low
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14 OUTLINE STRATEGY FOR RISK REDUCTION / REMEDIATION STRATEGY

14.1 General

The following section details any recommendations to reduce risk on site and recommends remedial actions (as per the previous sections of this report). For clarity, the section is split into sub-sections as per the conceptual site model (Section 14).

14.2 Construction / Maintenance Workers

No significantly elevated contamination was encountered on site and could be considered a risk to site workers. There are currently no assessment criteria for risks to construction workers, the following recommendations should be adhered to during site works:

- Site workers should wear gloves, boots and overalls and wash their hands before eating, drinking and smoking. Excessive dust generation should be avoided.
- It is recommended that during all excavations adequate ventilation should be maintained. If man entry into excavations is required, gas monitoring should be carried out as a precaution.
- If areas of suspected contamination are found then a suitably qualified person should undertake appropriate sampling, testing and further risk assessment.

14.3 Site-End Users

Limited contamination was observed during the site investigation, with exceedances of arsenic and asbestos noted within MADE GROUND.

The installation of a 600mm clean and inert capping layer with geotextile break-layer is required for all gardens where made ground is encountered and is to be in line with NHBC guidelines. . Subject to layout, levels and regulatory sign off, zonation of cover system requirements could be possible.

14.4 Preliminary Ground Gas Protection Measures

Areas in the vicinity of WS123 and WS124 require low-level ground gas protection measures, using a gas resistant membrane and ventilated sub-floor void that creates a permeability contrast to limit the ingress of gas into buildings.

Gas protection measures are to be installed as prescribed in BRE 414. Ventilation of the sub-floor void should be designed to provide a minimum of one complete volume change per 24 hours.

14.6 Ground Water / Aquifer

No significant contamination was observed during the Betts Geo investigation. E3p determined the site to have a low risk as it is underlain by low-permeability, predominantly cohesive glacial till deposits beneath granular deposits, these will afford protection to the underlying Secondary B Aquifer, furthermore, there are no groundwater abstraction points within close proximity of the site.

14.7 Off-Site Disposal of Soils

The handling, re-use or disposal of waste is regulated by the Environment Agency. Any material excavated on-site may be classified as waste and it is the responsibility of the holder of a material to form their own view on whether or not it is waste. One of the ways this can be achieved is set out in the Development Industry Code of Practice (CoP; Ref. 13). This builds on the Environment Agency guidance document Definition of waste: developing greenfield and brownfield sites (2006). The Agency will take into account the use of the CoP in deciding whether to regulate materials as waste. If materials are dealt with in accordance with the CoP, the Agency considers that those materials are unlikely to be waste at the point when they are to be used for the purpose of land development.

All material proposed for off-site disposal (e.g. during future construction works) should be given a proper description and waste classification assessment as required by the Environmental Protection Duty of Care Regulations (Ref. 14), and in accordance with WM3 and the Environment Agency Technical Guidance on the assessment and classification of Hazardous Waste.

It is recommended that the results of the contamination testing (including the history of the site) be presented to the proposed landfills to obtain their acceptance of the information to date. However, further testing maybe required to fully assess the waste classification of the soils requiring offsite disposal.

Segregation of the Topsoil, Made Ground and Natural Strata should be possible given the chemical analysis and very different visual identification. If moved to other sites for use, it is proposed to use the results of the contamination testing to determine if it is deemed suitable for re-use as topsoil or subsoil.

If there is the need to remove soil / Made Ground off-site it is recommended that the number of results required may not have been met using the sampling density requirements given in the Environment Agency (EA) *Waste Sampling and Testing for Disposal to Landfill 2013*. Additional samples of segregated soils whilst in stockpiles may be required before waste classification assessment can be carried out. A minimum of five (5 No.) samples of heterogenous material are required for offsite disposal.

Once an adequate number of samples have been analysed then the results of the chemical analysis will need to be assessed in order to classify the materials as non-hazardous or hazardous. The waste classification of soils is carried out in line with the *Guidance on the classification and assessment of waste (1st edition v1.1)*, *Technical Guidance WM3*, published by the EA, SEPA, NIEA and NRW. Betts Geo can provide a cost for the testing of any additional samples and a waste classification report, if materials will be disposed of offsite.

If the materials are classified as non-hazardous then the materials will not require any further assessment, unless there is possibility of disposal at an inert landfill. In order to dispose of material at an inert landfill the material must meet certain criteria physically and the leachable contamination must be below the inert Waste Acceptance Criteria (WAC) thresholds. WAC (single stage leachate, unless requested otherwise) analysis will therefore need to be carried out on the material. Due to time constraints or the availability of storage on site it may be advised to dispose of the material at a non-hazardous landfill, to allow materials to be removed from site quickly.

If the waste classification determines that there is hazardous material to be disposed of then hazardous WAC testing must be carried out on the material before it can be removed from site. This will determine whether the material requires treatment before being disposed at a hazardous landfill. Any exceedances of the hazardous WAC thresholds will need to be discussed with the receiving landfill.

The hazardous waste threshold for asbestos is 0.1% or any materials which contain visible asbestos containing materials. Asbestos was identified on site with quantification values greater than the hazardous waste threshold. Materials which are chemically non-hazardous but hazardous with respect to asbestos can potentially be disposed of at a non-hazardous landfill within a Stable Non-Reactive Hazardous (SNRW) cell.

Further information about disposal of soils offsite is provided in Appendix K.

14.8 Piped Drinking Water Supplies

The use of Protect-A-Line is not anticipated due to the lack contamination; regardless, a pipeline assessment should be undertaken to confirm.

15 GEOTECHNICAL ASSESSMENT

15.1 Introduction

It is understood that the proposed development will consist of the construction of low-rise residential properties with associated private gardens, associated infrastructure, public open space and new highway. Specific loadings have not been provided; however, it is anticipated that associated foundation loadings will be low. Furthermore, no site levels have been provided, however, it is anticipated that they will tie in with existing housing.

15.2 Site Preparation and Excavation

Excavations of shallow soils should not present any difficulty for conventional plant and equipment, however, a number of obstructions were noted across both the e3p and Betts Geo investigations.

Refer to groundwater section, sections 1.55 and 15.2, for groundwater regime.

Collapses within SAND strata were noted within trial pits and should be planned for accordingly.

All excavations should be planned, and due consideration should be given to providing temporary support or suitable battering. Excavations should be regularly inspected by a competent person to ensure continued safety. Further advice on the safety of excavations is given in *Health and Safety in Construction*. Shallow (<1.20mbgl) excavations for service trenches should be straight forward however, could be complicated by variable Made Ground and unstable granular deposits on site.

General care and due diligence in excavations in close proximity to the services located on site.

15.3 Control of Groundwater

Groundwater / perched water was observed from 1.50mbgl.

Provision of pumping / shuttering could be necessary during all excavations. It is good practice to have such equipment on standby in case of seasonal / abnormal weather conditions.

Should sewers / excavations deeper than the boreholes / trial pits undertaken be required, further SI will be needed.

15.4 Foundations

At the time of investigation, a detailed layout, foundation loadings nor finished floor level plan was available. As such no detailed assessment is possible. A detailed foundation zoning plan is advised when details are available.

Founding strata can generally be described as loose to medium dense SAND.

The following allowable pressures can be assumed on dry natural undisturbed materials described below;

- Loose to medium dense SAND – 75 kN/m²
- Medium dense SAND – 100 kN/m²
- Medium dense SAND & GRAVEL 100 kN/m²

It is important to note that shallow groundwater may reduce bearing capacities by half when found in conjunction with granular soils.

CLAY was observed in one location below the granular deposits. The following allowable pressure can be assumed on dry undisturbed material;

- Soft to firm CLAY – 75 kN/m²

Localised deepening of foundations and/or piled foundations are likely to be required in the vicinity of trees or in the areas of deeper Made Ground/soft clays/silt/peats encountered. A specialist piling contractor should be contacted for appropriate design.

A foundation zoning plan should be undertaken when proposed levels are made available.

Foundations should be excavated wholly on one stratum. Should proposed foundations span different strata, trenching and stepping of foundations and/or nominal reinforcement will be required.

Calculations on the allowable bearing capacity indicate settlements of less than 25mm for a square pad using the above allowable bearing capacity.

15.5 Ground Floor Construction

Shrinkable soils are not generally present at shallow depth, however, it is recommended that suspended floor construction (e.g. either in-situ RC slabs or block and beam flooring) is adopted in accordance with NHBC guidance.

15.6 Heave / Shrinkage Potential

The results of Atterberg Tests are given below, with modified plasticity and volume change potential;

Location	Depth (mbgl)	Moisture Content (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index	Passing <425µm(%)	Modified Plasticity Index (%)	Volume Change Potential
WS206	2.50	16	31	13	18	86	15	Low

E3P confirmed low-medium volume change potential, full foundation assessment plan and tree assessment required

15.7 Highway

According to the criteria of Highways Agency HD 25/95 Volume 7 Section 2 Part 2 HD 25/94, a CBR value of circa 3-% on the MADE GROUND is anticipated, however confirming in-situ CBR's should be

undertaken. Placement of geotextiles within the areas of roads / parking could also be designed to minimise the subgrade thickness.

15.8 Soakaway Testing

Soakaway testing carried out at the site has shown that the use of soakaways at the site is unlikely. The results are summarised below;

Location	Infiltration Rate	Likely Drainage Ability / Comments
SA1	NA	Very poor / test unable to start / data taken from below drainage pipe
SA2	1.77×10^{-5}	Poor / 1 test complete
SA3	1.41×10^{-5}	Poor / 1 test complete
SA4	6×10^{-6}	Very poor / Test data extrapolated, 1 test complete
SA5	2.31×10^{-6}	Very poor / Test data extrapolated, 1 test complete

The majority of pits were undertaken in MADE GROUND with wet SAND and / or SAND & GRAVEL below, perched groundwater ingress was therefore present.

A lands drain was noted in SA1, which gave a false impression of infiltration, but it immediately slowed down after passing the land drain. The soakaway results for SA1 was adapted to try and determine infiltration below the pipe but the result should be considered with a level of conservatism applied.

15.9 Protection of Buried Concrete

It is considered for concrete design purposes that a greenfield site and mobile groundwater conditions are applicable, and the results are summarised below:

Concrete Classification	
Design Sulphate Class	DS-1s
ACEC Class	AC-1

16 REFERENCES

- 16.1** *Desk Study Report for TMC Northenden Campus, Wythenshawe by REC on Behalf of The Manchester College. Report ref. 108393P1R0 dated October 2019.*
- 16.2** *Phase II Geoenvironmental Site Assessment for Northenden College by e3p, on behalf of Cushman and Wakefield / The Manchester College, Report ref.13-969-R1-1, dated July 2020.*
- 16.3** *'Land Contamination Risk Management (LCRM)' Environment Agency (October 2020).*
- 16.4** *BS 5930:2015 Code of Practice for Site Investigation*
- 16.5** *BS1377: 2016 Methods of Test for Soils for Civil Engineering Purposes.*
- 16.6** *Assessment of risks to human health from land contamination: an overview of the development of guideline values and related research. EA, 2002.*
- 16.7** *Contaminated Land Risk Assessment; A Guide to Good Practice; CIRIA C552: 2001.*
- 16.8** *Health and Safety in Construction, HSG150, HSE, 1996.*
- 16.9** *Hazardous Waste: Interpretation of the Definition and Classification of Hazardous Waste, Environment Agency, WM2 Version 1.0, June 2003.*
- 16.10** *DoE (1991), The Building Regulations Approved Document C, Site Preparation and Resistance to Moisture, HMSO.*
- 16.11** *Baker W (1987), Investigation Strategy - lecture at City of Birmingham Development Department Symposium on Methane Generating Sites, 9 December 1987, Industrial Research Laboratories, Birmingham.*
- 16.12** *NHBC Standards, Chapter 4.2, 2017 Building Near Trees.*
- 16.13** *Highways Agency HD 25/95 volume 7 section 2 Part 2 HD 25/94.*
- 16.14** *Water Regulations Advisory Scheme (2002) The selection of materials for water supply pipes to be laid in contaminated land.*
- 16.15** *Anon (1997) Dutch in Policy Retreat on Contaminated Land ENDS (Environmental Data Services), 269, 46.*
- 16.16** *Piling In Layered Ground: Risks to Groundwater and Archaeology Science Report SC020074/SR Environment Agency October 2006.*
- 16.17** *Piling and Penetrative Ground Improvement Methods on Land Affected by Contamination: Guidance on Pollution Prevention National Groundwater & Contaminated Land Centre report NC/99/73 F J Westcott, C M B Lean & M L Cunningham May 2001.*
- 16.18** *Guidance on Evaluation of Development Proposals on Sites Where Methane and Carbon Dioxide are Present', Report Edition No.04 March 2007 NHBC – designed for use with low rise residential properties.*
- 16.19** *CIRIA C665 'Assessing risks posed by hazardous ground gases for buildings' 2007 - for high rise residential / flats.*

- 16.20** BS8485:2015 'Code of practice for the design of protective measures for methane and carbon dioxide ground gases for new buildings'.
- 16.21** BRE 414 'Protective measures for housing on gas-contaminated land' Roger Johnson, Parkman Environment 2001.
- 16.22** BS 8500- 1:2006 'Concrete – Complementary British Standard to BS EN 206-1 – Part 1: Method of specifying and guidance for the specifier' November 2006.
- 16.23** 'Planning Policy 23: Planning and Pollution Control' Office of the Deputy Prime Minister 2004.
- 16.24** CLR11 'Model Procedures for the Management of Land Contamination' DEFRA 2004.
- 16.25** BRE 465 'Cover Systems for Land Regeneration' 2004.
- 16.26** 'The UK Approach for Evaluating the Human Health Risks from Petroleum Hydrocarbons in Soils, Environment Agency Science Report P5-080/TR3', Environment Agency (May 2005).
- 16.27** TOX12- Contaminants in Soil: Collation of Toxicological Data and Intake Values for Humans. Dioxins, Furans and Dioxin-like PCBs' Environment Agency 2003.
- 16.28** Atkins AtRisksoil.co.uk SSV's derived using CLEA for 1 or 6% SOM. Residential with home *grown produce*.2017

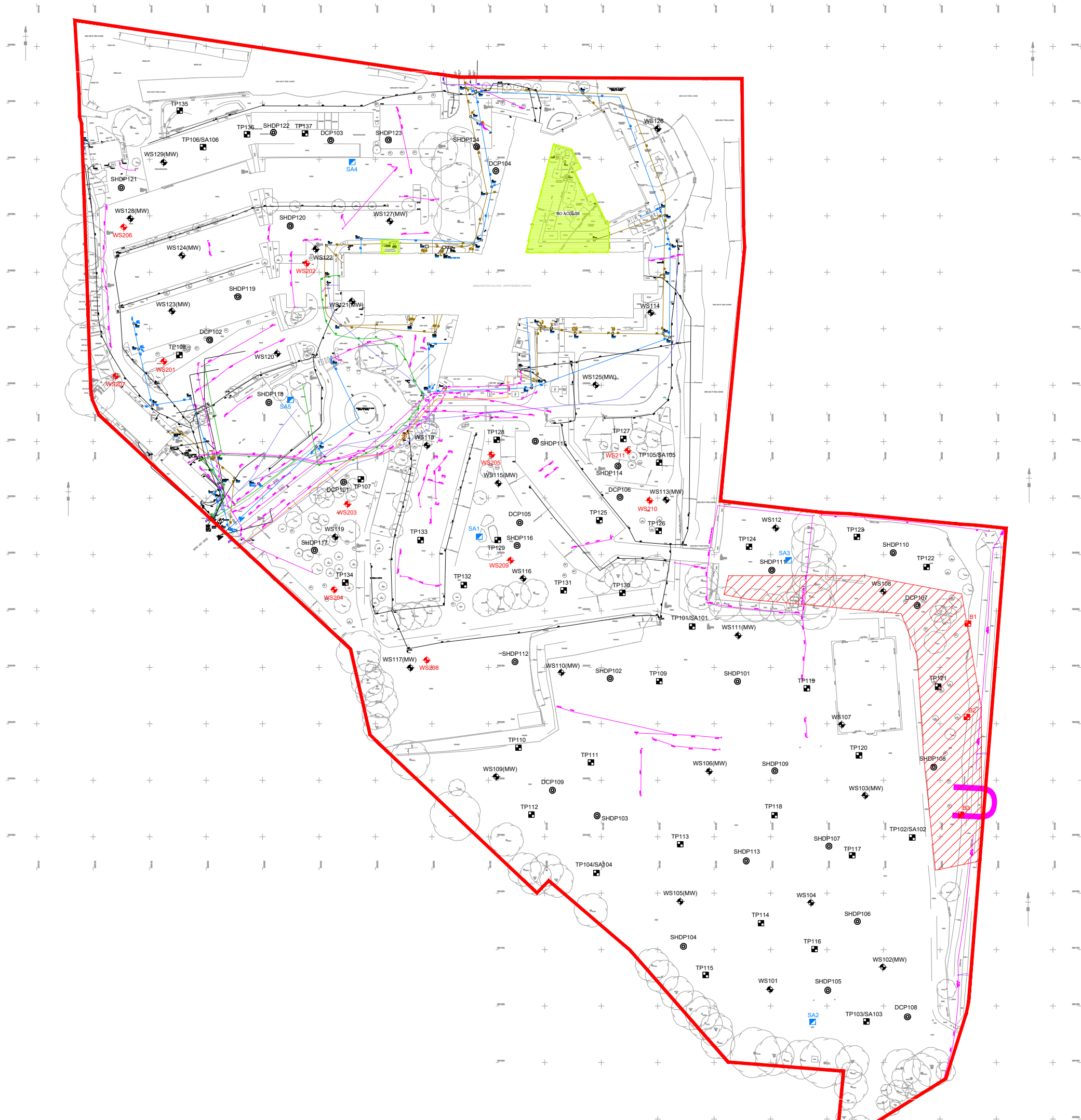
APPENDIX A

(i) Site Location Plan



APPENDIX B

- (i) Betts Exploratory Hole Location Plan



DO NOT SCALE

NOTES

THIS SKETCH SHOWS THE LOCATIONS OF THE E3P INVESTIGATION (JULY 2020), BETTS GEO (DECEMBER 2020 & JANUARY 2021) OVERLAIN THE SERVICES PLAN AND TOPOGRAPHICAL SURVEY.

