



Phase 2 Intrusive Site Investigation Report

LOCATION	Land at Fieldsend Road, Goldthorpe S63 9AA
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FOR	Bliss Investment Properties Ltd
CLIENT REF.	
OUR REF.	G21119 Rev A (Incl Full Gas Results)

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1 Introduction

In accordance with your instruction, Geoinvestigate Ltd. has carried out a Phase 2 Intrusive Investigation on a plot of land at Fieldsend Road, Goldthorpe S63 9AA.

The purpose of this Phase 2 investigation was to establish the true nature of the ground conditions at the site with regard to the potential for contamination and hazardous gas to occur, and determining appropriate foundation types, and to further investigate the risk regarding the potential presence of shallow coal mine workings.

It is proposed to construct a mixture of semi-detached and detached residential dwellings at the site including soft landscaping and hardstanding for parking. At the time of the investigation, the site was covered with hardstanding with peripheral soft landscaping and was an active car park.

The investigation has been designed in accordance with the findings and recommendations of the Desk Study and CMRA reports previously compiled by others for the site.

A Phase 1 Desk Study was carried out by Peak Environmental Solutions (41887LR1, November 2017) which concluded that the site is located on a former railway cutting dating back to 1900s and was infilled around 1960s. The line was associated with Hickleton Main Colliery. The site is also located within a Development High Risk Area with regard to shallow coal mining.

2 Scope of Investigation

2.1 Investigation

Given the above the following investigation was carried out to assess the potential contamination risks at the site:

- Five (5) boreholes (BH1 to BH5) to depths of between 3.00m and 4.00m with associated soil sampling and supervision of the works by a suitably qualified geo-environmental engineer. The boreholes were sunk using windowless sampling techniques with a Dando Terrier 2002 mini drilling rig.
- A single (1) cable percussion borehole (CP1) sunk to 7.95m with associated soil sampling and supervision of the works by a suitably qualified geo-environmental engineer. The boreholes were sunk using windowless sampling techniques with a Dando 2000 cable percussive drilling rig.
- The sinking of three (3) rotary open-hole boreholes (RH1 to RH3) to a depth of between 30.0m and 40.0m under licence from the Coal Authority to probe for shallow mine workings. The boreholes were sunk using Geoinvestigate's Microdrill® with water flush.
- The installation of three (3) gas monitoring wells in boreholes BH1, BH4 and BH5 with allowance for up to six (6) gas monitoring visits over a period of up to three (3) months (if appropriate), including readings below 1000mb and where possible following a sharp drop in atmospheric pressure.

- Contamination analyses of six (6) samples of made ground were recovered from depths of between 0.30m and 2.50m at the site to confirm that metals, Asbestos, polycyclic aromatic hydrocarbons (PAHs) and petroleum hydrocarbons are absent or within acceptable limits. Leachate from two (2) samples was also analysed to check the mobility of potential contaminants.
- Provision of a factual and interpretative report including; site plan, borehole logs, contamination results, together with advice on appropriate foundation type, the contamination situation and, if required, remediation and validation.

No Phase 1 Desk Study has been compiled prior to this investigation. The borehole positions are shown on the plan provided in Appendix 1.

The excavations were sampled and logged at site by a geo-environmental engineer and the ground conditions encountered are described on the borehole logs also provided in Appendix 1.

The results of the contamination testing are included in Appendix 2.

2.2 Sampling Rationale

The borehole positions were chosen to give an indication of the ground conditions generally throughout the site, both in terms of geotechnical appraisal and assessment of soil contamination. The soils encountered in the boreholes are considered to be broadly representative of soils throughout the site.

Additionally, ground gas monitoring wells were installed in boreholes BH1, BH4 and BH5 to determine the ground gas conditions throughout the study area including proposed building footprints. This was considered prudent given the potential gas sources below and relatively close to the site, namely the potential for coal mine workings and made ground associated with the infilled railway cutting.

3 Investigation Findings

3.1 Boreholes

As anticipated, the boreholes at the site encountered made ground comprising essentially medium dense clayey sandy gravel of mudstone and coal, considered to be of colliery spoil origin. Based on the site's location within a backfilled railway cutting, this deposit extended to a depth of 7.10m. The windowless sampling boreholes encountered similar made ground to their termination depth of between 3.00m and 4.00m.

3.1.1 Windowless Sampling Boreholes

The initial asphalt hardstanding was found to be circa 0.25m and was underlain by dense sandy gravel of concrete and dolomitic limestone (road sub-base).

Beneath the initial made ground further fill comprising ostensibly medium dense clayey sandy gravel of mudstone and coal was encountered to the base of each borehole at between 3.00m and 4.00m. In BH4 and BH5 the deposit was noted to become loose and loose to medium dense below depths of 2.30m and 3.50m respectively.

In situ SPT testing (carried out with a solid cone sampler) returned values between N=12 and N=22, with BH4 and BH5 recording lower values of between N=4 and N=9 below circa 3.00m.

The boreholes remained open and dry on completion, with no significant roots encountered.

3.1.2 Cable Percussive Borehole.

The Cable Percussive Borehole (CP1) encountered similar ground conditions with asphalt hardstanding underlain by similar compact sandy gravel sub-base then made ground comprising ostensibly medium dense clayey sandy gravel of mudstone and coal (former colliery spoil). Many sandstone cobbles were present within the base of the fill below 6.50m, with weathered sandstone rock commencing below 7.10m.

In situ SPT Testing returned values of N=8 to N=19 within the made ground and a refusal value of N=60/135mm within the sandstone rock.

The cable percussion borehole remained stable and dry on completion.

3.2 Rotary Open Hole Boreholes

The findings of the CMRA report necessitated that rotary open hole boreholes be sunk at the site as part of this investigation to explore for possible shallow coal mine workings. These were drilled using Geoinvestigate's custom-built and trademarked Microdrill system, a lightweight tracked drilling rig which uses water flush.

Three (3) holes were drilled to depths between 30.0m and 40.0m (RH1 to RH3) and logs of the findings of these holes are presented in Appendix 1.

The rock descriptions are tentative and generally based on the contents of returned water flush, drilling progress (speed of advance) and water pressures observed during drilling; no cores were recovered from the boreholes to verify these though at several times during excavation the drill-string is withdrawn from the ground to inspect the composition of the build-up on the drill bit.