KEY

E3P (JULY 2020)

- TRIAL PIT/SOAKAWAY
- WINDOW SAMPLE
- DCP/SHDP

BETTS GEO (DECEMBER 2020)

- WINDOW SAMPLE
- BUND AREA
- BUND SAMPLE

BETTS GEO (JANUARY 2021)

- SOAKAWAY

REV	DATE	BY	DESCRIPTION	CHK

DRAWING STATUS: **DRAFT**



BETTS GEO
CONSULTING ENGINEERS

Unit 6, Old Marsh Farm Barns, Welsh Road, Sealand, Flintshire CH5 2LY
Tel: 01244 288178 Fax: 01244 288516 enquiries@betts-associates.co.uk



miller homes
the place to be®

PROJECT:

NORTHENDEN

TITLE:

EXPLORATORY
HOLE LOCATION PLAN

DATE: 19/01/21	SCALE @ SIZE: NTS	DRAWN: RD	CHECKED: BL
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PROJECT No: 20MIL039	DRAWING No: EXP001	REV: -
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APPENDIX C

- (i) Betts Exploratory Borehole Hole Logs

BOREHOLE LOG

Project Northenden College, Northenden				BOREHOLE No B1
Job No 20MIL039	Date 17-12-20 17-12-20	Ground Level (m)	Co-Ordinates ()	
Contractor BETTS GEO Ltd				Sheet 1 of 1

[illegible]

Boring Progress and Water Observations						Chiselling			Water Added		GENERAL REMARKS
Date	Time	Depth	Casing Depth	Dia. mm	Water Dpt	From	To	Hours	From	To	

All dimensions in metres Scale 1:50	Client Miller Homes	Method/ Plant Used	HAND TOOLS	Logged By KR
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BOREHOLE LOG

Project Northenden College, Northenden				BOREHOLE No B2
Job No 20MIL039	Date 17-12-20 17-12-20	Ground Level (m)	Co-Ordinates ()	
Contractor BETTS GEO Ltd				Sheet 1 of 1

[illegible]

Boring Progress and Water Observations						Chiselling			Water Added		GENERAL REMARKS
Date	Time	Depth	Depth	Casing Dia. mm	Water Dpt	From	To	Hours	From	To	
All dimensions in metres Scale 1:50		Client Miller Homes				Method/ Plant Used		HAND TOOLS			Logged By KR

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BOREHOLE LOG

Project Northenden College, Northenden				BOREHOLE No B3
Job No 20MIL039	Date 17-12-20 17-12-20	Ground Level (m)	Co-Ordinates ()	
Contractor BETTS GEO Ltd				Sheet 1 of 1

[illegible]

Boring Progress and Water Observations						Chiselling			Water Added		GENERAL REMARKS
Date	Time	Depth	Depth	Casing Dia. mm	Water Dpt	From	To	Hours	From	To	
All dimensions in metres Scale 1:50		Client Miller Homes				Method/ Plant Used		HAND TOOLS			Logged By KR

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BOREHOLE LOG

Project Northenden College, Northenden				BOREHOLE No WS201	
Job No 20MIL039	Date 16-12-20 16-12-20	Ground Level (m)	Co-Ordinates ()		
Contractor BETTS GEO Ltd				Sheet 1 of 1	

SAMPLES & TESTS			STRATA					Geology	Instrument/ Backfill
Depth	Type No	Test Result	Water	Reduced Level	Legend	Depth (Thickness)	DESCRIPTION		
0.50	ES	N27				0.15 (0.75)	MADE GROUND: Brown slightly clayey slightly gravelly fine to coarse SAND. Gravel is fine to coarse angular to subangular of brick and concrete.		
1.10	ES					0.90	MADE GROUND: Medium dense brown and grey very gravelly fine to coarse SAND with rare cobbles. Gravel and cobbles are fine to coarse subangular to angular of brick and concrete.		
1.20						1.10	MADE GROUND: CONCRETE		
2.00						1.30	MADE GROUND: Firm black gravelly CLAY. Gravel is fine to medium of ash, brick and concrete.		
		N23				(1.20)	Medium dense yellow slightly very gravelly clayey SAND. Gravel is fine medium subrounded to subangular of mixed lithology. Possible reworked natural.		
						2.50			
3.00		N8				(0.50) 3.00	Medium dense grey slightly very gravelly clayey SAND. Gravel is fine medium subrounded to subangular of mixed lithology.		

Boring Progress and Water Observations						Chiselling			Water Added		GENERAL REMARKS
Date	Time	Depth	Casing Depth	Casing Dia. mm	Water Dpt	From	To	Hours	From	To	
											Concrete obstruction 0.90-1.10mbgl.
All dimensions in metres Scale 1:50			Client Miller Homes			Method/ Plant Used Competitor Rig			Logged By KR		

BOREHOLE LOG

Project Northenden College, Northenden				BOREHOLE No WS202	
Job No 20MIL039	Date 16-12-20 16-12-20	Ground Level (m)	Co-Ordinates ()		
Contractor BETTS GEO Ltd				Sheet 1 of 1	

SAMPLES & TESTS			STRATA					Geology	Instrument/ Backfill
Depth	Type No	Test Result	Water	Reduced Level	Legend	Depth (Thick- ness)	DESCRIPTION		
0.40	ES	N50				0.15	MADE GROUND: Brown slightly clayey slightly gravelly fine to coarse SAND. Gravel is fine to coarse angular to subangular of brick and concrete. MADE GROUND: Medium dense brown and grey very gravelly fine to coarse SAND with rare cobbles. Gravel and cobbles are fine to coarse subangular to angular of brick and concrete. Medium dense yellow slightly very gravelly clayey SAND. Gravel is fine medium subrounded to subangular of mixed lithology including brick.		
0.80					(0.45) 0.80				

Boring Progress and Water Observations						Chiselling			Water Added		GENERAL REMARKS
Date	Time	Depth	Casing Depth	Casing Dia. mm	Water Dpt	From	To	Hours	From	To	
											Brick cobbles throughout pit. Concrete obstruction at 0.80mbgl.
All dimensions in metres Scale 1:50			Client Miller Homes			Method/ Plant Used Competitor Rig			Logged By KR		

BOREHOLE LOG

Project Northenden College, Northenden				BOREHOLE No WS203	
Job No 20MIL039	Date 16-12-20 16-12-20	Ground Level (m)	Co-Ordinates ()		
Contractor BETTS GEO Ltd				Sheet 1 of 1	

SAMPLES & TESTS			STRATA					Geology	Instrument/ Backfill
Depth	Type No	Test Result	Water	Reduced Level	Legend	Depth (Thickness)	DESCRIPTION		
0.70	ES					0.15 (0.50) 0.65 0.70 0.80	MADE GROUND: Brown slightly clayey slightly gravelly fine to coarse SAND. Gravel is fine to coarse angular to subangular of brick and concrete. Medium dense yellow slightly very gravelly clayey SAND. Gravel is fine to medium subrounded to subangular of mixed lithology including brick. MADE GROUND: COBBLE of brick		
1.20		N12				(1.10)	MADE GROUND: Medium dense black, brown and grey very gravelly fine to coarse SAND with rare cobbles. Gravel and cobbles are fine to coarse subangular to angular of brick and concrete.		
2.00		N7				1.90 (1.10)	MADE GROUND: Heterogeneous strata of clay, fine to coarse sand and gravel. Gravel is fine to coarse subangular to angular of brick and concrete. Rare cobbles of brick noted. MADE GROUND: Loose brown and grey very clayey gravelly fine to coarse SAND. Gravel is fine to coarse subangular to angular of brick and gravel.		
3.00		N50				3.00			

Boring Progress and Water Observations						Chiselling			Water Added		GENERAL REMARKS
Date	Time	Depth	Casing Depth	Casing Dia. mm	Water Dpt	From	To	Hours	From	To	
											Brick Cobble 0.65-0.70mbgl
All dimensions in metres Scale 1:50			Client Miller Homes			Method/ Plant Used Competitor Rig			Logged By KR		

BOREHOLE LOG

Project Northenden College, Northenden				BOREHOLE No WS204
Job No 20MIL039	Date 16-12-20 16-12-20	Ground Level (m)	Co-Ordinates ()	
Contractor BETTS GEO Ltd				Sheet 1 of 1

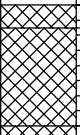
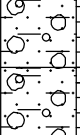
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Boring Progress and Water Observations						Chiselling			Water Added		GENERAL REMARKS
Date	Time	Depth	Depth	Casing Dia. mm	Water Dpt	From	To	Hours	From	To	
											Concrete or brick obstruction at base.
All dimensions in metres Scale 1:50		Client Miller Homes				Method/ Plant Used		Competitor Rig		Logged By KR	

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BOREHOLE LOG

Project Northenden College, Northenden				BOREHOLE No WS205	
Job No 20MIL039	Date 16-12-20 16-12-20	Ground Level (m)	Co-Ordinates ()		
Contractor BETTS GEO Ltd				Sheet 1 of 1	

SAMPLES & TESTS			STRATA					Geology	Instrument/ Backfill
Depth	Type No	Test Result	Water	Reduced Level	Legend	Depth (Thick-ness)	DESCRIPTION		
0.80	ES	N20	Water ↓			0.15	MADE GROUND: Brown slightly clayey slightly gravelly fine to coarse SAND. Gravel is fine to coarse angular to subangular of brick and concrete.		
				(0.65)		0.80	MADE GROUND: Medium dense brown and grey very gravelly fine to coarse SAND with rare cobbles. Gravel and cobbles are fine to coarse subangular to angular of brick, timber and concrete.		
				(0.60)		1.40	MADE GROUND: Medium dense brown and grey very gravelly cobbley fine to coarse SAND. Gravel and cobbles are fine to coarse subangular to angular of brick, timber and concrete.		
1.20						(0.50)	Medium dense brown and mottled grey grey clayey slightly gravelly fine to coarse SAND. Gravel and cobbles are fine to medium subangular to angular of mixed lithology. Single brown clay lens 1.50-1.55mbgl.		
2.00	N19			(1.10)		3.00	Medium dense grey grey slightly gravelly fine to coarse SAND. Gravel and cobbles are fine to medium subangular to angular of mixed lithology. Single brown clay lens 1.50-1.55mbgl.		
3.00	N5								

Boring Progress and Water Observations						Chiselling			Water Added		GENERAL REMARKS
Date	Time	Depth	Casing Depth	Casing Dia. mm	Water Dpt	From	To	Hours	From	To	
											Sand is wet from 2.95mbgl.
All dimensions in metres Scale 1:50			Client Miller Homes			Method/ Plant Used Competitor Rig			Logged By KR		

BOREHOLE LOG

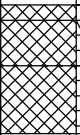
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Job No 20MIL039	Date 17-12-20 17-12-20	Ground Level (m)	Co-Ordinates ()		
Contractor BETTS GEO Ltd				Sheet 1 of 1	

SAMPLES & TESTS			STRATA					Geology	Instrument/ Backfill
Depth	Type No	Test Result	Water	Reduced Level	Legend	Depth (Thickness)	DESCRIPTION		
0.50	ES	N14				0.10	MADE GROUND: Asphalt		
						0.20	MADE GROUND: Medium dense grey fine to coarse SAND & GRAVEL. Gravel is fine to coarse subangular to angular of limestone.		
						(0.50)	MADE GROUND: Loose to medium dense black, brown and grey fine to coarse SAND & GRAVEL. Gravel is fine to coarse subangular to angular of mixed lithology including brick and concrete.		
						0.95	Loose to medium dense orangish brown slightly clayey fine to medium SAND.		
1.20						(0.55)	Medium dense brown very gravelly slightly clayey fine to medium SAND. Gravel is fine to medium rounded to subrounded of mixed lithology.		
2.00		N6				(1.00)	Loose to medium dense brown very gravelly slightly clayey fine to coarse SAND. Gravel is fine to medium rounded to subrounded of mixed lithology. Waterstrike at 2.00bgl.		
2.50	D					2.50			
						(0.50)	Soft to firm reddish brown sandy silty CLAY.		
						3.00			

Boring Progress and Water Observations						Chiselling			Water Added		GENERAL REMARKS
Date	Time	Depth	Casing Depth	Casing Dia. mm	Water Dpt	From	To	Hours	From	To	
											Water at 2.00m bgl, rising to 1.55m bgl.
All dimensions in metres Scale 1:50			Client Miller Homes			Method/ Plant Used Competitor Rig			Logged By KR		

BOREHOLE LOG

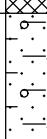
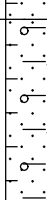
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Job No 20MIL039	Date 17-12-20 17-12-20	Ground Level (m)	Co-Ordinates ()		
Contractor BETTS GEO Ltd				Sheet 1 of 1	

SAMPLES & TESTS			STRATA					Geology	Instrument/ Backfill
Depth	Type No	Test Result	Water	Reduced Level	Legend	Depth (Thick- ness)	DESCRIPTION		
0.40	ES					0.10	MADE GROUND: Asphalt		
						0.40	MADE GROUND: Medium dense grey fine to coarse SAND & GRAVEL. Gravel is fine to coarse subangular to angular of limestone.		
						(0.45) 0.85	MADE GROUND: Loose to medium dense black and brown fine to coarse SAND.		
						1.10	Loose to medium dense grey and orangish brown slightly clayey fine to coarse SAND. Solid but hollow sounding obstruction at base, hole aborted.		

Boring Progress and Water Observations						Chiselling			Water Added		GENERAL REMARKS
Date	Time	Depth	Casing Depth	Casing Dia. mm	Water Dpt	From	To	Hours	From	To	
											Hole aborted at 1.10mbgl on solid but hollow sounding obstruction.
All dimensions in metres Scale 1:50			Client Miller Homes			Method/ Plant Used Competitor Rig			Logged By KR		

BOREHOLE LOG

Project Northenden College, Northenden				BOREHOLE No WS208	
Job No 20MIL039	Date 17-12-20 17-12-20	Ground Level (m)	Co-Ordinates ()		
Contractor BETTS GEO Ltd				Sheet 1 of 1	

SAMPLES & TESTS			STRATA					Geology	Instrument/ Backfill
Depth	Type No	Test Result	Water	Reduced Level	Legend	Depth (Thick-ness)	DESCRIPTION		
1.20		N19				0.10	MADE GROUND: Asphalt		
						0.35	MADE GROUND: Loose to medium dense very sandy fine to coarse GRAVEL and COBBLES of brick and concrete.		
						(0.40) 0.75	MADE GROUND: Loose to medium dense brown and black slightly clayey fine to coarse SAND.		
						(0.95) 1.70	Medium dense orangish brown slightly clayey gravelly fine to coarse SAND. Gravel is fine to medium of mixed lithology.		
2.00		N10				(1.30) 3.00	Loose grey slightly clayey gravelly fine to coarse SAND. Gravel is fine to medium of mixed lithology. Waterstrike at 2.00mbgl.		
3.00		N9							

Boring Progress and Water Observations						Chiselling			Water Added		GENERAL REMARKS
Date	Time	Depth	Casing Depth	Casing Dia. mm	Water Dpt	From	To	Hours	From	To	
											Waterstrike at 2.00mbgl.
All dimensions in metres Scale 1:50			Client Miller Homes			Method/ Plant Used Competitor Rig			Logged By KR		

BOREHOLE LOG

Project Northenden College, Northenden				BOREHOLE No WS209
Job No 20MIL039	Date 17-12-20 17-12-20	Ground Level (m)	Co-Ordinates ()	
Contractor BETTS GEO Ltd				Sheet 1 of 1

SAMPLES & TESTS			Water	STRATA			Geology	Instrument/ Backfill
Depth	Type No	Test Result		Reduced Level	Legend	Depth (Thickness)		
0.50	ES	N19			0.20	MADE GROUND: Brown slightly clayey slightly gravelly fine to coarse SAND. Gravel is fine to coarse angular to subangular of brick and concrete.		
					(1.55)	MADE GROUND: Medium dense brown and black gravelly slightly clayey fine to coarse SAND with rare brick cobbles. Gravels are fine to coarse subangular to angular of brick, concrete, sandstone and metal.		
					1.75			
2.00					2.00	MADE GROUND: Medium dense orangish brown gravelly slightly clayey fine to coarse SAND with rare brick gravel.		

Boring Progress and Water Observations						Chiselling			Water Added		GENERAL REMARKS
Date	Time	Depth	Depth	Casing Dia. mm	Water Dpt	From	To	Hours	From	To	
											Barrel Stuck in MADE GROUND.
All dimensions in metres Scale 1:50		Client Miller Homes				Method/ Plant Used		Competitor Rig		Logged By KR	

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BOREHOLE LOG

Project Northenden College, Northenden				BOREHOLE No WS210	
Job No 20MIL039	Date 17-12-20 17-12-20	Ground Level (m)	Co-Ordinates ()		
Contractor BETTS GEO Ltd				Sheet 1 of 1	

SAMPLES & TESTS			STRATA					Geology	Instrument/ Backfill
Depth	Type No	Test Result	Water	Reduced Level	Legend	Depth (Thick- ness)	DESCRIPTION		
0.50	ES	N50				0.20	MADE GROUND: Brown slightly clayey slightly gravelly fine to coarse SAND. Gravel is fine to coarse angular to subangular of brick and concrete.		
0.75						(0.55)	MADE GROUND: Medium dense brown and grey very gravelly cobbly fine to coarse SAND. Gravel and cobbles are fine to coarse subangular to angular of brick and concrete.		

Boring Progress and Water Observations						Chiselling			Water Added		GENERAL REMARKS
Date	Time	Depth	Casing Depth	Casing Dia. mm	Water Dpt	From	To	Hours	From	To	
											Brick obstruction, possible wall / footing.
All dimensions in metres Scale 1:50			Client Miller Homes			Method/ Plant Used Competitor Rig			Logged By KR		

BOREHOLE LOG

Project Northenden College, Northenden				BOREHOLE No WS211
Job No 20MIL039	Date 17-12-20 17-12-20	Ground Level (m)	Co-Ordinates ()	
Contractor BETTS GEO Ltd				Sheet 1 of 1

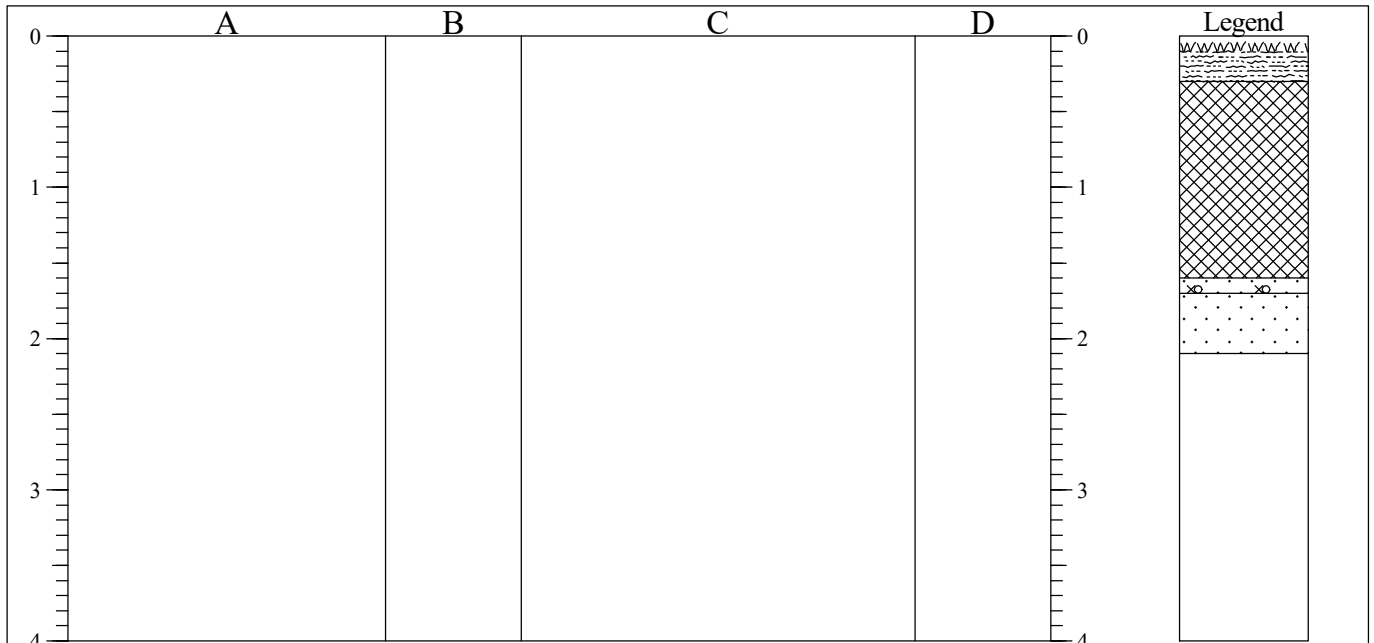
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Boring Progress and Water Observations						Chiselling			Water Added		GENERAL REMARKS
Date	Time	Depth	Casing Depth	Dia. mm	Water Dpt	From	To	Hours	From	To	
											Brick obstruction, possible wall / footing.
All dimensions in metres Scale 1:50		Client Miller Homes				Method/ Plant Used		Competitor Rig		Logged By KR	

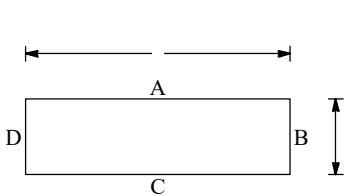
AGS3 UK BH 20MIL039 - NORTHENDEN.GPJ GINT STD AGS 3 1.GDT 23/12/20

TRIAL PIT LOG

Project Northenden College, Northenden				TRIAL PIT No SA1
Job No 20MIL039	Date 18-01-21	Ground Level (m)	Co-Ordinates ()	
Contractor BETTS GEO Ltd				Sheet 1 of 1

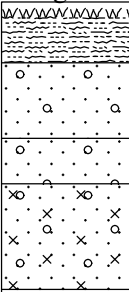


STRATA				SAMPLES & TESTS		
Depth	No	DESCRIPTION	Depth	No	Remarks/Tests	
0.00-0.30		Grass over TOPSOIL: Dark brown very sandy CLAY. Occasional rootlets.				
0.30-1.60		MADE GROUND: Black cobblely sandy very gravelly CLAY. Frequent concrete. Rare brick and reddish brown sand pocket. 1.10 Relic brick structure.				
1.60-1.70		Medium dense grey slightly gravelly slightly silty fine to medium SAND. Gravel is sub angular to sub rounded of various lithologies.				
1.70-2.10		Medium dense brown fine to medium SAND.				

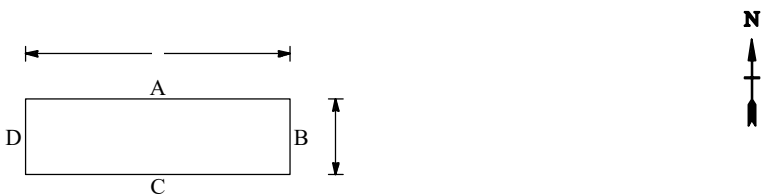
Shoring/Support: Stability: Slight unstable below 1.60mbgl. 				GENERAL REMARKS Seepages between 0.30mbgl - 1.60mbgl. Damp below 1.60mbgl. Land drain at 1.60mbgl - Soakaway water soaked into here before level fell below 1.60mbgl. SOAYAWAY RESULTS MAY NOT BE REPRESENTITIVE.	
All dimensions in metres Scale 1:50	Client Miller Homes	Method/ Plant Used JCB 3CX	Logged By JS		

TRIAL PIT LOG

Project Northenden College, Northenden				TRIAL PIT No SA2
Job No 20MIL039	Date 18-01-21	Ground Level (m)	Co-Ordinates ()	
Contractor BETTS GEO Ltd				Sheet 1 of 1

A		B		C		D		Legend	
0								0	
1								1	
2								2	
3								3	
4								4	

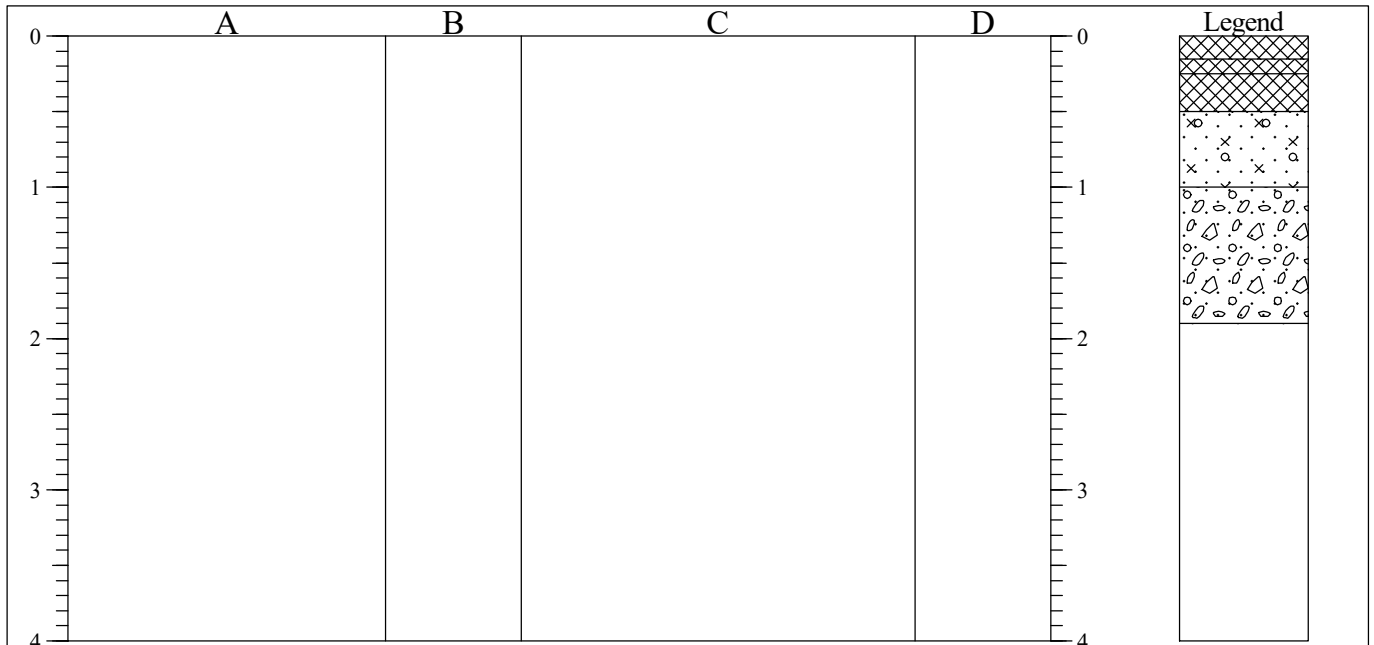
STRATA			SAMPLES & TESTS		
Depth	No	DESCRIPTION	Depth	No	Remarks/Tests
0.00-0.40		Grass over TOPSOIL: Dark brown very sandy CLAY. Frequent rootlets.			
0.40-0.90		Medium dense orangish brown occasionally greyish brown slightly gravelly fine to medium SAND. Gravel is sub angular to sub rounded of various lithologies.			
0.90-1.20		Medium dense dark orangish brown gravelly fine to medium SAND. Gravel is sub angular to sub rounded of various lithologies.			
1.20-1.90		Medium dense greyish brown silty very gravelly fine to medium SAND. Occasional cobble. Gravel is sub angular to sub rounded of various lithologies.			

Shoring/Support: Stability: Collapse below 1.20mbgl. 				GENERAL REMARKS Damp below 1.20mbgl. Slow groundwater ingress at base of pit.	
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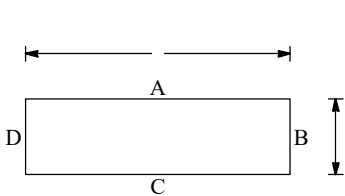
All dimensions in metres Scale 1:50	Client Miller Homes	Method/ Plant Used JCB 3CX	Logged By JS
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TRIAL PIT LOG

Project Northenden College, Northenden				TRIAL PIT No SA3
Job No 20MIL039	Date 18-01-21	Ground Level (m)	Co-Ordinates ()	
Contractor BETTS GEO Ltd				Sheet 1 of 1



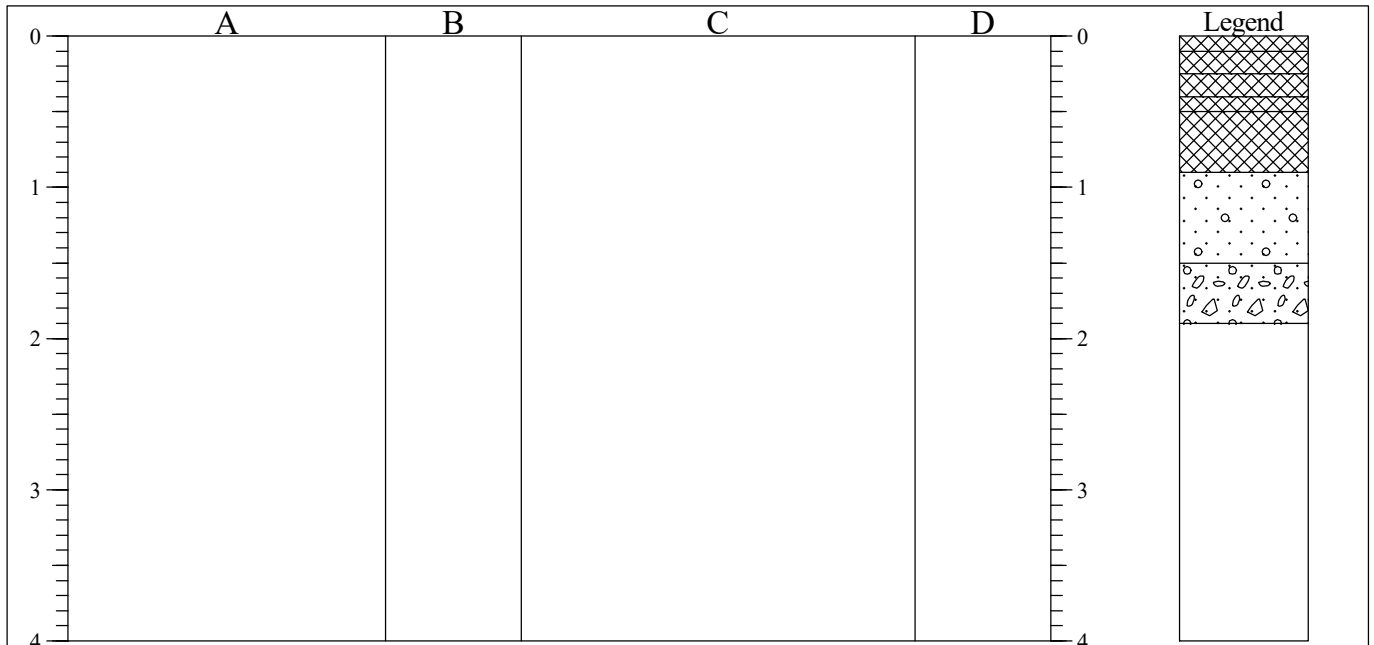
STRATA				SAMPLES & TESTS		
Depth	No	DESCRIPTION	Depth	No	Remarks/Tests	
0.00-0.15		MADE GROUND: Tarmac and sub base.				
0.15-0.25		MADE GROUND: Dark brown fine to coarse SAND. Occasional rootlets.				
0.25-0.50		Possible MADE GROUND: Medium dense orangish brown gravelly fine to medium SAND.				
0.50-1.00		Rare gravel of brick.				
		Medium dense orangish brown slightly silty very gravelly fine to coarse SAND. Gravel is sub angular to sub rounded of various lithologies.				
1.00-1.90		Loose to medium dense grey SAND & GRAVEL. Gravel is sub angular to sub rounded of various lithologies.				