Gas readings were taken in the boreholes during and following drilling. These are shown on the logs in Appendix 1 (no hazardous gas concentrations were detected).

3.2.1 Strata Encountered In Rotary Boreholes.

The rotary boreholes encountered made ground to a similar depth to the deep Cable Percussion Borehole with sandstone commencing below depths of 7.10m to 7.50m. Below 16.10m and 17.10m sandstone interbedded with siltstone was found to depths of between 26.30m and 28.50m, underlain by mudstone which was proven to the base of each of RH1 and RH3 at 30.00m. In RH2 this siltstone commenced below 33.60m and was proven to the base of the borehole.

No coal seams, voids or broken ground indicative of shallow mine workings were present within the boreholes. Water flush was lost within the upper made ground at depths between 1.80m and 5.80m, in RH1 flush returned at below 8.10m.

3.2.2 Conclusions with respect to Coal Mining Risk

- The boreholes encountered no coal seams.
- No voiding or broken ground was encountered in any of the boreholes.
- At least 32m of unbroken rock cover was proven in both boreholes.
- No elevated levels of hazardous gas were recorded in the boreholes.

Given the above, there is concluded to be no risk to the proposed development posed by historical coal mining.

The South Yorkshire Mining Advisory Service reported that the High Gate Coal Seam (up to 0.70m thick) is likely to be present at shallow depths with an outcrop recorded within 10m south of the site and records of opencast extraction 80m south of the site within a railway cutting. This seam was not discovered in the boreholes, nor were any voids or broken ground.

The discrepancy between the South Yorkshire Mining Advisory Service and the findings of the boreholes may perhaps be due to the seam being extracted and removed from the site during the excavation of the railway cutting in 1900s which predates the current records. Nonetheless, no coal or evidence of mining is present within 40m of the site surface and an ample 32m of unbroken rock cover has been confirmed.

4 Contamination Testing

As mentioned in section 1, the site was position within a former railway cutting which was infilled in the 1960s, therefore deep made ground was anticipated.

Potential contaminants could occur throughout the full thickness of the made ground which was recovered from the boreholes to a maximum depth of 7.10m. Soils close to surface would be the most relevant regarding human health risk assessment though analysis of deeper soils would also be appropriate to ensure no risk to local ground and surface waters exists through potential contaminant leaching and mobilisation. The made ground showed no obvious visual or olfactory evidence of potential contamination or contaminative materials apart from the present of brick and coal fragments. However due to the presence of the infilled railway cutting, site history and potential contamination risk existed at the site.

Based on the findings of the site works six (6) samples of near surface made ground between 0.30m and 2.50m recovered from the excavations at the site were tested for a range of substances. These included common contaminants such as Arsenic, Lead and Cadmium which are normally included in a general human health contamination suite together with analysis for Speciated PAHs petroleum hydrocarbons and Asbestos. In addition, analysis was included in the testing for petroleum hydrocarbons where appropriate. Leachate from two (2) of the samples was analysed also to check the mobility of any potential contaminants. In addition, one (1) sample was selected for PCB analysis.

The results of the contamination testing are included in Appendix 2 of this report (Chemtech Environmental Ltd. report 94935) and have been used in the contamination risk assessment, set out in the following sections.

5 Contamination Risk Assessment

5.1 Method

Geoinvestigate Ltd. uses a combination of assessment criterion provided by the environment agency, DEFRA and by the Chartered Institute of Environmental Health; Environment Agency Environmental Quality Standards (EQSs), Site Specific Assessment Criteria (SSAC) generated using CLEA software version 1.06 site specific risk assessment modelling, DEFRA Category 4 Screening Levels (C4SLs), and Land Quality Management / Chartered Institute of Environmental Health (LQM/CIEH) Safe for use Levels (S4ULs) in order to assess the presence of potentially harmful chemicals within soils and water.

As the site is to be developed as a residential dwelling, it falls within the residential end-use category. As it is possible that persons living on the site may cultivate vegetables / fruit for consumption, consideration to this end is also necessary.

No site-specific assessment criteria (SSAC) have been created for the site as no unusual circumstances (i.e. occupation periods etc.) are considered to be present/likely at the site that would render the generic residential assessment criteria unsuitable.

The results of the contamination testing that has been carried out have been compared to the soil quality values from the above sources. Where they fall below these limit values, they have been deemed safe for a residential end use. Had any results been found to be above the intervention values, an assessment of the available pathways and receptors would have been carried out to determine whether further investigation or remediation might have been necessary.

An appraisal of the chemical results and relevant limits is set out in the Contamination Risk Assessment that follows.

5.2 Contamination Risk to Identified Receptors

5.2.1 Contamination Risk to Human Health

Made ground was encountered to depths of 7.10m comprised a surface layer of granular fill underlain by colliery spoil.

No soils encountered at the site exhibited any noteworthy visual or olfactory evidence of possible contamination. Further to this, no visible evidence of Asbestos contamination such as roofing board was noted in any of the soils encountered in the excavations.

As discussed earlier in the report, levels of determinands have been compared to the soil assessment criteria for residential end-use, as published by the Environment Agency, DEFRA and LQM/CIEH.

The results of the analyses of six (6) samples of soil recovered from the site from depths between 0.30m and 2.50m returned concentrations of a range of substances falling for the most part below respective assessment criteria adopted from the sources named above with some exceptions discussed later. Further discussion is presented in the following sections. A summary of the returned soil concentrations together with the adopted assessment criteria is presented in Table 1 on the following page.

A mean Total Organic Carbon Content (TOC) of 23.25% and mean Soil Organic Matter Content (SOM) of 40.08% (estimated from the TOC) were returned from the soil analyses. Therefore, the LQM/CIEH GAC for PAHs and Hydrocarbons were chosen using the lowest Soil Organic Matter (SOM) option of 6.0%, which is considered the most representative (and conservative) value for the samples returned.

Table 1: Chemical Determinands in Soils

	Range of Returned concentrations (mg/kg)	S4UL (LQM/CIEH)* (mg/kg)	C4SL (DEFRA)* (mg/kg)
Asbestos	None detected (all 4 samples)	Any presence unacceptable	
Arsenic	<1.0- 48	37	37
Boron	<0.5-5.2	290	
Cadmium	<0.2-0.7	11	26
Chromium VI	<1.0 (all 5 samples)	6	21
Chromium III	10-36	910	
Copper	4.0-61	2,400	
Lead	12-38		200
Mercury (elemental)	<0.5 (all 5)	1.2	
Nickel	3.0-43	180	
Selenium	<0.3-3.9	250	
Zinc	35-86	3,700	
pH	5.3-9.1	See Report Section 7.3 "Concrete Design"	
Water Soluble SO ₄	29-957		
Phenol	<0.5 (all 5)	1100	
Total PAH	<0.34-1.83		
PAH Naphthalene	<0.02-1.10	13	
PAH Acenaphthylene	<0.02 (all 5)	920	
PAH Acenaphthene	<0.02-0.03	1100	
PAH Fluorene	<0.02-0.05	860	
PAH Phenanthrene	0.06-0.36	440	
PAH Anthracene	<0.02-0.05	11000	
PAH Fluoranthene	0.04-0.09	890	
PAH Pyrene	0.07-0.11	2000	
PAH Benzo[a]anthracene	<0.02-0.04	13	
PAH Chrysene	0.04-0.06	27	
PAH Benzo(b)fluoranthene	0.04-0.07	3.7	
PAH Benzo(k)fluoranthene	<0.03 (all 5)	100	
PAH Benzo(a)pyrene	<0.02-0.04	3.0	5
PAH Indeno(123-cd)pyrene	<0.02-0.03	41	
PAH Dibenz(a,h)anthracene	<0.02 (all 5)	0.30	
PAH Benzo(ghi)perylene	<0.02-0.03	350	
TPH Aromatic C5-C7	<0.01 (all 5)	300	0.87 (benzene)
TPH Aromatic C7-C8	<0.01-0.02	660	
TPH Aromatic C8-C10	<0.01-0.02	190	
TPH Aromatic C10-C12	<1.0-2.0	380	
TPH Aromatic C12-C16	<1 (all 5)	660	
TPH Aromatic C16-C21	<1.0 (all 5)	930	
TPH Aromatic C21-C35	<1.0 (all 5)	1700	
TPH Aromatic C35-C44	<1.0 (all 5)	1700	
TPH Aliphatic C5-C6	<0.1 (both)	160	
TPH Aliphatic C6-C8	<0.1 (both)	530	
TPH Aliphatic C8-C10	<0.1 (both)	150	
TPH Aliphatic C10-C12	<4.0-11	760 (283)**	
TPH Aliphatic C12-C16	<4-46	4300 (142)**	
TPH Aliphatic C16-C35	124-199	110000	
TPH Aliphatic C35-C44	13-98	110000	

*For residential use with allowance for plant uptake / consumption of homegrown produce and SOM of 2.5% where relevant.

**Value in parentheses denotes estimated soil saturation limit above which a possibility of free-phase contamination might exist in soil.

Exceedances of assessment Criteria shown in BOLD type

As can be seen from the results in Table 1 and the detailed results presented in Chemtech Environmental Ltd. report 94935 (Appendix 3) the returned results are generally below the adopted target values, however an elevated arsenic concentration of 48.8mg/kg was returned in the sample from BH1 at 0.50m.

No asbestos was detected in any of the three samples inspected, no results of any significant concern were returned for petroleum hydrocarbons. In addition, PCB test results returned concentrations below the limits of detection.

The deeper colliery spoil, which comprises the bulk of the fill at the site has shown to consistently contain no elevated levels of potential contaminants.

5.2.2 Contamination Risk to Controlled Waters

Given the possible sources of historical contamination and potential surface water receptors close to the site leachate was analysed from two (2) samples obtained from BH4, 2.50m and BH5, 0.30m. This screening returned generally negligible concentrations and concentrations below detectable limits and/or safe levels for domestic water supply or the protection of aquatic life levels as published by the Environment Agency which were used as the assessment criteria, with the exception for chromium, copper and individual PAHs species. The results of the testing and the assessment criteria are shown Table 2 below.

Table 2: Chemical Determinands in Leachate

	Returned Concentrations (µg/l)	UK Standard for Surface Waters intended for Drinking Water Abstraction* (DW) and/or protection of Aquatic Life in surface waters* (Aq) (µg/l)
<u>Inorganic Chemicals</u>		
Arsenic	0.12-0.29	50 (DW, range: 50-100) / 50 (Aq)
Boron	17-213	1000 (DW & Aq)
Cadmium	<0.07 (both)	5 (DW & Aq)
Chromium	<0.2 (both)	50 (DW) / 5 (Aq, range: 5-250)
Copper	0.6-0.8	50 (DW) / 5 (Aq, range: 5-112)
Lead	<0.2 (both)	50 (DW) / 4 (Aq, range: 4-250)
Mercury (elemental Hg)	<0.08 (both)	1 (DW & Aq)
Nickel	0.5-7.8	20** (DW) / 50 (Aq, range: 50-200)
Selenium	0.29-2.62	10 (DW) (No Aq standard)
Zinc	<1.0-3.0	3000 (DW, range: 3000-5000) / 30 (Aq, range: 30-2000)
pH	8.3-8.4	Range 5.5 to 10 (UK drinking water standards)
<u>Organic Chemicals</u>		
Cyanide	<20 (both)	50 (DW) / 5 (Aq)
Phenols	<10 (both)	50**(DW) / 300 (Aq)
PAHs (total)	***1.7-2.6	0.2 (DW, range: 0.2-1.0) (No Aq standard)
<i>PAHs returning above detectable concentrations</i>		
Acenaphthene	0.8-1.3	No applicable UK standard
Fluoranthene	<0.1 (both)	1 (surface water quality, max. allowable)
Fluorene	0.9-1.2	No applicable UK standard
Naphthalene	<1.0 (both)	10 (Aq, UK inland waters)
Phenanthrene	<1.0-0.1	No applicable UK standard
Pyrene	<0.1 (both)	No applicable UK standard

*sourced from Environment Agency database at <http://evidence.environment-agency.gov.uk/ChemicalStandards/home.aspx>.

If more than one option is available (dependant on other water properties or environmental setting) the lowest value has been adopted.

**Standard for water supply as no standard available for surface water abstraction for drinking water.

***Sum of USEPA 16, each at Lower Limit of Detection of <0.1

As can be seen from Table 2 and the detailed results presented in Chemtech Environmental Ltd report 94935 (Appendix 2), levels of potential contaminants in analysed leachates returned negligible concentrations and concentrations below detectable limits and/or adopted assessment criteria.