Shoring/Support: Stability: Collapse below 0.50mbgl. 				GENERAL REMARKS Damp below 1.00mbgl. Very slow groundwater ingress at base.	
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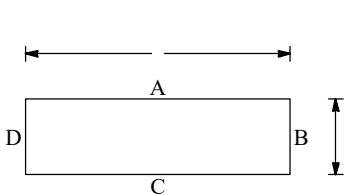
All dimensions in metres Scale 1:50	Client Miller Homes	Method/ Plant Used JCB 3CX	Logged By JS
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TRIAL PIT LOG

Project Northenden College, Northenden				TRIAL PIT No SA4
Job No 20MIL039	Date 19-01-21	Ground Level (m)	Co-Ordinates ()	
Contractor BETTS GEO Ltd				Sheet 1 of 1



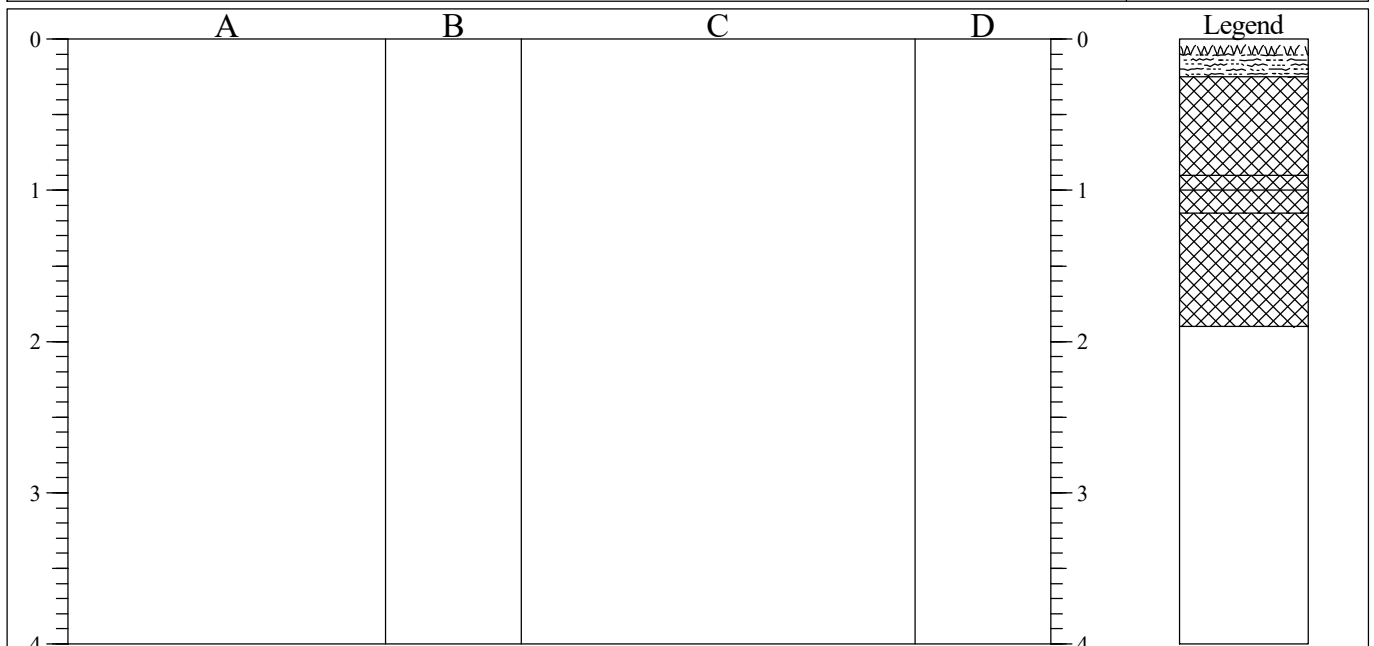
STRATA			SAMPLES & TESTS		
Depth	No	DESCRIPTION	Depth	No	Remarks/Tests
0.00-0.10		MADE GROUND: Tarmac.			
0.10-0.25		MADE GROUND: White SAND & GRAVEL sub base.			
0.25-0.40		MADE GROUND: Dark brown gravelly sandy CLAY. Frequent gravel and cobble of concrete.			
0.40-0.50		MADE GROUND: White SAND & GRAVEL sub base.			
0.50-0.90		MADE GROUND: Dark brown gravelly sandy CLAY. Frequent gravel and cobble of concrete.			
0.90-1.50		Medium dense orangish brown slightly gravelly fine to medium SAND. Gravel is sub angular to sub rounded of various lithologies.			
1.50-1.90		Medium dense pale brown silty fine to coarse SAND & GRAVEL. Gravel is sub angular to sub rounded of various lithologies.			

Shoring/Support: Stability: Collapse below 1.50mbgl. 				GENERAL REMARKS Seepages between 0.10mbgl - 0.25mbgl and 0.40mbgl - 0.50mbgl. Slow groundwater ingress at base of pit.	
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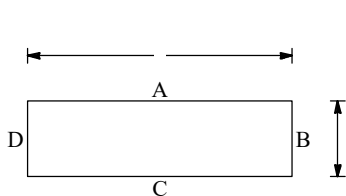
All dimensions in metres Scale 1:50	Client Miller Homes	Method/ Plant Used JCB 3CX	Logged By JS
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TRIAL PIT LOG

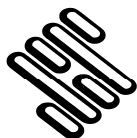
Project Northenden College, Northenden				TRIAL PIT No SA5
Job No 20MIL039	Date 19-01-21	Ground Level (m)	Co-Ordinates ()	
Contractor BETTS GEO Ltd				Sheet 1 of 1



STRATA				SAMPLES & TESTS		
Depth	No	DESCRIPTION	Depth	No	Remarks/Tests	
0.00-0.25		Grass over TOPSOIL: Dark brown sandy CLAY. Occasional rootlets.				
0.25-0.90		MADE GROUND: Brown cobblely very gravelly SAND. Occasional clay pockets. Frequent brick and concrete. Occasional whole bricks. Rare black rag.				
0.90-1.00		MADE GROUND: Black ashy SAND & GRAVEL.				
1.00-1.15		MADE GROUND: Concrete slab recovered as SAND & GRAVEL.				
1.15-1.90		Possible MADE GROUND: Reworked orangish brown with rare black bands slightly clayey very gravelly fine to medium SAND.				

Shoring/Support: Stability: Slightly unstable between 0.90mbgl - 1.00mbgl.		GENERAL REMARKS
		Dry.

All dimensions in metres Scale 1:50	Client Miller Homes	Method/ Plant Used JCB 3CX	Logged By JS
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STRUCTURAL SOILS LTD

INSITU TESTING REPORT



1774

Report No. 784808.R01(00)

Date 20-January-2021 Contract Northenden College

Client Betts Associates Limited

Address 6 Old Marsh Farm

Welsh Road

Sealand

Flintshire

CH5 2LY

For the Attention of Gina Smith

Order received 12-January-2021

Testing Started 18-January-2021

Testing Completed 19-January-2021

Client Reference

Client Order No. BG3976

Instruction Type Written

Tests marked 'Not UKAS Accredited' in this report are not included in the UKAS Accreditation Schedule for our Laboratory.

UKAS Accredited Tests

Not - UKAS Tests:

* 5 no. Soakaway Testing to BRE Digest 365

Please note that 3 fills in each pit was not achievable due to time constraints/ground conditions

The results represent the ground conditions at the specified locations and depths at the time of testing.

Please Note: Remaining samples will be retained for a period of one month from today and will then be disposed of.

Test were undertaken on samples 'as received' unless otherwise stated.

Opinions and interpretations expressed in this report are outside the scope of accreditation for this laboratory.

Structural Soils Ltd, The Potteries, Pottery Street, Castleford, WF10 1NJ Tel.01977552255. e-mail matthew.doran@soils.co.uk

TESTING VERIFICATION CERTIFICATE

The test results included in this report are certified as:-

ISSUE STATUS: **FINAL**

In accordance with the Structural Soils Ltd Laboratory Quality Management System, results sheets and summaries of results issued by the laboratory are checked by an approved signatory. The integrity of the test data and results are ensured by control of the computer system employed by the laboratory as part of the Software Verification Program as detailed in the Laboratory Quality Manual.

This testing verification certificate covers all testing compiled on or before the following datetime: **20/01/2021 10:28:51**.

Testing reported after this date is not covered by this Verification Certificate.



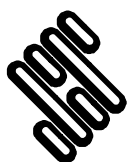
Approved Signatory
Matthew Doran (Deputy Site Testing Manager)

(Head Office)
Bristol Laboratory
Unit 1A, Princess Street
Bedminster
Bristol
BS3 4AG

Castleford Laboratory
The Potteries, Pottery Street
Castleford
West Yorkshire
WF10 1NJ

Hemel Laboratory
18 Frogmore Road
Hemel Hempstead
Hertfordshire
HP3 9RT

Tonbridge Laboratory
Anerley Court, Half Moon Lane
Hildenborough
Tonbridge
TN11 9HU



**STRUCTURAL
SOILS LTD**

Contract:

Northenden College

Job No:

784808

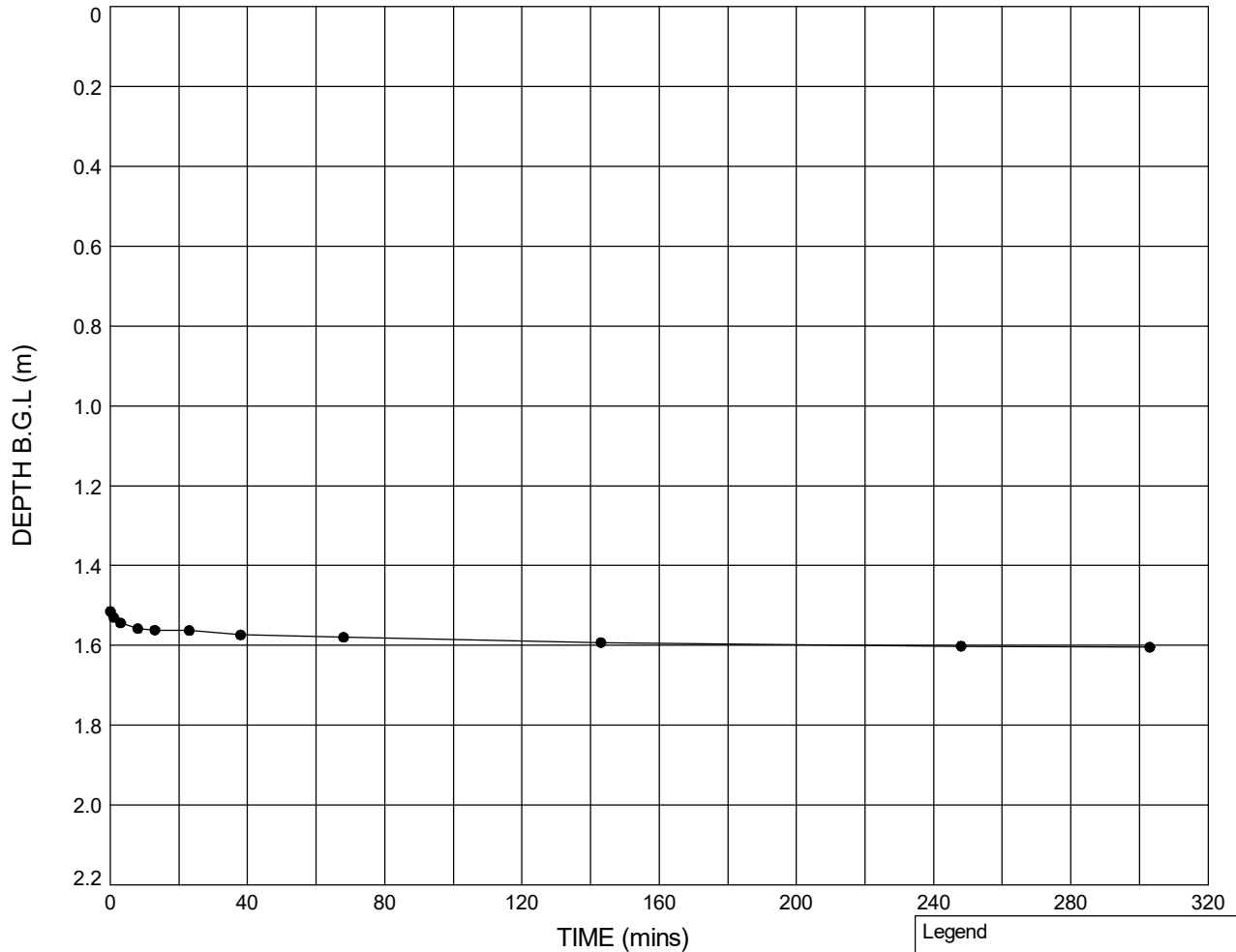


FULL SCALE SOAKAWAY TEST

Non-standard test

Soakaway Test - Position ID : **SA1**

PLOT OF DEPTH OF WATER BELOW GROUND LEVEL AGAINST TIME



Test 1

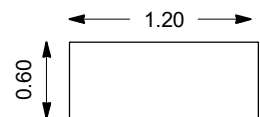
Pit start depth: = **2.10** m
 Pit final depth: = **2.05** m
 Effective depth, D_e = **0.54** m
 Effective storage volume, V_{p75-25} = **0.1926** m³
 Surface area, a_{p50} = **1.6830** m²
 Time, t_{p75-25} = **N/A** secs
 Infiltration rate, f = **N/A** m/s

Notes: Test 1 - Land Drain encountered at 1.5m. Water level start depth 1.030m. Total of 7 mins to reach 1.5m due to the Land drain.

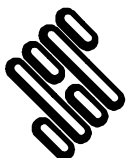
Legend

● Test 1 (18.01.21)

Plan (Not to scale)



No Bearing Taken



STRUCTURAL SOILS
 The Potteries
 Pottery Street
 Castleford
 W. Yorkshire WF10 1NJ

Compiled By

K. L. W. M. Acher

Date

20/01/21

Checked By

M. D. A. W.

Date

20/01/21

Contract

Northenden College

Contract Ref:

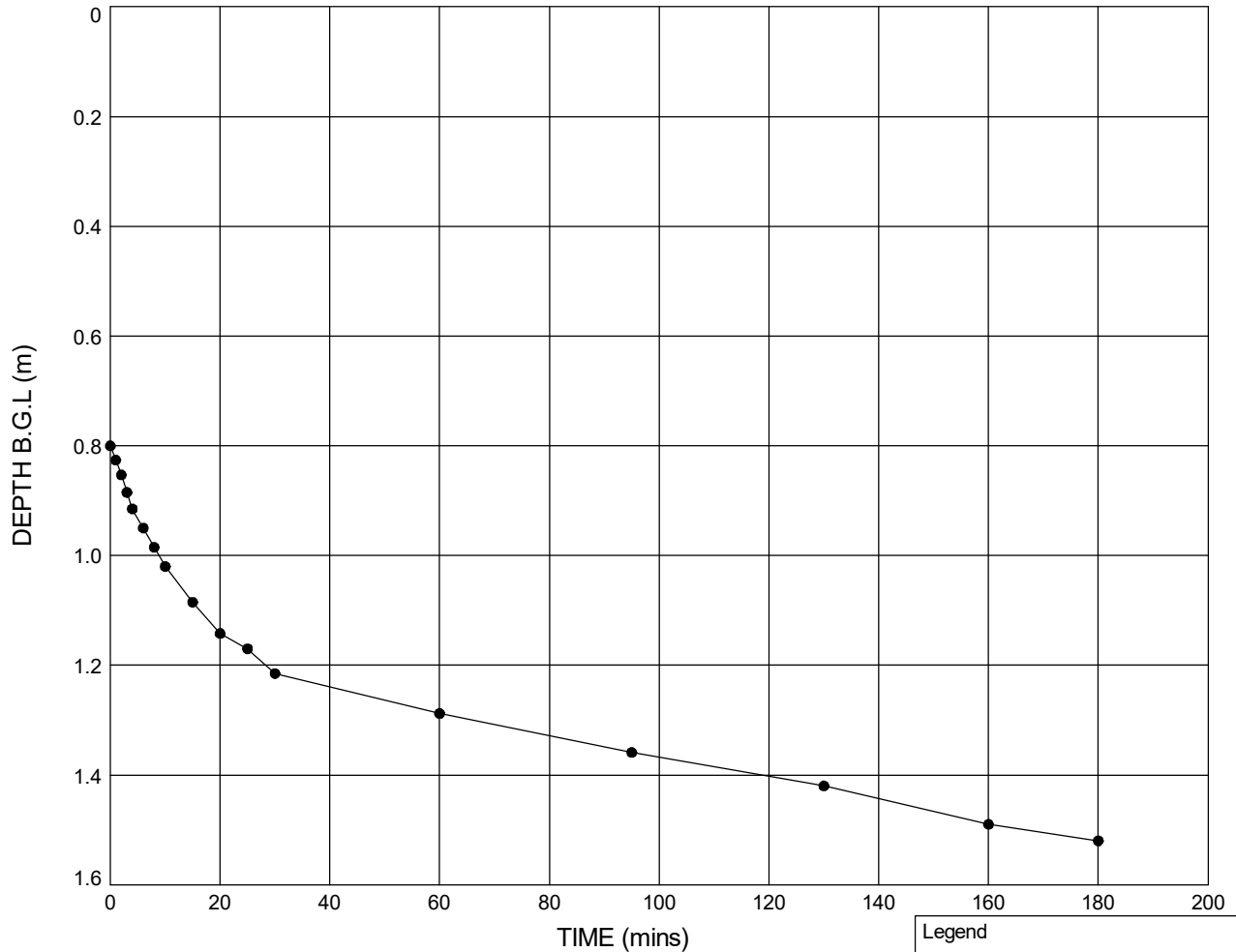
784808

FULL SCALE SOAKAWAY TEST

Non-standard test

Soakaway Test - Position ID : **SA2**

Plot of Depth of Water Below Ground Level Against Time



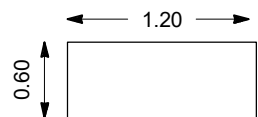
Test 1

Pit start depth: = **1.65** m
 Pit final depth: = **1.65** m
 Effective depth, D_e = **0.85** m
 Effective storage volume, V_{p75-25} = **0.3060** m³
 Surface area, a_{p50} = **2.2500** m²
 Time, t_{p75-25} = **7676** secs
 Infiltration rate, f = **1.77×10^{-5}** m/s

Legend

● Test 1 (18.01.21)

Plan (Not to scale)



No Bearing Taken



STRUCTURAL SOILS
 The Potteries
 Pottery Street
 Castleford
 W. Yorkshire WF10 1NJ

Compiled By

K. L. W. M. Acher

Date

20/01/21

Checked By

M. D. W. Acher

Date

20/01/21

Contract

Northenden College

Contract Ref:

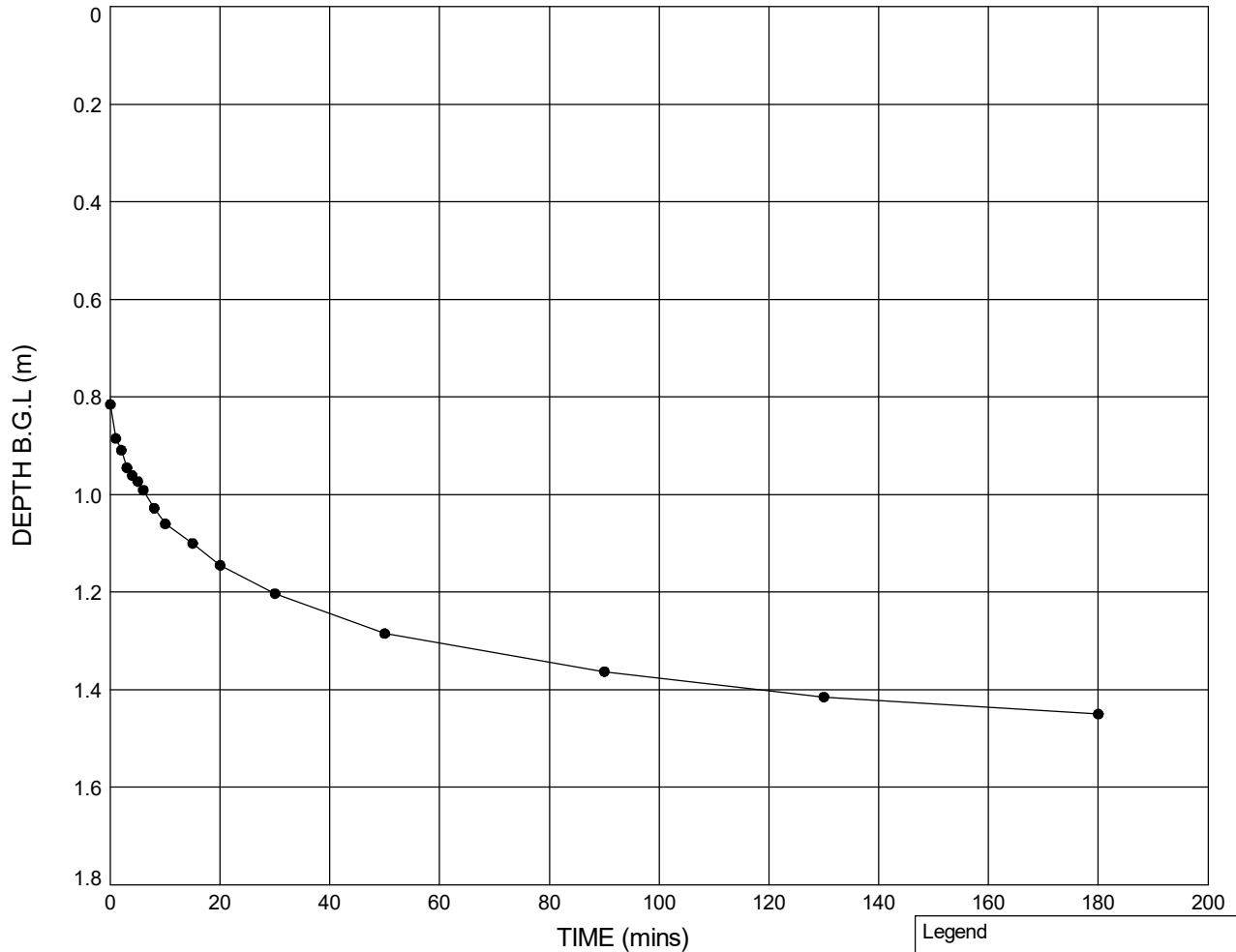
784808

FULL SCALE SOAKAWAY TEST

Non-standard test

Soakaway Test - Position ID : **SA3**

PLOT OF DEPTH OF WATER BELOW GROUND LEVEL AGAINST TIME



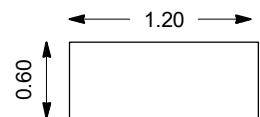
Test 1

Pit start depth: = **1.70** m
 Pit final depth: = **1.65** m
 Effective depth, D_e = **0.84** m
 Effective storage volume, V_{p75-25} = **0.3006** m³
 Surface area, a_{p50} = **2.2230** m²
 Time, t_{p75-25} = **9584** secs
 Infiltration rate, f = **1.41×10^{-5}** m/s

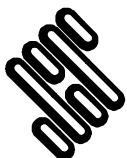
Legend

● Test 1 (18.01.21)

Plan (Not to scale)



No Bearing Taken



STRUCTURAL SOILS
 The Potteries
 Pottery Street
 Castleford
 W. Yorkshire WF10 1NJ

Compiled By

K. Flincher

Date

20/01/21

Checked By

M. Daw

Date

20/01/21

Contract

Northenden College

Contract Ref:

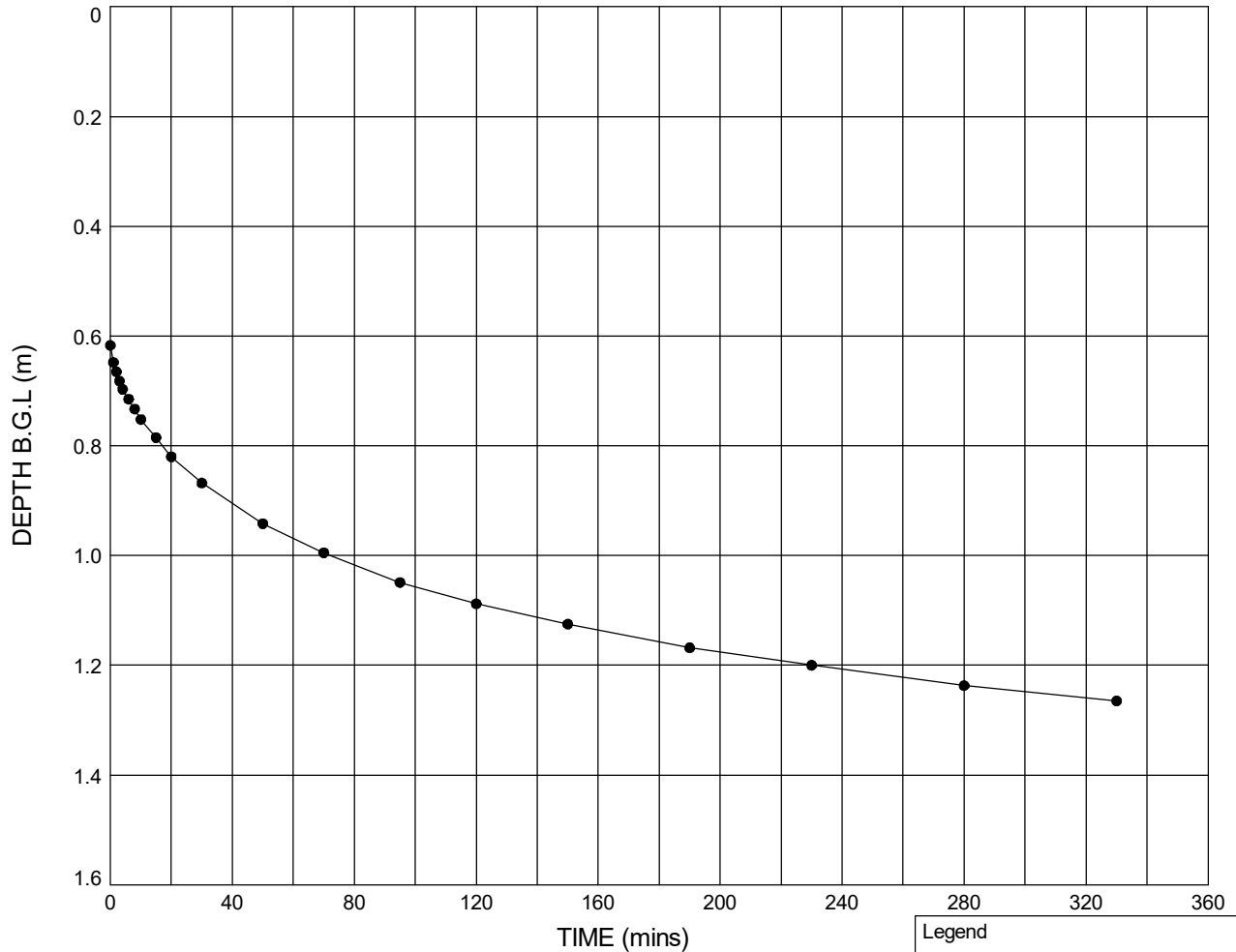
784808

FULL SCALE SOAKAWAY TEST

Non-standard test

Soakaway Test - Position ID : **SA4**

PLOT OF DEPTH OF WATER BELOW GROUND LEVEL AGAINST TIME



Test 1

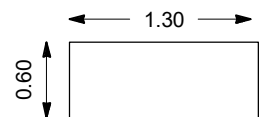
Pit start depth: = **1.55** m
 Pit final depth: = **1.55** m
 Effective depth, D_e = **0.93** m
 Effective storage volume, V_{p75-25} = **0.3639** m³
 Surface area, a_{p50} = **2.5527** m²
 Time, t_{p75-25} = **23767** secs
 Infiltration rate, f = **6.00×10^{-6}** m/s

Please note test data was extrapolated to obtain $t_{p75-tp25}$.

Legend

● Test 1 (19.01.21)

Plan (Not to scale)



No Bearing Taken



STRUCTURAL SOILS
 The Potteries
 Pottery Street
 Castleford
 W. Yorkshire WF10 1NJ

Compiled By

K. L. W. M. Acher

Date

20/01/21

Checked By

M. D. A. W.

Date

20/01/21

Contract

Northenden College

Contract Ref:

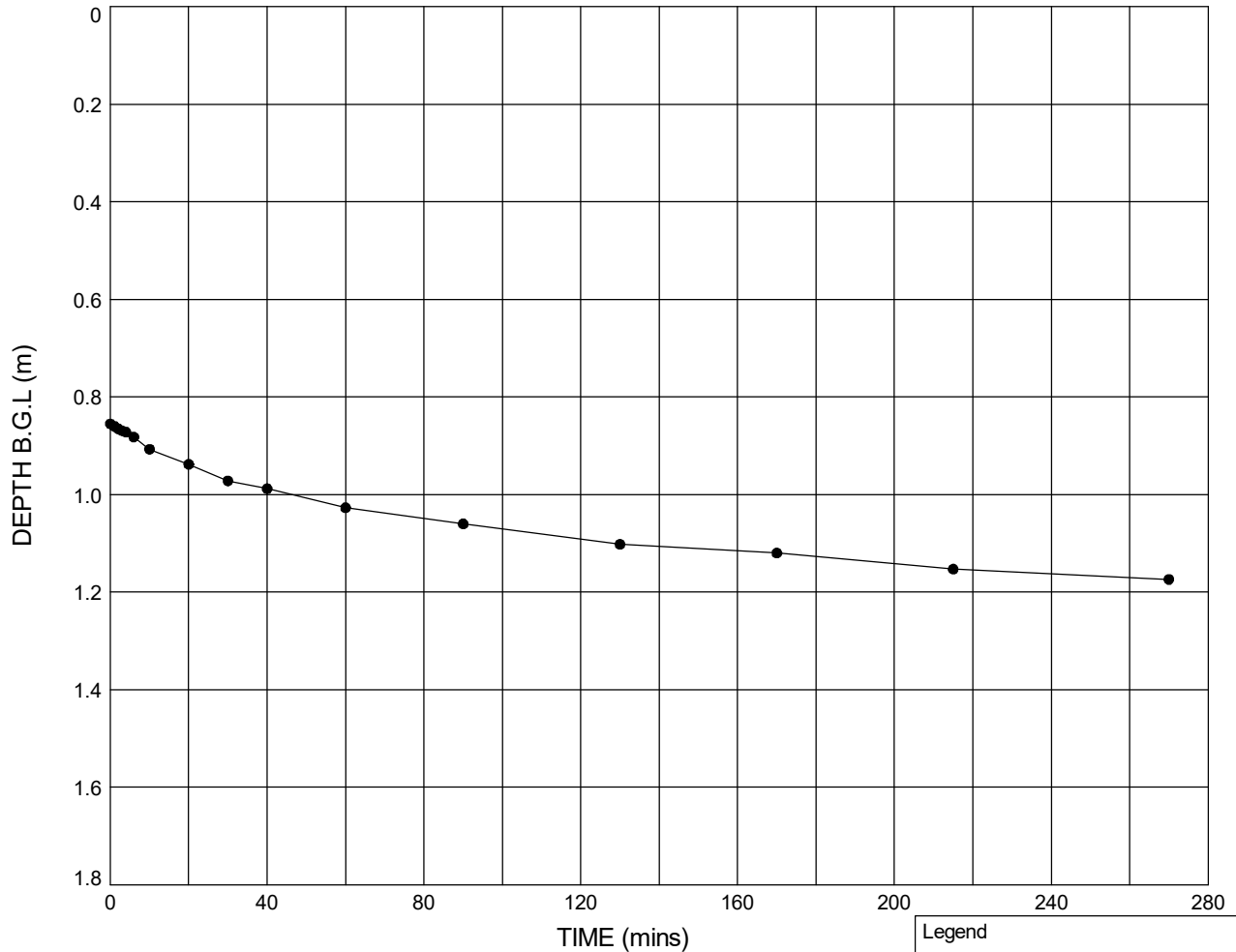
784808

FULL SCALE SOAKAWAY TEST

Non-standard test

Soakaway Test - Position ID : **SA5**

Plot of Depth of Water Below Ground Level Against Time



Test 1

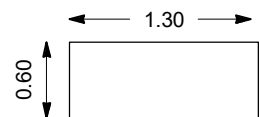
Pit start depth: = **1.70** m
 Pit final depth: = **1.70** m
 Effective depth, D_e = **0.85** m
 Effective storage volume, V_{p75-25} = **0.3296** m³
 Surface area, a_{p50} = **2.3855** m²
 Time, t_{p75-25} = **59904** secs
 Infiltration rate, f = **2.31×10^{-6}** m/s

Please note test data was extrapolated to obtain $t_{p75-t_{p25}}$.

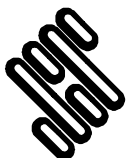
Legend

● Test 1 (19.01.21)

Plan (Not to scale)



No Bearing Taken



STRUCTURAL SOILS
 The Potteries
 Pottery Street
 Castleford
 W. Yorkshire WF10 1NJ

Compiled By

K. Flincher

Date

20/01/21

Checked By

M. Daw

Date

20/01/21

Contract

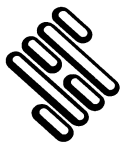
Northenden College

Contract Ref:

784808

APPENDIX D

(i) Contamination Test Results



STRUCTURAL SOILS LTD
TEST REPORT



Report No. 784805 R1

Date 20-January-2021 Contract 20/11100

Client Envirolab Ltd
Address Units 7 & 8 Sandpits Business Park
Mottram Road
Hyde
SK14 3AR

For the Attention of Holly Neary-King

Samples submitted by client 06/01/2021
Testing Started 08/01/2021
Testing Completed 14/01/2021

Client Reference 20/11100
Client Order No.
Instruction Type Written

Tests marked 'Not UKAS Accredited' in this report are not included in the UKAS Accreditation Schedule for our Laboratory.

UKAS Accredited Tests Undertaken

Moisture Content (oven drying method) BS1377:Part 2:1990,clause 3.2 (superseded) **
Liquid Limit (definitive method) BS1377:Part 2:1990,clause 4.3
Plastic Limit BS1377:Part 2:1990,clause 5.3
Plasticity Index Derivation BS1377:Part 2:1990,clause 5.4

* This clause of BS1377 is no longer the most up to date method due to the publication of ISO17892

Please Note: Remaining samples will be retained for a period of one month from today and will then be disposed of.
Test were undertaken on samples 'as received' unless otherwise stated.
Opinions and interpretations expressed in this report are outside the scope of accreditation for this laboratory.

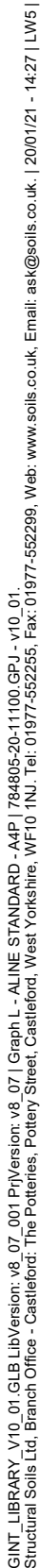
Structural Soils Ltd, The Potteries, Pottery Street, Castleford, WF10 1NJ Tel.01977 552255. E-mail luke.fisher@soils.co.uk

SUMMARY OF SOIL CLASSIFICATION TESTS

In accordance with clauses 3.2,4.3,4.4,5.3,5.4,7.2,8.2,8.3 of BS1377:Part 2:1990

Exploratory Position ID	Sample Ref	Sample Type	Depth (m)	Moisture Content %	Liquid Limit %	Plastic Limit %	Plasticity Index	% <425µm	Description of Sample
WS206	20/11100/7	D	2.50	16	31	13	18	86	Dark brown slightly sandy slightly gravelly CLAY

In accordance with BS5930:2015
Testing in accordance with BS1377-2:1990



TESTING VERIFICATION CERTIFICATE



1774

The test results included in this report are certified as:-

ISSUE STATUS: **FINAL**

In accordance with the Structural Soils Ltd Laboratory Quality Management System, results sheets and summaries of results issued by the laboratory are checked by an approved signatory. The integrity of the test data and results are ensured by control of the computer system employed by the laboratory as part of the Software Verification Program as detailed in the Laboratory Quality Manual.