The soils at the site are concluded to pose no risk to controlled waters.

5.3 Review of Results

The data presented in Tables 1 and 2 and the associated discussion show the majority of analyses samples have returned no elevated results of any concern.

Soils

In general, all samples tested at the site returned concentrations of all (tested) potential contaminants within acceptable limits with a notable exception.

However, the presence of a single elevated arsenic concentration from a sample of granular fill from BH1 at 0.50m infer that the made ground present provides a viable source of contamination to the site's end users. This would not be untypical given the nature of the fill beneath the site mand the overlying asphalt hardstanding.

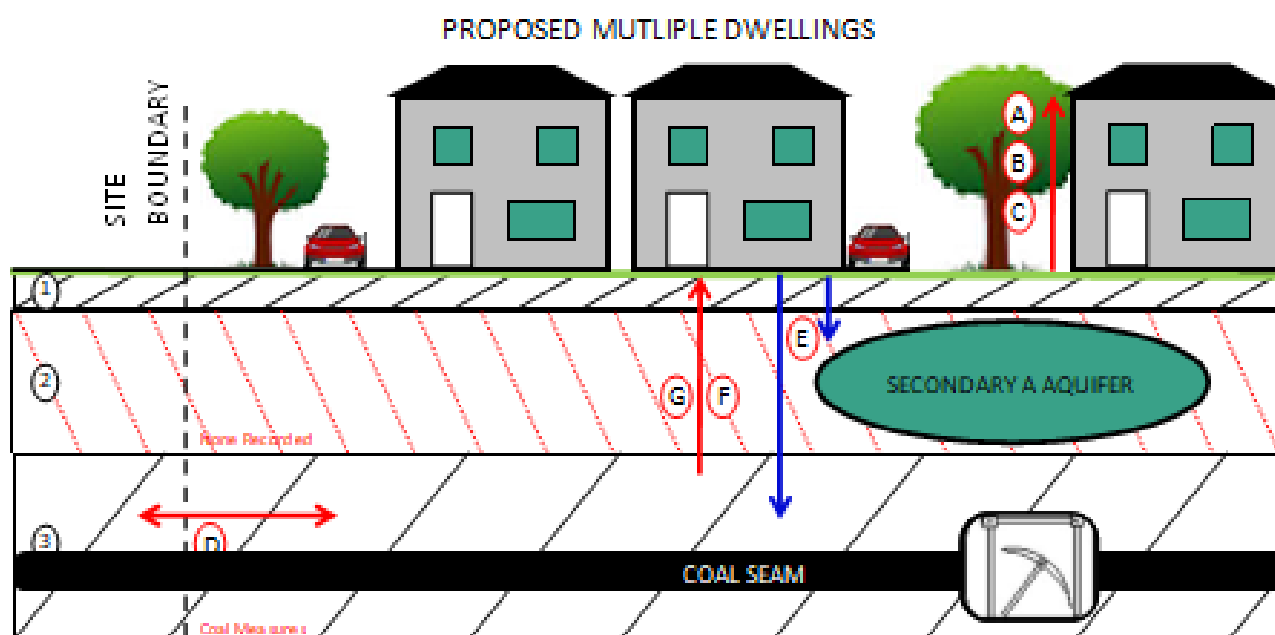
Waters

Leachate analysis has shown all (tested) potential contaminants are not mobile/leachable at noteworthy levels. As such, soils at the site are not expected to pose any significant risk to ground and surface waters.

Therefore, it is concluded that remedial works will be required at the site before it can be deemed suitable for residential use.

CGHM

The conceptual ground hazard model (CGHM) presented on the following page shows the potential hazards and pollutant linkages which have been considered at the site, and those which would be considered to be present or complete if the site were to be developed in its current condition.

Figure 1: CGHM – Conceptual cross section of site including a Source, Pathway and Receptor Model

- ① MADE GROUND—TARMAC UNDERLAIN BY COLLIERY SPOIL
- ② SUPERFICIAL GEOLOGY— NONE RECORDED
- ③ BEDROCK GEOLOGY—COAL MEASURES

IDENTIFIED HAZARDS Including Potential CONTAMINATION SOURCES

- Deep Made ground present
- Potential hazardous gasses sourced from made ground, infilled railway cutting and coal workings.
- Past and current land use on and nearby to the site.

IDENTIFIED RECEPTORS and ASSOCIATED PATHWAY

- A— End Users through Direct Contact / Inhalation / Ingestion. Buildings and hard standing will encompass some of the site, removing any pathway to end users through direct contact in these areas.
- B— Plants and Trees through uptake, possible given the intended end use of the site.
- C— End Users through cultivation and consumption of vegetables / fruit. Possible given the intended end use of the site.

- D— Neighbouring Sites through lateral migration (in soil and water, including surface water run off).
- E— Ground water through leaching of sub-soil.

- F— Buildings and services through direct contact.

Linkages A —F are considered broken due to generally low contamination results (locally elevated arsenic level to be removed)

- G— End users and buildings through ground gas migration.

Gas monitoring results to date show elevated carbon dioxide and limited measure maybe required to Amber 1.

- H— Ground surface instability due to coal mining legacy.

No worked coal seams were proven during the works therefore there is no risk

6 Hazardous Gas

6.1 Gas Regime

Given the suspected shallow mine workings and deep made ground at the site, allowance was made in the investigation for a ground gas monitoring exercise to be undertaken at the site. Gas monitoring wells were installed in boreholes BH1, BH2 and BH4.

The results of all six (6) gas monitoring visits at the site are presented in Table 3 below.