This testing verification certificate covers all testing compiled on or before the following datetime: **20/01/2021 15:01:48**.

Testing reported after this date is not covered by this Verification Certificate.

Approved Signatory
Daniel Smith (Contract Manager)

(Head Office)
Bristol Laboratory
Unit 1A, Princess Street
Bedminster
Bristol
BS3 4AG

Castleford Laboratory
The Potteries, Pottery Street
Castleford
West Yorkshire
WF10 1NJ

Hemel Laboratory
18 Frogmore Road
Hemel Hempstead
Hertfordshire
HP3 9RT

Tonbridge Laboratory
Anerley Court, Half Moon Lane
Hildenborough
Tonbridge
TN11 9HU



**STRUCTURAL
SOILS LTD**

Contract:

20/11100

Job No:

784805



Page 1 of 1

Inventory of samples 20/11/20

Inventory of samples 20/11/20

Inventory of samples 20/11/20

Sample ID	20/11/20/1	20/11/20/2	20/11/20/3	20/11/20/4	20/11/20/5	20/11/20/6	20/11/20/7	Unit	Detection	Method
Sample ID										
Sample ID	201	201	202	203	204	205	206			
Depth (m)	0.0	1.0	0.0	0.0	0.0	0.0	2.0			
Depth (m)										
Date of collection	1 Dec 20	1 Dec 20	1 Dec 20	1 Dec 20	1 Dec 20	1 Dec 20	1 Dec 20			
Sample type	Water	Water	Water	Water	Water	Water	Water			
Sample Matrix code	1	1	1	1	1	1	1			
Temperature (°C)	10	10	10	10	20	10	0.1	g/L	0.1	0.01
pH	10	10	10	10	20	12	20	pH	0.01	0.01
Dissolved oxygen (mg/L)	0.0	0.0	0.0	0.10	0.01	0.0	0.01	g/L	0.01	0.02
Organic matter (M)	10	10	0	2	2.1	2	1	g/L	0.1	0.02 M
Chlorophyll (M)	1	1	1	1	1	1	1	g/L	1	0.02
Adipic acid (M)	0	0	0	0	0	1	1	g/L	0	0.02
Protein (M)	21	2	2	1	2	2	1	g/L	1	0.02
Crystallinity (M)	1	1	1	1	1	1	1	g/L	1	0.0
Lead (M)	1	21	20	1	0	10	1	g/L	1	0.02
Mercury (M)	1	0	0.2	0.2	0	0	1	g/L	0.1	0.02
Chloride (M)	1	1	1	1	1	12	1	g/L	1	0.02
Benzoic acid (M)	1	1	1	1	1	1	1	g/L	1	0.02
Iron (M)	1	1	0	1	1	1	1	g/L	1	0.02
Total suspended solids (mg/L)	1	2	1	1	1	1	1	g/L	1	0.02
1.02 Nitrogen (mg/L)	1	1	1	1	1	1	1	ppended	1	0.01
1.01 Manganese (mg/L)	1	1	1	1	1	1	1	ppended	1	0.01

inrichting 0000 0000 0000 20/11100

identificatie 0000 0000 0000 0000 0000 0000 0000 0000

identificatie 0000 20M 0000

0000 0000 0000 0000 0000 0000 0000 0000	20/11100/1	20/11100/2	20/11100/3	20/11100/4	20/11100/5	20/11100/6	20/11100/7	0000	0000 0000 0000	0000 0000 0000
identificatie 0000										
identificatie 0000 0000	0000 201	0000 201	0000 202	0000 203	0000 204	0000 205	0000 206			
Dept 0000 0000	0000	1000	0000	0000	0000	0000	0000			
Dept 0000 0000 0000										
Date 0000 0000	1000 Dec 20	1000 Dec 20	1000 Dec 20	1000 Dec 20	1000 Dec 20	1000 Dec 20	1000 Dec 20			
0000 0000 type	00000000	00000000	00000000	00000000	00000000	00000000	00000000			
0000 0000 Matr 0000 0000	0000	0000	0000	0000	0000	0000	0000			
0000 0000 0000 0000 0000 0000 0000										
0000 0000 0000 0000	0000 D	0000 D	0000 D	0000 D	0000 D	0000 D	0000 D			0000 0000
0000 0000 0000 0000 0000 0000 0000 0000 0000 0000	00/00	00/00	00/00	00/00	00/00	00/00	00/00			0000 0000

Environa ou der20/1100

Ent reet a e r t enden

Ent reet e 20M 0

Ca a p e ID	20/1100/1	20/1100/2	20/1100/3	20/1100/4	20/1100/5	20/1100/6	20/1100/7	n	t t Det t n	Met d re
Ent a a p e										
Ent a a p e ID	201	201	202	20	20	20	20			
Dept t o p	00	110	00	00	00	00	20			
Dept o o t t										
Date a a p ed	1 De 20	1 De 20	1 De 20	1 De 20	1 De 20	1 De 20	1 De 20			
a a p e type										
a a p e Matr o o de										
o o 1 M										
enap t ene M	001	002	001	00	00	00		g/g	001	001
enap t y ene M	001	001	001	002	002	001		g/g	001	001
nt ra ene M	002	00	002	012	001	001		g/g	002	001
en a ant ra ene M	00	01	00	00	100	100		g/g	00	001
en a pyrene M	00	021	00	00	100	100		g/g	00	001
en u rant ene M	00	02	00	000	100	100		g/g	00	001
en g pery ene M	000	012	000	02	001	002		g/g	00	001
en u rant ene M	000	010	000	02	00	000		g/g	00	001
ry ene M	00	021	000	00	100	202		g/g	00	001
De en a ant ra ene M	000	000	000	00	01	01		g/g	00	001
u rant ene M	010	00	000	002	000	00		g/g	00	001
u rene M	001	001	001	00	00	00		g/g	001	001
nden 12 d pyrene M	000	012	00	02	00	00		g/g	00	001
ap t a ene M	000	000	000	000	000	00		g/g	00	001
enant rene M	00	01	00	00	00	22		g/g	00	001
yrene M	00	00	00	00	02	00		g/g	00	001
ta o o 1 M M	000	21	00	00	100	21		g/g	001	001

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aa p e ID	20/1100/1	20/1100/2	20/1100/	20/1100/	20/1100/	20/1100/	20/1100/	n	t t Deten	Met d re
Ent aa p e										
Ent aa p e ID	201	201	202	20	20	20	20			
Dept t p	00	10	00	00	00	00	20			
Dept p t t										
Date a p ed	1 De 20	1 De 20	1 De 20	1 De 20	1 De 20	1 De 20	1 De 20			
aa p e type										
aa p e Matr ode										
	001	001	001	001	001	001		g/g	001	022
	001	001	001	001	001	001		g/g	001	022
10	1	1	1	1	1	1		g/g	1	000
10 12 M	1	1	1	1	1	1		g/g	1	000
12 1 M	1	1	1	1	1	1		g/g	1	000
1 21 M	1	2	1	1	1	1		g/g	1	000
21 M	1	2				11		g/g	1	000
cta p at	1	0				12		g/g	1	000
r 0	001	001	001	001	001	001		g/g	001	022
r 0	001	001	001	001	001	001		g/g	001	022
r 10	1	2	1	1	1	1		g/g	1	000
r 10 12	1	1	1	1	1	1		g/g	1	000
r 12 1	1	2	1		2			g/g	1	000
r 1 21 M	2		1	2				g/g	1	000
r 21 M	1	1			2	11		g/g	1	000
cta r at	22	2		102		1		g/g	1	000
00 000 r 000000			12	111		1		g/g	1	000
0000 en ene	001	001	001	001	001	001		g/g	001	022
0000 uene	001	001	001	001	001	001		g/g	001	022
0000 cty en ene	001	001	001	001	001	001		g/g	001	022
0000 p y ene	001	001	001	001	001	001		g/g	001	022
0000 y ene	001	001	001	001	001	001		g/g	001	022
M	001	001	001	001	001	001		g/g	001	022

Inventory of samples 20/11/20

Inventory of samples 20/11/20

Inventory of samples 20/11/20

Sample ID	20/11/20/1	20/11/20/2	20/11/20/10	20/11/20/11	20/11/20/12	20/11/20/13	20/11/20/14	Unit	Detection	Method
Sample ID										
Sample ID	20	20	20	20	210	211	1			
Depth (m)	0.0	0.0	0.0	0.0	0.0	0.0	0.0			
Depth (m)										
Date of collection	1 Dec 20	1 Dec 20	1 Dec 20	1 Dec 20	1 Dec 20	1 Dec 20	1 Dec 20			
Sample type										
Sample Matrix code	2		2	2	2		2			
Concentration (mg/L)	2	0.1	11	12	1.2	0.1	2.0	g/L	0.1	0.0
pH		2					1	pH	0.01	0.1
Water content (2.1 mg)	0.01	0.01	0.10	0.01	0.01	0.01	0.01	g/L	0.01	0.02
Organic matter (M)		1			2.0	1.1	2.0	g/L	0.1	0.2 M
Concentration (M)	1				11			g/g	1	0.02
Radon (M)	0.0	1.0	0.0	1.0	0.0	1.2	0.0	g/g	0.0	0.02
Upper (M)		1	2	2	2	1	1	g/g	1	0.02
Concentration of elements	1	1	1	1	1	1	1	g/g	1	0.0
Lead (M)	1				111			g/g	1	0.02
Mercury	0.2	0.1	0.1	0.0	0.2	1.0	0.0	g/g	0.1	0.02
Concentration (M)			11		11			g/g	1	0.02
Concentration (M)	1	1	1	1	1	1	1	g/g	1	0.02
Concentration (M)	12	1			210	2		g/g		0.02
Total concentration (10)	1	1	1	1	1	1	1	g/g	1	0.0

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Sample ID	20/11100/	20/11100/	20/11100/10	20/11100/11	20/11100/12	20/11100/1	20/11100/1	Int	t Detection	Method re
ent Sample										
ent Sample ID	20	20	20	20	210	211	1			
Depth to top	00	00	00	00	00	00	00			
Depth to bottom										
Date sampled	1Dec20	1Dec20	1Dec20	1Dec20	1Dec20	1Dec20	1Dec20			
Sample type										
Sample Matrix code	2		2	2	2		2			
ent in atr										
ent in	D	D	D	D	D	rytie	D			00
ent Matrix type						re re				00
ent M utate rater rptn test	/	/	/	/	/	/	/			00
ent in quantitation and gng										
ent in position and png and gng						0.001		/	0.001	00

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Chemical Name	20/11/2000	20/11/2001	20/11/2002	20/11/2003	20/11/2004	20/11/2005	20/11/2006	Unit	Detection	Method
Chemical Name										
Chemical Name	20	20	20	20	210	211	1			
Department	00	00	00	00	00	00	00			
Department										
Date of Purchase	1 Dec 20	1 Dec 20	1 Dec 20	1 Dec 20	1 Dec 20	1 Dec 20	1 Dec 20			
Chemical Type	000000	000000	000000	000000	000000	000000	000000			
Chemical Matrix Code	2		2	2	2		2			
000001M										
000001M	0001	0001	000	000	000	000	002	g/g	001	0001
000001M	0001	0001	000	000	0001	0001	0001	g/g	001	0001
000001M	0002	0002	020	010	020	010	000	g/g	002	0001
000001M	000	000	000	000	000	000	010	g/g	000	0001
000001M	000	000	100	000	000	020	022	g/g	000	0001
000001M	000	000	110	000	020	000	020	g/g	000	0001
000001M	000	000	020	020	010	020	011	g/g	000	0001
000001M	000	000	000	020	010	020	011	g/g	000	0001
000001M	000	000	000	000	020	000	020	g/g	000	0001
000001M	000	000	010	000	000	000	000	g/g	000	0001
000001M	010	000	100	100	100	000	000	g/g	000	0001
000001M	0001	0001	000	000	000	000	002	g/g	001	0001
000001M	000	000	020	020	010	020	011	g/g	000	0001
000001M	000	000	000	000	010	000	000	g/g	000	0001
000001M	000	000	020	000	000	000	022	g/g	000	0001
000001M	010	000	100	100	000	020	010	g/g	000	0001
000001M	000	012	000	010	000	000	200	g/g	001	0001

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aa pe ID	20/1100/	20/1100/	20/1100/10	20/1100/11	20/1100/12	20/1100/1	20/1100/1	n	t Deten	Metd re
ent aa pe										
ent aa pe ID	20	20	20	20	210	211	1			
Dept to pp	00	00	00	00	00	00	00			
Dept ou ott										
Date aa ped	1De20	1De20	1De20	1De20	1De20	1De20	1De20			
aa pe type										
aa pe Matr ode	2		2	2	2		2			
	001	001	001	001	001	001	001	g/g	001	022
	001	001	001	001	001	001	001	g/g	001	022
10	1	1	1	1	1	1	1	g/g	1	000
1012M	1	1	1	1	1	1	1	g/g	1	000
121M	1	1	1	1	1	1	1	g/g	1	000
121M	1	1	2	1	1	1	1	g/g	1	000
21M		1	12	1		10	1	g/g	1	000
cta p at		1	11	1		11	1	g/g	1	000
ra	001	001	001	001	001	001	001	g/g	001	022
ra	001	001	001	001	001	001	001	g/g	001	022
ra 10	1	1	1	1	1	1	1	g/g	1	000
ra 1012	1	1	1	1	1	1	1	g/g	1	000
ra 121	1	1	2	2		2	2	g/g	1	000
ra 121M	1	1	11		1			g/g	1	000
ra 21M		2	11		0	0	2	g/g	1	000
cta r at		2	1			1		g/g	1	000
ra r			2	1				g/g	1	000
en ene	001	001	001	001	001	001	001	g/g	001	022
ene	001	001	001	001	001	001	001	g/g	001	022
cty en ene	001	001	001	001	001	001	001	g/g	001	022
p y ene	001	001	001	001	001	001	001	g/g	001	022
y ene	001	001	001	001	001	001	001	g/g	001	022
M	001	001	001	001	001	001	001	g/g	001	022

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tent direct e 20M00

aanpak ID	20/1100/1	20/1100/1	20/1100/1							
tent aanpak										
tent aanpak ID	2		20							
Dept t p	00	00	00							
Dept o o t t										
Date a p ed	1 De 20	1 De 20	1 De 20							
a p e type										
a p e Matr o de	2	2								
o t t e 10	1	01	11							
p o	2		22							
u p a t e a t e r 21 o	001	001	002							
o r g a n o a t t e r o	2	1	0							
o r e n o			1							
a d u o	0	0	0							
o p p e r o	20	1								
o r o u o e a a e n t o	1	1	1							
a d o	1									
M e r c u r y o	00	01	01							
o e e o	10									
e e n u o	1	1	1							
n o		1	11							
o t t a 10	1	1	1							

Project Number 20/11100

Project Name: ...

Project Reference: 20M000

Sample ID	20/11100/1	20/11100/1	20/11100/1							
Parent Sample										
Parent Sample ID	2		20							
Depth to top	0.0	0.0	0.0							
Depth to bottom										
Date sampled	1 Dec 20	1 Dec 20	1 Dec 20							
Sample type										
Sample Matrix code	2	2								
Location in ...										
Location in ...	D	ry ...	D							0.0
Location Matrix ...		...e ...								0.0
Location M ...	/	/	/							0.0
Location ...										
Location in ...										
Location in ...		0.001							0.001	0.0

Project Number 20/11100

Project Name ependen

Project Code 20M00

Sample ID	20/11100/1	20/11100/1	20/11100/1					Unit	Detection	Method ref
Parent Sample										
Parent Sample ID	2		20							
Depth top	0.0	0.0	0.0							
Depth bottom										
Date sampled	1 Dec 20	1 Dec 20	1 Dec 20							
Sample type	sediment	sediment	sediment							
Sample Matrix code	2	2								
1-M										
benz[a]anthracene _M	0.0	0.0	0.01					g/g	0.01	0.01
benz[b]fluoranthene _M	0.01	0.01	0.01					g/g	0.01	0.01
benz[e]pyrene _M	0.1	0.0	0.02					g/g	0.02	0.01
benz[a]anthracene _M	0.0	0.2	0.0					g/g	0.0	0.01
benz[a]pyrene _M	0.2	0.0	0.0					g/g	0.0	0.01
benz[a]anthracene _M	0.0	0.1	0.0					g/g	0.0	0.01
benz[a]gerylene _M	0.2	0.1	0.0					g/g	0.0	0.01
benz[a]anthracene _M	0.22	0.1	0.0					g/g	0.0	0.01
erylene _M	0.0	0.0	0.0					g/g	0.0	0.01
Dibenz[a,h]anthracene _M	0.0	0.0	0.0					g/g	0.0	0.01
fluoranthene _M	1.1	0.2	0.0					g/g	0.0	0.01
fluorene _M	0.0	0.02	0.01					g/g	0.01	0.01
indeno[1,2,3-cd]pyrene _M	0.2	0.1	0.0					g/g	0.0	0.01
ap[?]anthracene _M	0.0	0.0	0.0					g/g	0.0	0.01
enantrene _M	0.0	0.2	0.0					g/g	0.0	0.01
pyrene _M	1.1	0.1	0.0					g/g	0.0	0.01
ta[?]anthracene _M	0.1	0.0	0.0					g/g	0.01	0.01

Project Name: 20/11100

Project Description: 20M00

Sample ID	20/11100/1	20/11100/1	20/11100/1							
Sample Name										
Sample ID	2		20							
Depth	0.0	0.0	0.0							
Depth										
Date	1 Dec 20	1 Dec 20	1 Dec 20							
Sample Type										
Sample Matrix Code	2	2								
	0.01	0.01	0.01					g/g	0.01	0.022
	0.01	0.01	0.01					g/g	0.01	0.022
10	1	1	1					g/g	1	0.000
10 12 M	1	1	1					g/g	1	0.000
12 1 M	1	1	1					g/g	1	0.000
1 21 M	1	1	1					g/g	1	0.000
21 M			1					g/g	1	0.000
Octaplat			1					g/g	1	0.000
0.01	0.01	0.01	0.01					g/g	0.01	0.022
0.01	0.01	0.01	0.01					g/g	0.01	0.022
10	1	1	1					g/g	1	0.000
10 12	2	1	1					g/g	1	0.000
12 1		1	1					g/g	1	0.000
1 21 M			1					g/g	1	0.000
21 M	10	2	1					g/g	1	0.000
Octaplat	1		1					g/g	1	0.000
1	1		1					g/g	1	0.000
ene	0.01	0.01	0.01					g/g	0.01	0.022
ene	0.01	0.01	0.01					g/g	0.01	0.022
octyene	0.01	0.01	0.01					g/g	0.01	0.022
p yene	0.01	0.01	0.01					g/g	0.01	0.022
yene	0.01	0.01	0.01					g/g	0.01	0.022
M	0.01	0.01	0.01					g/g	0.01	0.022

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The results reported here are related to the material involved in the laboratory.

The residue can also be obtained from the report and also received in the case delivery will be delivered once seen after initial condition. For a case tested for content the will retain a certain number of dried residue for a period of time after the initial test to test if the deleted.

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The left table and the right table represent the same data and are all provided in the left.

Case analysis

All results are reported as direct effects.

Our analysis of the lateral time course and rate of lateral volume loss in the rat brain revealed that the lateral volume loss in the rat brain is related to the lateral volume loss in the rat brain. The lateral volume loss in the rat brain is related to the lateral volume loss in the rat brain.

For samples with Matrix Code 7 the whole sample is dried and crushed prior to analysis and this supersedes any "A" subscripts

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ana_y ater y et_d 00

Free and variable are encoded in the code as a pair of bits that the reported result represents the derived value of.

Electroactivity Water by Method 0

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et

The defendant is a married man, aged 40, who is a resident of the defendant's home. The defendant is a resident of the defendant's home. The defendant is a resident of the defendant's home.

These are the relevant to the article or not at all.

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 r a a d a d e r a l l t e a e t r e t a r e r e a t a t e e t e r r e d

Where $\square\square$ M are $\square\square$ d a e r e t a e a e t $\square\square$ a $\square\square$ d t e a $\square\square$ t i r e r e t e $\square\square$ $\square\square\square\square\square\square$ e t $\square\square$ T e $\square$ r v e $\square\square$ d e a d t e $\square$ a l l a t e d a e t $\square\square$ t e t e r e d a a e r e t a e t e d r e d $\square\square$ a a l e a t t e d.

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Monday, March 11, 2019 1:00 PM

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Secondary Matrix Mode

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Project No: 20/11100
Date Received: 21/12/2020 (am)
Cool Box Temperatures (°C): 9.3, 8.9

Project: Northenden
Clients Project No: 20MIL039

that at a given time there really is the latent variable temperature of the candle as readed to the set of standard deviation. The standard deviation of the latent variable is a function of the standard deviation of the observed variable.

APPENDIX E

(i) Geotechnical Test Results

APPENDIX F

(i) Gas Monitoring Data

APPENDIX G

(i) Conceptual Model

The report aims to identify land which could potentially be affected by contamination, such that it could affect the value or re-use of the land, or such that mitigation would be required for certain proposed end uses of the land.

The assessment also aims to identify land which would be regarded as 'contaminated land' under the terms of the Environmental Protection Act 1990, Part IIa. This act includes a stricter test for contaminated land than that outlined above. Land is considered to be contaminated if either:

- the land is causing significant harm to people, ecosystems or infrastructure; or
- there is a significant possibility that such harm could be caused; or
- Pollution of controlled waters is being, or is likely to be, caused.

The following situations are defined as being where harm is to be regarded as significant:

- chronic or quite toxic effect, serious injury or death to humans;
- irreversible or other adverse harm to the ecological system;
- substantial damage to or failure of buildings;
- death of, or disease or other physical damage affecting, livestock or crops;
- Pollution of controlled waters.

The risk assessment uses a 'Source-Pathway-Receptor' methodology for assessing whether a source of contamination could potentially lead to harmful consequences. This means that there needs to be a pollutant linkage from source to receptor for harm to be caused, this linkage consisting of:

- a source of pollution;
- a pathway for the pollutant to move along;
- A receptor that is affected by the pollutant.

As an example, the pollutant source could be an identified leak of oil or an area of dumped waste.



The pathways could include transport of the contaminant by groundwater, surface water, windblown dust, or vapours, and for human receptors will include the means, by which contaminants enter the body, for example skin contact, ingestion and inhalation.

Receptors include people, other living organisms, the built environment and groundwater and surface waters (these latter two also being contaminant pathways).

The source-pathway-receptor methodology relationship allows an assessment of the environmental risk to be determined, based on the nature of the source, the degree of exposure of the receptor to the source and the sensitivity of the receptor.

This section of the report is based on the information set out in the previous sections of the report and should not be read independently of such sections.

Initial Conceptual Model

From the available information the preliminary conceptual model is visualised as follows:

Target (Receptor)	POTENTIAL SOURCE-PATHWAY LINKAGE
Site Users / Residents	Inhalation of soil gas, odours or dust.
	Ingestion of, and skin contact with, contaminated soil.
	Ingestion of contaminants in vegetables etc. or in soils adhering to vegetables, etc.
Construction/ Maintenance Workers.	Inhalation of soil gas, odours or dust
	Ingestion of, and skin contact with, contaminated soil
Plants	Adverse effects on growth caused by presence of contaminants in soil
Buildings and Structures	Flow of ground gas into buildings. Asphyxiation, toxicity, explosion and fire hazards
	Sulphate attack of foundations
	Hydrocarbons penetrating plastic water supply pipes
Groundwater	Migration of soluble contaminants into groundwater on or off site. Migration of oils into groundwater on or off site.
Surface Water	Migration of soluble contaminants and/or direct run-off of contaminants. Migration of oils into groundwater on or off site.

Initial Environmental Risk Assessment

General

It is accepted that an environmental risk assessment can be based on a source-pathway-target model. An examination is carried out as to whether a target will be at risk from a contamination source, that a source exists, and whether there are any pathways (routes of exposure) which might actually link the source to the target.

Environmental risk assessments rely heavily on numerical trigger concentrations or guidelines because exposure of targets to contamination is difficult to quantify directly. Quantification of risk is therefore mainly undertaken for general scenarios in order to derive trigger levels. These are derived for various contaminants for particular targets and routes of exposure. An example of a sensitive target would be users of a domestic back garden, where routes of exposure might be skin contact, dust inhalation, direct ingestion and indirect ingestion via cultivation and consumption of fruit and vegetables.

In March 2002, the first parts of the new CLEA risk assessment guidance were released by DEFRA/Environment Agency.

The risk assessment approach is an extension of the 'fit for use' concept whereby land is cleaned up to a standard fit for the proposed use, that is, so all remaining risks are acceptable. However, as well as being 'fit for use', the environmental risk assessment approach also addresses the soil and water environment so that these are also safeguarded where necessary. For example if a site was contaminated with heavy metals and the development comprised the proposed construction of hard standings and buildings only, the fit-for-use approach might require no remediation for the site. However, consideration of the wider environment needs to address whether groundwater is being contaminated, and if so whether remediation is required for this reason.

The following classification presented by CIRIA has been used in the assessment of risk:

Estimation of risk from consideration of magnitude, consequences and probabilities				
Probability	Consequences			
	Severe	Moderate	Mild	Minor
High	Very high	High	Moderate	Moderate / Low
Medium	High	Moderate	Moderate / Low	Low
Low	Moderate	Moderate / Low	Low	Very Low
Unlikely	Moderate / Low	Low	Very Low	Very Low

Reference: Contaminated Land Risk Management; A Guide to Good Practice, CIRIA C552:2001.

CIRIA C665 Situation A Ground Gas Conceptual Model

The risk table contained in C665 is basically a modified risk assessment from CIRIA 152 1995, by which a conceptual model and semi-quantitative risk assessment can be made.

APPENDIX J

(i) Notes on Ground Gas

Ground Gas

The Building Regulations and BRE Report 212 state that precautions are not mandatory against carbon dioxide unless 5.0% volume is exceeded. These documents do not give a threshold level for methane, but Baker suggests that this level is 0.1% volume. For methane up to 1.0% volume, and carbon dioxide above 5.0% volume, the Building Regulations and BRE Report state that passive measures may be adopted. Above 1.0% methane further specific guidance must be sought.

CIRIA Report 149 gives further guidance on the appropriate precautions for various gas regimes, called characteristic situations in this report. In the DETR Guide for Design by Ove Arup, various types of passive measures are assessed for performance with different gas regimes. The assessments used computational fluid dynamic (CFD) modelling.

A gas regime is essentially defined by two parameters:

- i) The concentration of the gas (e.g. % methane)
- ii) The emission rate of the gas from the ground.

The fact that two parameters are used is problematic if the site is to be classified on the basis of Table 28 in CIRIA Report 149. This is because high gas concentrations are often encountered which fall into an onerous gas regime; whereas the low flow rates which are also frequently encountered fall into less onerous gas regimes.

In order to use the Guide for Design to decide if passive measures are suitable, it is necessary to combine the gas concentration and the emission rate.

Three recent publications are used for ground gas risk assessment:

- CIRIA C665 (2007) for high rise residential / flats,
- 'Guidance on Evaluation of Development Proposals on Sites Where Methane and Carbon Dioxide are Present' Report Edition No.04 March 2007 NHBC – designed for use with low rise residential properties,
- BS8485:2015 (June 2015) 'Code of practice for the design of protective measures for methane and carbon dioxide ground gases for new buildings'

These documents improve upon the approach used in previous CIRIA and Wilson /Card Papers, by placing emphasis on gas flow rates, but still retain some reliance on the gas concentrations themselves.

CIRIA C665 Situation A Ground Gas Conceptual Model

The risk table contained in C665 is basically a modified risk assessment from CIRIA 152 1995, by which a conceptual model and semi-quantitative risk assessment can be made.

High Rise / Flats (CIRIA 665 Table 8.5)

Characteristic Situation (CIRIA Report 149)	Risk Classification	Gas Screening Value (CH₄ or CO₂) (l/hr) ¹	Additional Factors	Typical Source of Generation
1	Very Low Risk	<0.07	Typically methane $\leq 1\%v/v$ and/or carbon dioxide $\leq 5\%v/v$. Otherwise consider increase to Situation 2	Natural soils with low Organic content. "Typical" Made Ground
2	Low risk	<0.7	Borehole flow rate not to exceed 70l/hr. Otherwise consider increase to Situation 3	Natural soil, high peat/organic content. "Typical" Made Ground
3	Moderate Risk	<3.5		Old landfill, inert waste, Mine working flooded
4	Moderate to High Risk	<15	Quantitative risk assessment required to evaluate scope of protective measures	Mine working susceptible to flooding, completed landfill (WMP 26B criteria)
5	High Risk	<70		Mine working unflooded inactive with shallow workings near surface
6	Very High Risk	>70		Recent landfill site
Notes: 1. Gas screening value: litres of gas/hour is calculated by multiplying the gas concentration (%) by the measured borehole flow rate (l/hr); 2. Site characterisation should be based on gas monitoring of concentrations and borehole flow rates for the minimum periods as defined within CIRIA Report 665; 3. Source of gas and generation potential/performance must be identified; 4. Soil gas investigation to be in accordance with guidance contained within CIRIA Report 665; 5. If there is no detectable flow, use the limit of detection of the instrument; 6. The boundaries between the Partners in Technology classifications do not fit exactly with the boundaries for the above classification.				

Typical scope of protective measures (extract from CIRIA Report 665 Table 8.6)

Characteristic Situation (from Table 8.5)	Number of Levels of Protection	Typical Scope of Protective Measures for Residential Building (not low-rise traditional housing) ¹
1	None	No special precautions
2	2	a) Reinforced concrete cast in situ floor slab (suspended, non-suspended or raft) with at least 1200g DPM and under-floor venting b) Beam and block or pre-cast concrete and 2000 g DPM/reinforced gas membrane and under-floor venting. All joints and penetrations sealed.
3	2	All types of floor slab as above. All joints and penetrations sealed. Proprietary gas resistant membrane and passively ventilated or positively pressurised under-floor sub-space.
4	3	All types of floor slab as above. All joints and penetrations sealed. Proprietary gas resistant membrane and passively ventilated under-floor subspace or positively pressurised under-floor sub-space, over-site capping or blinding and in ground venting layer
5	4	Reinforced concrete cast in situ floor slab (suspended, non-suspended or raft). All joints and penetrations sealed. Proprietary gas resistant membrane and ventilated or positively pressurised under-floor sub-space, over-site capping and in ground venting layer and in ground venting wells or barriers.
6	5	Not suitable unless gas regime is reduced first and quantitative risk assessment carried out to assess design of protection measures in conjunction with foundation design.

Notes:

1. Not suitable for use with low rise traditional housing. (Use the NHBC document instead);
2. Typical scope of protective measures may be rationalised for specific developments on the basis of quantitative risk assessments;
3. Note the type of protection is given for illustration purposes only. Information on the detailing and construction of passive protection measures is given in BR414 (Johnson, 2001). Individual site specific designs should provide the same number of separate protective methods for any given characteristic situation. See CIRIA Report 49;
4. In all cases there should be minimum penetration of ground slabs by services and minimum number of confined spaces such as cupboards above the ground slab. Any confined spaces should be ventilated;
5. Foundation design must minimise differential settlement particularly between structural elements and ground-bearing slabs;
6. Commercial buildings with basement car parks, provided with ventilation in accordance with the Building Regulations, may not require gas protection for Characteristic Situations 3 and 4;
7. Floor slabs should provide an acceptable formation on which to lay the gas membrane. If a block beam floor is used it should be well detailed so it has no voids in it that membranes have to span, and all holes for service penetrations should be filled. The minimum density of the blocks should be 600kg/m³ and the top surface should have a 4:1 ratio sand to cement grout brushed into all joints before placing any membrane (this is also good practice to stabilise the floor and should be carried out regardless of the need for ground gas membranes);
8. The ground gas-resistant membrane can also act as the damp-proof membrane;
9. Based on Building Regulations Approved Document C (Office of the Deputy Prime Minister, 2004a), which states that "a membrane below the concrete could be formed with a sheet of polyethylene, which should be at least 300µ thick (1200 gauge)". Please note the alteration from 300mm (as stated in the Approved Document C) to 300µ, as 300mm is a typographical error that has been recognised and corrected for within this report and CIRIA Report 665.

Low Rise Residential (NHBC)

Table 14.1: Gas Risk Assessment - Traffic Lights with Typical Maximum Concentrations and Gas Screening Values

Classification	Methane ¹		Carbon Dioxide ¹	
	Typical Maximum Concentration ³ (%v/v)	Gas Screening Value ^{2,4} (l/hr)	Typical Maximum Concentration ³ (%v/v)	Gas Screening Value ^{2,4} (l/hr)
Green	1	0.13	5	0.78
Amber 1	5	0.63	10	1.60
Amber 2	20	1.60	30	3.10
Red				

Notes:

1. 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 will be the decider as to what Traffic Light is allocated;
2. Borehole Gas Volume Flow Rate, in litres per hour as defined in Wilson and Card (1999), is the borehole flow rate multiplied by the concentration in the air stream of the particular gas being considered;
3. The Typical Maximum Concentrations can be exceeded in certain circumstances should the Conceptual Site Model indicate it is safe to do so;
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.