Table 3 Summary of Gas Monitoring Data

Job Number G21119		CH ₄ (%)		CO ₂ (%)	O ₂ (%)
Client Bliss Investment Properites Ltd		Minimum		<0.1	0
Site Land at Fieldsend Road, Goldthorpe S63 9AA		Maximum		0.2	10.1

Borehole	Number of Visits	CH ₄ (%)		CO ₂ (%)		O ₂ (%)		Flow Rate (l/hr)	H ₂ S (ppm)	CO (ppm)	Atmospheric Pressure (mb)
		Min.	Max.	Min.	Max.	Min.	Max.				
BH1	1	<0.1	0.2	1.2	6.2	8.1	18.6	<0.1	<1	<1	991
BH2	4	<0.1	0.2	0.7	10.1	6.3	19.3	<0.1	<1	<1	to
BH3	5	<0.1	0.2	0	4.8	10.9	20.3	<0.1	<1	<1	1018

The six gas monitoring visits carried out to date at atmospheric pressures of 991mb and 1018mb returned:

- Levels of CO₂ between 0.0% and 10.1%
- Negligible to very low levels of CH₄ of between <0.1% and 0.2%
- Some oxygen depletion recorded in BH1 and BH2. (Range of 20.3% to 6.3%)
- Consistently negligible H₂S and CO below detectable limits (<1ppm).
- Consistently negligible flow rates below detectable limits (<0.1 l/hr).

6.2 Radon Gas

Reference to the UK Radon's Interactive Map Viewer reports that the site is within an area of between 1% and 3% maximum radon potential, and as such a site – specific report would be required to determine the level of Radon Protection required at the site.

7. Conclusions

7.1 Contamination

Analysis of the ground conditions at the site and an assessment of the potential pathways have confirmed that soils on the site (excluding surface gravel from BH1) is suitable for its end use.

The “hot spot” which is gravel fill which extended between 0.20m and 0.30m recorded elevated arsenic and is located within the proposed soft landscaping area. It is considered that this area will require remediation to render it suitable for the intended end-use. Based on the favourable results elsewhere, remediation will not be required at the remainder of the site.

The most suitable remedial solution would be a “cover system” or “capping layer”. This system involves the removal of near-surface soils to an agreed depth (normally 600mm below proposed finished ground levels), followed by replacement with a 600mm thickness of proven uncontaminated material. Due to the presence of contaminated soils and lack of site won subsoil and topsoil, the Local Planning Authority (LPA) will require a Remediation Strategy document for review prior to commencement of these remedial works and will also require a Validation Report on completion of the work to confirm that the site has been left in a suitable condition.

This will include analysis of any new soils brought into the site (e.g. topsoil for finishing gardens) to confirm that it is suitable for use. Where this is required, soils should be sampled at the supplier's premises to confirm their quality before purchase and transport.

No discernible risk has been identified to local ground and surface waters through leaching and contaminant mobility.

7.2 Hazardous Gas

Gas monitoring has concluded at the site and the results of the six monitoring visits having been compiled and can be found in Appendix 3. The monitoring undertaken has returned elevated carbon dioxide above 10% and some oxygen depletion, however no methane was recorded during the visits.

Therefore, on the basis of the monitoring data, the site is concluded to fall into **"Characteristic Situation 3" (CS3)** of the Modified Wilson and Card classification or **"Amber 2"** of the NHBC Traffic Light System for low rise housing with a ventilated under-floor void (min 150mm) (CIRIA C665). Therefore, gas protection measures in line with the above would be required for the proposed building.

Additional Information

Reference to Tables 2 and 3 (Appendix 3 of this report) and BS 8485: 2015 guidance, the proposed development might be classified as a Type "A" building, and with a site classification of CS3 would therefore require a mitigation point score of **4.5** to ensure that the property is mitigated correctly (Table 3). i.e. no ground gas protection measures will be required in the new structure(s).

Please note that these tables (in Appendix 3) are illustrative and further information can be found in BRE 414 and BS8485:2015.

7.3 Historical Coal Mining

Three rotary open hole boreholes have been sunk to depths of up to 40m to probe for evidence of possible shallow coal mine working:

- The boreholes encountered no coal seams.
- No voiding or broken ground was encountered in any of the boreholes.
- A minimum 32m of unbroken rock cover was proven in each borehole.
- No elevated levels of hazardous gas were recorded in the boreholes.

Given the above, there is concluded to be no risk to the proposed development posed by historical coal mining.

7.4 Foundation Design

The ground conditions encountered at the site comprised of deep made ground comprising essentially medium dense clayey gravel of likely colliery waste origin, underlain by sandstone interbedded with mudstone. No coal seams, voids or broken ground was encountered in the deeper rotary holes.

In terms of underground hazards from historical mining activities there were no shallow (<40m) coal seams proven within the boreholes and no voids/loss of flush recorded, therefore there is no risk for the proposed development.

The ground conditions at the site have been proven to comprised of medium dense locally loose (below 3m in BH3) colliery spoil which would be unstable for traditional shallow foundation due to the high risk of differential settlement.

Therefore, the foundations for the proposed building should comprise piles extending into the sandstone present below 7.10m and 7.50m. Information provided in this report should be made available to a competent piling contractor who can design appropriate pile type and length.

A suspended floor, incorporating void and appropriate gas mitigation measures, in line with those mentioned in section 7.2 above and the subsequent gas addendum report should be incorporated into the development also.

7.5 Concrete Design

The results of chemical analyses of the fill returned Water Soluble Sulphate levels of between 29mg/l⁻¹ and 957mg/l⁻¹ and pH levels of between 5.3 and 9.1. Additionally, the site is inferred to classify as brownfield site with mobile water.

On this basis concrete in contact with the ground may be designed to ACEC Class DS-2 AC-5z of "BRE Special Digest 1 – Concrete in aggressive ground".

END OF REPORT

The findings and contents of this (intrusive) Site Investigation Report pertain solely to the study area(s) outlined herein and are based solely on the findings of the excavations undertaken as part of the current exercise unless otherwise stated. The findings and/or recommendations of this report do not take into account any ground conditions that may be present but have hitherto not been encountered and as such further investigation and/or a reconsideration of the findings of this report should be undertaken if such conditions are subsequently encountered or an alternative development plan or land use is subsequently proposed.

This report considers various environmental and/or geological risks posed to the site and/or proposed development and offers advice accordingly as guidance only. The findings of this report will remain valid provided no change of ground or groundwater conditions, either natural or anthropogenic, take place and no warrantee is offered or implied.