Table 14.2: Ground Gas Protection Measures Required for the Traffic Lights

Traffic Light	Ground Gas Protection Measures Required
Green	Ground gas protection measures are not required. (note based on standard NHBC house detail with 150mm void space under suspended floor)
Amber 1	Low-level ground gas protection measures are required, using a membrane and ventilated sub-floor void that creates a permeability contrast to limit the ingress of gas into buildings. Gas protection measures are to be installed as prescribed in BRE 414. Ventilation of the sub-floor void should be designed to provide a minimum of one complete volume change per 24 hours.
Amber 2	High-level ground gas protection measures are required, creating a permeability contrast to prevent ingress of gas into buildings. Gas protection measures are to be installed as prescribed in BRE 414. Membranes used should always be fitted by a specialist contractor and should be fully certified (see Appendix G). As with Amber 1, ventilation of the sub-floor void should be designed to provide a minimum of one complete volume change per 24 hours.
Red	Standard residential housing is not normally acceptable without further Ground Gas Risk Assessment and/or possible remedial mitigation measures to reduce/remove the source of the ground gases. In certain circumstances, active protection methods could be applied, but only when there is a legal agreement assuring the management and maintenance of the system for the life of the property.

BS8485:2015 Code of Practice for design of protective measures for CH₄ and CO₂ ground gases for new buildings

Table 3 page 21: Building Types

	Type A	Type B	Type C	Type D
Ownership	Private	Private or commercial/public, possible multiple	Commercial/Public	Commercial/Industrial
Control (change of use, structural alterations, ventilation)	None	Some but not all	Full	Full
Room Sizes	Small	Small/medium	Small to large	large industrial/retail park style

Type A) Private ownership with no building management controls on alterations to the internal structure, the use of rooms, the ventilation of the rooms or the structural fabric of the building. Some small rooms present. Probably conventional building construction (rather than civil engineering). Examples include private housing and some retail premises.

Type B) Private or commercial property with central building management control of any alterations to the buildings or its uses but limited or no central building management control of the maintenance of the building, including gas protection measures. Multiple occupancy. Small to medium size rooms with passive ventilation of rooms and other internal spaces throughout the ground floor and basement areas. May be conventional building or civil engineering construction. Examples include managed apartments, multiple occupancy offices, some retail premises and parts of public buildings (such as schools, hospitals and leisure centres) and parts of hotels.

Type C) Commercial building with central building management control of any alterations to the building or its uses and central building management control of the maintenance of the building, including the gas protection measures. Small to large rooms with active ventilation or good passive ventilation of all rooms and other internal spaces throughout ground floor and basement areas. Probably civil engineering construction. Examples include offices, some retail premises and parts of some public buildings (such as schools, hospitals, leisure centres and parts of hotels).

Type D) Industrial style building having large volume internal spaces that are well ventilated. Corporate ownership with building management controls on alterations to the ground floor and basement of the building and on maintenance of ground gas protective measures. Probably civil engineering construction. Examples are retail park sales buildings, factory shop floors, warehouses. (Small rooms within these style buildings should be separately categorised as Type B or Type C).

Table 4 page 22: Gas Protection Score by CS and Type of Building

Characteristic Gas Situation, CS	NHBC Traffic Light	Required Gas Protection High Risk			
		High Risk		Medium Risk	Low Risk
		Type A Building	Type B Building	Type C Building	Type D Building
1	Green	0	0	0	0
2	Amber 1	3.5	3.5	2.5	1.5
3	Amber 2	4.5	4	3	2.5
4	Red	6.5 A)	5.5 A)	4.5	3.5
5		- B)	6.5 A)	5.5	4.5
6		- B)	- B)	7.5	6.5

NOTE Traffic light indications are taken from NHBC Report No: 10627-R01 (04) [3] and are mainly applicable to low-rise residential housing. These are for comparative purposes but the boundaries between the traffic light indications and CS values do not coincide.

- A) Residential buildings should not be built on CS4 or higher sites unless the type of construction or site circumstances allow additional levels of protection to be incorporated e.g. high performance ventilation or pathway intervention measures, and an associated sustainable system of management of maintenance of the gas control system e.g. in institutional and/or fully service contractual situations.
- B) The gas hazard is too high for this empirical method to be used to define the gas protection measures.

Selection of Appropriate Measures Section 7.2 BS8485:2015

Structural Barriers - Table 5 Gas Protection Scores for Structural Barriers pg 23

Floor and Substructure Design (Annex A)	Score ^{A)}
Precast suspended segmental subfloor (i.e. beam and block)	0
Cast in situ ground bearing floor slab (with nominal mesh reinforcement)	0.5
Cast in situ monolithic reinforced ground bearing raft or reinforced cast in situ suspended floor slab with minimal penetrations	1 or 1.5 ^{B)}
Basement floor and walls conforming to BS 8210:2009 Grade 2 waterproofing ^{C)}	2
Basement floor and walls conforming to BS 8210:2009 Grade 3 waterproofing ^{C)}	2.5
A) the scores are conditional on breaches of floor slabs etc being effectively sealed B) to achieve the score of 1.5 the raft or suspended slab should be well reinforced to control cracking and have minimal penetrations in cast in (A2.2.2) C) the score is conditional on the waterproofing not being used on the use of geosynthetic clay liner waterproofing product (see C3 Note 4)	

Ventilation Measures

Ventilation protection measures should be one of five types and points can only be scored for one of these measures;

- Pressure relief pathway only (no effective dispersal layer)
- Passive dispersal layer
- Active dispersal layer (fan suction)
- Active positive pressurisation (air blanket)
- Ventilated basement substructure present.

Note 1 - for Type A buildings active ventilation measures are inappropriate

Note 2 - There are a wide range of different media used to form gas dispersal layer for both passive and active systems, and are more likely to be developed

Note 3 - The types of media include expanded polystyrene void formers, geocomposite void formers, no (low) fines gravel and drains formed by perforated pipes or geocomposites.

Note 4 - The continuity of the media beneath the floor slab might be interrupted by ground beams, pile caps, edge beams and other intrusions extending below the level of the media blanket, which might significantly reduce the effectiveness of the dispersal layer.

Note 5 - The effective volume of the gas dispersal layer might be reduced by its placement on a soft layer (for example sand binding) which reduces its gas permeability and dispersal effectiveness. The effective volume would also be reduced or eliminated if the media became flooded with groundwater or clay heave.

Note 6 - The performance of passive systems can be significantly affected by the number and type of side ventilation terminals. Common side terminals are airbricks, low level vents and high level vent stacks. Guidance on side ventilation is given in Annex B

Table 6 Gas Protection Measures for Ventilation Protection Measures

Protection Element/System	Score	Comments
a) Pressure relief pathway (usually formed of low fines gravel or with a thin geocomposite blanket or strips terminating in a gravel trench external to the building).	0.5	Whenever possible a pressure relief pathway (as a min) should be installed in all gas protection measures systems. If the layer has a low perm and/or is not terminated in a venting trench (or similar) then the score is zero.
b) Passive sub floor dispersal layer: Very good performance Good performance Media used to provide dispersal layer are *Clear void *Polystyrene void former blanket *Geocomposite void former blanket *No fines gravel layer with gas drains *No fines gravel layer	2.5 1.5	Performance criteria for methane and carbon dioxide are shown in Fig B.6 and B.7 respectively. The ventilation effectiveness of different media depends on the number of different factors including the transmissivity of the medium, the width of the building, the side ventilation spacing and type and thickness of the layer. The selected score should be assigned taking into account the recommendations in Annex B. Passive ventilation should be designed to meet at least good performance, see Annex B.
c) Active dispersal layer , usually comprising fans with active abstraction (suction) from a subfloor dilution layer, with roof level vents. The dilution layer may comprise a clear void or be formed of geocomposite or polystyrene void formers.	1.5-2.5	This system relies on continued serviceability of the pumps, therefore alarm and response systems should be in place. There should be a robust management systems in place to ensure the continued maintenance of the system, including pumps and vents. Active ventilation should always be designed for good performance as described in Annex B.
d) Active pressurisation by the creation of a blanket of external fresh air beneath the building floor slab by pumps supplying air to the points across the central footprint of the building into a permeable layer, usually formed of a thin geocomposite blanket.	1.5-2.5	This system relies on continued operation of the pumps, therefore alarm and response systems in place. The score assigned should be based on the coverage of the building footprint and the redundancy of the system. Active ventilation should always be designed to meet at least good performance.

Gas Membranes

Gas resistant membranes should be;

- Sufficiently impervious to methane (CH₄) and carbon dioxide (CO₂)
- Capable after installation of providing a complete barrier to the entry of the relevant gas
- Sufficiently durable to remain serviceable for the anticipated life of the building and duration of gas emissions
- Sufficiently strong to withstand in service stresses (e.g. due to ground settlement if placed below floor slab)
- Sufficiently strong to withstand the installation process and following construction activities until covered (e.g. penetration from steel fibres in fibre reinforced concrete, penetration of reinforcement ties, tearing due to working above it and dropping of tools
- Chemically resistant to degradation by other contaminants that might be present

Note 1 – a methane gas transmission rate of <40ml/day/m²atm(avg) for sheets and joints (BSISO15105-1) usually considered sufficient

Note 2 – Guidance on the relevant properties of a), c) and e) is provided in CIRIA C748 [10]

Note 3 – Advice on membrane selection is in Annex C.

Note 4 – The installation and subsequent protection of the membrane are key factors in its performance. A poorly installed membrane cannot perform, however a well detailed and irrespective of the performance of the material. Historically ref was made to verification and integrity testing without any referenced documents against which to judge. The verification process is now described in CIRIA C735 [N1] and as such confidence in the installation can be measured. The process removes the uncertainty of unqualified or inexperienced installation operatives by requiring a **verification plan** to be drawn up prior to installation, with frequency and type of verification being dependent on the qualifications of the operatives, site risk and design criteria. (see 8.3.2 pg 30)

Note 5 – Current guidance on verification recommendations takes in account the risk of the overall design and confidence of installation and sets a frequency and level of verification appropriate.

Protection Element/System	Score	Comments
Gas resistant membrane meeting all of the following criteria:	2	The performance of the membranes is heavily dependent on the quality and design of the installation, resistance to damage after installation and integrity of joints. For example a minimum 0.4mm thickness (equivalent 370g/m ² for polyethylene) reinforced membrane (virgin polymer) meets performance in Table 7 (see C3). If a membrane is installed that does not meet all the criteria in Column 1 the score is Zero
* sufficiently impervious to the gases with a methane gas transmission rate <40ml/day/m ² atm(avg) for sheet and joints BS ISO15105-1		
*sufficiently durable to remain servicable for the anticipated life of the building and duration of gas emissions		
*sufficiently strong to withstand in-service stresses (eg settlement if placed below floor slab)		
*e) Sufficiently strong to withstand the installation process and following construction activities until covered (e.g. penetration from steel fibres in fibre reinforced concrete, penetration of reinforcement ties, tearing due to working above it and dropping of tools		
*capable after installation of providing a complete barrier to the entry of relevant gases		
*verified in accordance with CIRIA C735 [N1]		

In-Ground Pathway Intervention - A sites in-ground pathways from offsite sources should be investigated for migratory gases – **Note 1** methods of pathway intervention include simple vertical membrane installations, vent trenches, rows of stone columns, activated trenches and proprietary systems. **Note 2** – for residential dwellings, management and maintenance is only acceptable where pathway intervention measures (e.g. venting trenches) are beyond the extent of the buildings, on or close to the boundary of the property in a position where access can be guaranteed.

Detailed Design – Once the design measures have been selected in accordance with Section 7.2, these should be developed into a detailed design supported by detailed drawings and specifications. The design should be described in the design report Section 8.3.

APPENDIX K

(i) Off-site Disposal of Surplus Soil Guidance Notes

The disposal of waste (including surplus soils and contaminated soils) to landfill sites is governed by the *Landfill (England & Wales) Regulations 2002*, the *Hazardous Waste Technical Guidance document WM2 (2003)* and associated legislation.

One of the aims of the above legislation is to encourage waste producers (including developers disposing of surplus soils etc) to reduce their waste (and not just discard and disown it). This can be achieved by recycling or reusing the waste. In the case of contaminated sites where leaving contaminated material in-situ poses a risk to a potential receptor such as groundwater resources, further testing and assessment for such risk could reduce the quantities requiring disposal. If there is still unacceptable risk from contaminated soil being left in place, then it may be possible to reduce the risk to an acceptable level (such that the material can be left in place) by in-situ or ex-situ clean-up of the soils.

Before waste can be disposed of, the producer of the waste must undertake a number of steps. '*Initial Waste Testing and Characterisation*' is firstly undertaken to determine whether the waste is non-hazardous or hazardous. The exceptions are that some wastes such as coal tars, 'tank bottom sludge's', etc are immediately classed as hazardous, regardless of any testing or threshold concentrations.

Any inert or hazardous waste destined for landfill must undergo '*Compliance Testing*' using the Waste Acceptance Criteria (WAC). There are different inert and hazardous WAC limits relating to landfill sites that are correspondingly licensed to accept inert or hazardous waste.

If the '*Initial Waste Testing and Characterisation*' shows a waste to be hazardous, then it is a requirement that the material be tested against the WAC-hazardous suite of tests. If it passes the WAC-hazardous testing, then it can be taken to a hazardous waste landfill site. If the material fails the WAC-hazardous testing, then the material must be treated before undergoing re-characterisation, further WAC-hazardous testing and then potential disposal at a hazardous waste disposal site.

If the '*Initial Waste Testing and Characterisation*' shows a waste to be non-hazardous, then it can be taken to a non-hazardous waste landfill site, without further testing. The producer may however decide to undertake WAC-inert testing, in an attempt to reclassify the waste as inert, in which case the waste could then go to an inert landfill site.

The volumes of soils associated with potential hotspots on a site (be they hazardous or non-hazardous) which might require off-site disposal, could potentially be reduced by further on-site sampling and subsequent testing.

With regard to the *Compliance Testing*, it should be noted that some landfill sites are permitted to increase the standard WAC-hazardous/inert limit concentrations, such that they might accept waste that would normally fail such limits.

We would recommend that the contamination testing results (including the history of the site) be presented to the proposed landfills, to determine if they will accept waste generated at the site and what classification they would impose.

APPENDIX L

(i) Validation Report Guidance Notes

Unforeseen Hotspots of Contamination

Given the existence of made ground on the site it would be prudent to maintain vigilance during site clearance and construction, in case any further areas of suspected contamination are encountered.

If areas are found then a suitably qualified person should undertake appropriate sampling, testing and further risk assessment.

Any hotspots encountered during site clearance, not previously encountered in the ground investigation, are to be removed to a suitably licensed landfill site.

A validation report (see below) will be produced on completion of these works. This report will serve to confirm that the works were undertaken in accordance with the relevant legislation, the method statement, specification and planning conditions.

Validation Report Recommendations

It is suggested that the following records will be kept on site to provide a basis for the validation report:

- Daily record sheets of the remediation works to include a summary of the day's activities
- Weather conditions
- Plant, personnel and visitors to the remediation site
- Aspects relating to Health & Safety, environmental control or non-compliance with the specification or the Method Statements.
- All in situ and laboratory testing results.

All requirements of the remediation specification should be complied with; on completion of the remediation a validation report should be provided. This report will comprise the relevant site records and act as certification that the remedial and ground preparation works have been carried out in accordance with the specification.

The validation report will include the following:

- A description of the works undertaken.
- Records of any remediation works, including daily diary sheets.
- Progress photographs.
- Any chemical and geotechnical validation test results.
- As built surveys, including base excavations and top and bottom of capping layer.
- A statement that the works have been undertaken in accordance with the agreed specification

APPENDIX M

(i) Notes on Limitations

This report does not consider ecological impacts (e.g. bats) or botanical risks (e.g. Japanese knotweed). It is recommended that these are considered as part of the assessment of development constraints for the site.

The assessment and judgements given in this report are directed by both the finite data on which they are based and the proposed works to which they are addressed. The data essentially comprised a study of available documented information from various sources (including Client Furnished reports) together with discussions with relevant authorities and other interested parties. There may also be circumstances at the site that are not documented. The information reviewed is not exhaustive and has been accepted in good faith as providing representative and true data pertaining to site conditions. If additional information becomes available which might impact our environmental conclusions, we request the opportunity to review the information, reassess the potential concerns and modify our opinion if warranted.

It should be noted that any risks identified in this report are perceived risks based on the available information. Actual risks can only be assessed following a physical investigation of the site.

The site investigation has been carried out to provide information concerning the type and degree of contamination, and ground and groundwater conditions to allow a reasonable risk assessment to be made. Betts Geo Environmental Ltd undertake to exercise all reasonable skill, care and due diligence in the exercise of the investigation with respect to sampling techniques, sample storage and report interpretation.

The assessments and judgement given in this report are directed by both the finite data on which they are based and the proposed works to which they are addressed. Data acquisition is subject to the limitations of the methods of investigation used. Exploratory holes undertaken during fieldwork investigate small a small volume of ground in relation to the size of the site and as such can only provide an indication of site conditions. There may be conditions pertaining to the site and the proposed development i.e. localised "hotspots" of contamination, which have not been disclosed by the investigations.

The findings and opinions are relevant to the dates of our site works and should not be relied upon to represent conditions at substantially later dates. Conditions at the site will change over time due to natural variations and anthropogenic activities. Groundwater, surface water and soil gas conditions should be anticipated to change with diurnal, seasonal and meteorological variations.

The opinions expressed in this report regarding any contamination are based on simple statistical analysis and comparison with available guidance values. No liability can be accepted for the retrospective effects of any changes or amendments to these values.

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