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TM

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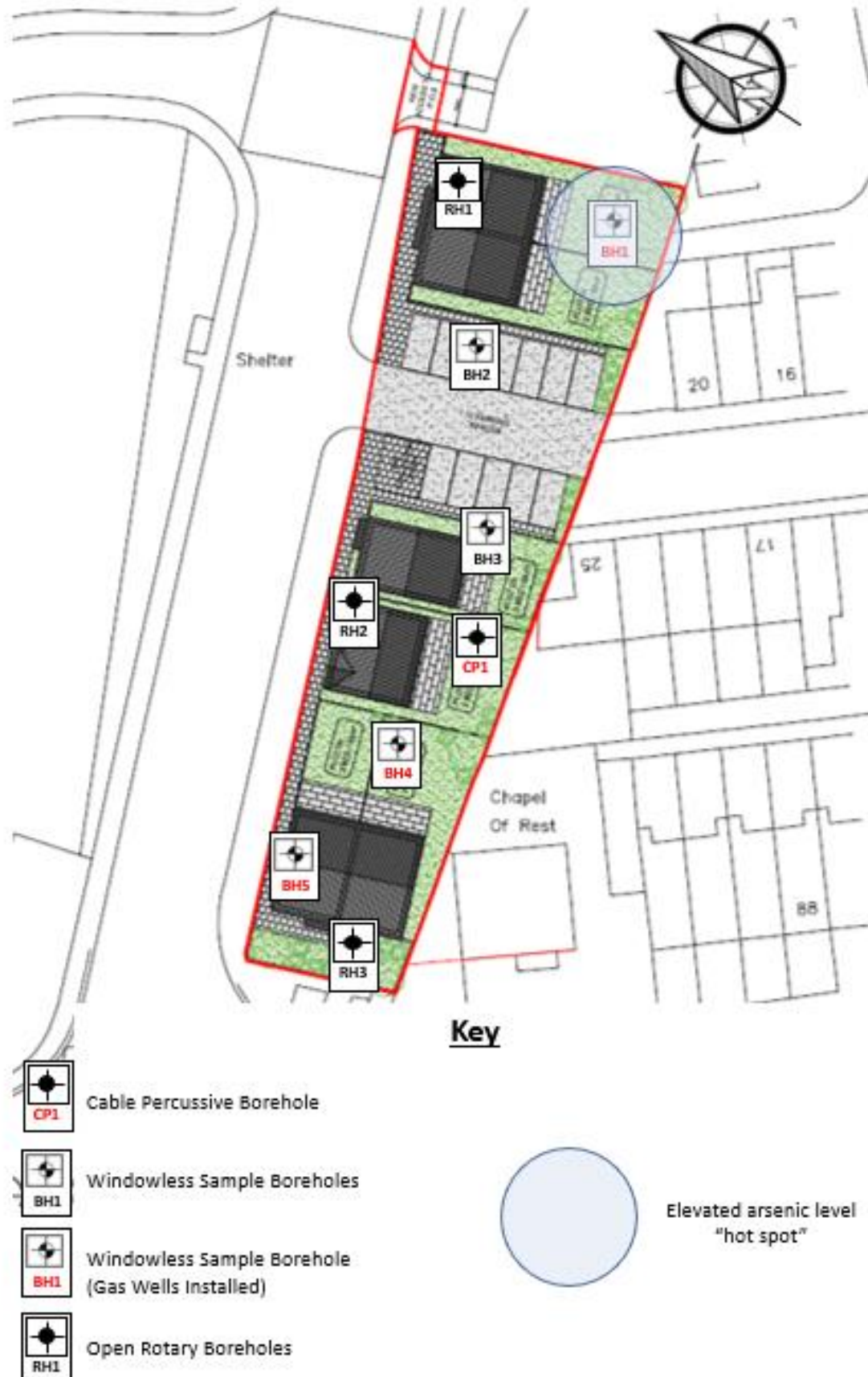
Email enquiries@geoinvestigate.co.uk

APPENDIX 1

Site Plan and Borehole Logs

GEOINVESTIGATE Ltd.

OUR REF: G21119	YOUR REF:	SITE PLAN (NOT TO SCALE)
DATE: 27/04/2021	LOCATION: Land at Fieldsend Road, Goldthorpe, S63 9AA	



GEOINVESTIGATE Ltd.

Your Ref.

Our Ref.

G21119

BH No.1 Sheet No. 1 of 1

Location: Land at Fieldsend Road, Goldthorpe S63 9AA

DATE: 29/03/21

Depth (m)	Description of Strata	Thickness	Legend	Gas Well	Sample	Test Type Result	SPT N Value (Depth)	Depth to Water	Depth (m)
0.25	ASPHALT HARDSTANDING	250			O	Cv kN/m ²			0.25
0.50	MADE GROUND. Dense white and light grey sandy gravel. Gravel is fine to coarse of concrete and dolomite.	150			O				0.50
	MADE GROUND. Medium dense black and grey very clayey sandy gravel/sandy gravelly clay/colliery spoil. Gravel is fine to coarse of mudstone, ironstone and coal.				O S		1.00m - 1.45m 3/4/5/5/5/6 N = 21		0.75
					O S				1.00
					O				1.25
	Much poor quality coal gravel from 1.30m to 1.70m.				O				1.50
		2500			O S		2.00m - 2.45m 3/3/3/3/3/3 N = 12		1.75
					O S				2.00
					O				2.25
					O				2.50
3.00					O S		3.00m - 3.45m 3/4/5/3/3/3 N = 14		2.75
					O S				3.00
	Borehole terminated at 3.00m								

Remarks:

No casing
 Dynamic windowless sampling by Terrier Rig to 3.00m
 Borehole remained dry on completion
 Gas well installed to 2.70m with gas bung and cover

Key:

Slotted Pipe
 Plain Pipe
 Bentonite
 Gravel Filter

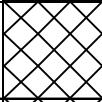
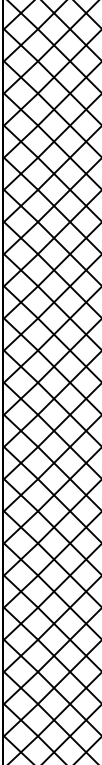
Disturbed sample
 Cv Shear vane
 W Water sample
 S Standard Penetration Test

BH1

GEOINVESTIGATE Ltd.**Your Ref.****Our Ref.**

G21119

BH No.2 Sheet No. 1 of 1**Location:** Land at Fieldsend Road, Goldthorpe S63 9AA**DATE:** 29/03/21

Depth (m)	Description of Strata	Thickness	Legend	Gas Well	Sample	Test Type Result	SPT N Value (Depth)	Depth to Water	Depth (m)
0.25	ASPHALT HARDSTANDING	250				Cv kN/m ²			0.25
0.60	MADE GROUND. Dense light yellowish brown sandy gravel. Gravel is fine to coarse concrete and sandstone.	550			O				0.50
	MADE GROUND. Medium dense black and grey very clayey sandy gravel/sandy gravelly clay/colliery spoil. Gravel is fine to coarse of mudstone, ironstone and coal. Much poor quality coal in places.				O S		1.00m - 1.45m 4/5/5/5/6/6 N = 22		0.75
									1.00
									1.25
					O				1.50
									1.75
	Plastic noted at 1.80m.	2400			O S		2.00m - 2.45m 4/4/3/3/3/3 N = 12		2.00
									2.25
					O				2.50
									2.75
3.00					O S		3.00m - 3.45m 3/3/4/3/4/3 N = 14		3.00
	Borehole terminated at 3.00m								

Remarks:

No casing

Dynamic windowless sampling by Terrier Rig to 3.00m

Borehole remained dry on completion

Key:
 Slotted Pipe
 Plain Pipe
 Bentonite
 Gravel Filter
O Disturbed sample**Cv** Shear vane**W** Water sample**S** Standard Penetration Test**BH2**

GEOINVESTIGATE Ltd.

Your Ref.

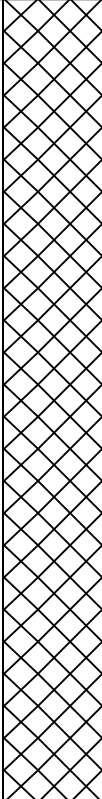
Our Ref.

G21119

BH No.3 Sheet No. 1 of 1

Location: Land at Fieldsend Road, Goldthorpe S63 9AA

DATE: 29/03/21

Depth (m)	Description of Strata	Thickness	Legend	Gas Well	Sample	Test Type Result	SPT N Value (Depth)	Depth to Water	Depth (m)
0.25	ASPHALT HARDSTANDING	250				Cv kN/m ²			0.30
0.50	MADE GROUND. Dense light yellowish brown sandy gravel. Gravel is fine to coarse of concrete and dolomite.	250			O				0.50
	MADE GROUND. Medium dense black and grey very clayey sandy gravel/sandy gravelly clay/colliery spoil. Gravel is fine to coarse of mudstone, ironstone and coal. Much poor quality coal in places.				O S		1.00m - 1.45m 3/4/5/6/5/6 N = 22		0.75
									1.00
									1.25
					O				1.50
									1.75
		2500			O S		2.00m - 2.45m 3/3/3/3/3/3 N = 12		2.00
									2.25
					O				2.50
									2.75
3.00					O S		3.00m - 3.45m 3/3/3/3/4/4 N = 14		3.00
	Borehole terminated at 3.00m								

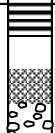
Remarks:

No casing

Dynamic windowless sampling by Terrier Rig to 3.00m

Borehole remained dry on completion

Key:



Slotted Pipe
Plain Pipe
Bentonite
Gravel Filter

O Disturbed sample
Cv Shear vane
W Water sample
S Standard Penetration Test

BH3

GEOINVESTIGATE Ltd.

Your Ref.

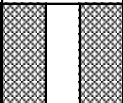
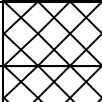
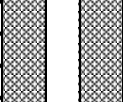
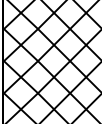
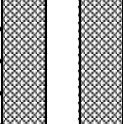
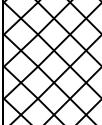
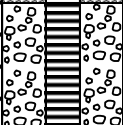
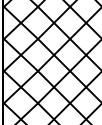
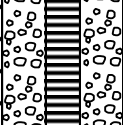
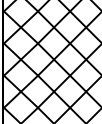
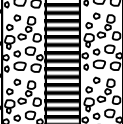
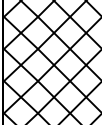
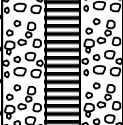
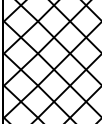
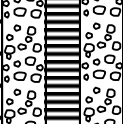
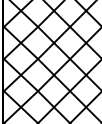
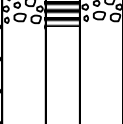
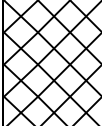
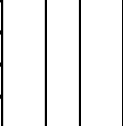
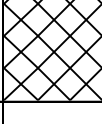
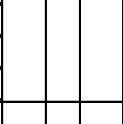
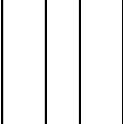
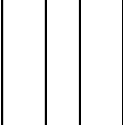
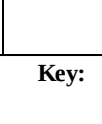
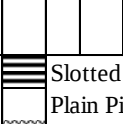
Our Ref.

G21119

BH No.4 Sheet No. 1 of 1

Location: Land at Fieldsend Road, Goldthorpe S63 9AA

DATE: 29/03/21

Depth (m)	Description of Strata	Thickness	Legend	Gas Well	Sample	Test Type Result	SPT N Value (Depth)	Depth to Water	Depth (m)
0.25	4 and BH5	250			O	Cv kN/m ²			0.30
0.50	MADE GROUND. Dense light yellowish brown sandy gravel. Gravel is fine to coarse of concrete and dolomite.	250			O				0.50
	MADE GROUND. Medium dense black and grey very clayey sandy gravel/sandy gravelly clay/colliery spoil. Gravel is fine to coarse of mudstone, ironstone and coal. Much poor quality coal in places.				O S		1.00m - 1.45m 3/4/5/6/6/6 N = 23		0.75
					O				1.25
					O S		2.00m - 2.45m 4/3/3/3/3/3 N = 12		1.50
					O S				1.75
	Becoming loose below 2.30m.	3500			O				2.00
					O S		3.00m - 3.45m 3/3/3/1/1/1 N = 6		2.25
					O				2.50
					O S				2.75
					O				3.00
					O S		4.00m - 4.45m 1/1/1/1/1/1 N = 4		3.25
4.00					O S				3.50
									3.75
	Borehole terminated at 4.00m								4.00

Remarks:

No casing

Dynamic windowless sampling by Terrier Rig to 4.00m

Borehole remained dry on completion

Gas well installed to 3.00m with gas bung and cover

Key:

 Slotted Pipe Plain Pipe Bentonite Gravel Filter

O Disturbed sample

Cv Shear vane

W Water sample

S Standard Penetration Test

BH4

GEOINVESTIGATE Ltd.

Your Ref.

Our Ref.

G21119

BH No.5 Sheet No. 1 of 1

Location: Land at Fieldsend Road, Goldthorpe S63 9AA

DATE: 29/03/21

Depth (m)	Description of Strata	Thickness	Legend	Gas Well	Sample	Test Type Result	SPT N Value (Depth)	Depth to Water	Depth (m)
0.25	ASPHALT HARDSTANDING	250			O	Cv kN/m ²			0.30
0.50	MADE GROUND. Dense light yellowish brown sandy gravel. Gravel is fine to coarse of concrete and dolomite.	250			O				0.50
	MADE GROUND. Medium dense black and grey very clayey sandy gravel/sandy gravelly clay/colliery spoil. Gravel is fine to coarse of mudstone, ironstone and coal. Lots of poor quality coal in places.				O S		1.00m - 1.45m 3/4/4/5/5/5 N = 19		0.75
					O				1.25
		2500			O S		2.00m - 2.45m 3/3/3/3/3/3 N = 12		1.50
					O				1.75
					O S				2.00
					O				2.25
					O				2.50
					O S		3.00m - 3.45m 3/4/3/1/4/4 N = 12		2.75
					O				3.00
					O				3.25
	Loose to medium dense from 3.50m.				O				3.50
4.00					O S		4.00m - 4.45m 2/2/3/2/2/2 N = 9		3.75
	Borehole terminated at 4.00m								4.00

Remarks:

No casing

Dynamic windowless sampling by Terrier Rig to 4.00m

Borehole remained dry on completion

Gas well installed to 3.00m with gas bung and cover

Key:

Slotted Pipe

Plain Pipe

Bentonite

Gravel Filter

O Disturbed sample

Cv Shear vane

W Water sample

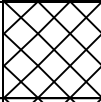
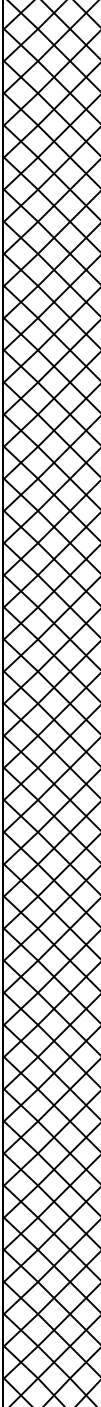
S Standard Penetration Test

BH5

GEOINVESTIGATE Ltd.**Your Ref.****Our Ref.**

G21119

CP No.1 Sheet No. 1 of 1**Location:** Land at Fieldsend Road, Goldthorpe S63 9AA**DATE:** 30/03/21

Depth (m)	Description of Strata	Thickness	Legend	Gas Well	Sample	Test Type Result	SPT N Value (Depth)	Depth to Water	Depth (m)
0.30	MADE GROUND: Black Tarmac	300			O	Cv kN/m ²			0.25
0.50	MADE GROUND. Dense white and light grey sandy gravel. Gravel is fine to coarse of concrete and dolomite.	200			O				0.50
	MADE GROUND. Medium dense black and grey very clayey sandy gravel/sandy gravelly clay/colliery spoil. Gravel is fine to coarse of mudstone, ironstone and coal.				S		1.00m - 1.45m 3/3/4/4/5/6 N = 19		0.75
	Mostly poor quality coal between 1.30m and 1.70m.				O				1.25
					O				1.50
					S		2.00m - 2.45m 2/2/3/3/4/3 N = 11		1.75
					O				2.00
					O				2.25
					O				2.50
		6600			S		3.00m - 3.45m 2/3/2/4/3/4 N = 13		2.75
					O				3.00
					O				3.25
					O				3.50
					S		4.00m - 4.45m 2/2/2/2/2/2 N = 8		3.75
					O				4.00
					O				4.25
					O				4.50
					S		5.00m - 5.45m 3/3/3/3/2/4 N = 12		4.75
					S				5.00

Remarks:

No casing
Cable Percussive Drilling to 7.95m using Dando 2000
Borehole remained dry on completion
30mins Chiselling between 7.30m and 7.50m

Key:

 Slotted Pipe
 Plain Pipe
 Bentonite
 Gravel Filter

O Disturbed sample
Cv Shear vane
W Water sample
S Standard Penetration Test

CP1

GEOINVESTIGATE Ltd.

Your Ref.

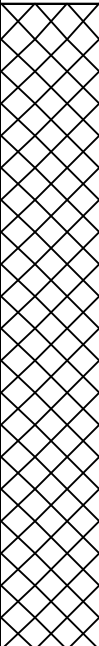
Our Ref.

G21119

CP No.1 Sheet No. 2 of 2

Location: Land at Fieldsend Road, Goldthorpe S63 9AA

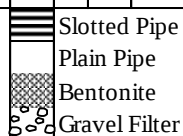
DATE: 30/03/21

Depth (m)	Description of Strata	Thickness	Legend	Gas Well	Sample	Test Type Result	SPT N Value (Depth)	Depth to Water	Depth (m)
7.10	MADE GROUND. Medium dense black and grey very clayey sandy gravel/sandy gravelly clay/colliery spoil. Gravel is fine to coarse of mudstone, ironstone and coal. Sandstone cobbles noted below 6.50m	6600				O	Cv kN/m ²		5.25
									5.50
									5.75
						S	6.00m - 6.45m 5/4/3/3/2/4 N = 12		6.00
									6.25
						O			6.50
									6.75
						O			7.00
7.95	Grey weathered SANDSTONE	850				S	7.50m - 7.95m 25/50+ N = 50+		7.25
									7.50
									7.75
									7.95
	Borehole terminated at 7.95m								

Remarks:

No casing
Cable Percussive Drilling to 7.95m using Dando 2000
Borehole remained dry on completion
30mins Chiselling between 7.30m and 7.50m

Key:



O Disturbed sample
Cv Shear vane
W Water sample
S Standard Penetration Test
C Cone Penetration Test

CP1

GEOINVESTIGATE Ltd.

Your Ref. S21119

Our Ref.

RH No.1 Sheet No. 2 of 2

Location: Land at Fieldsend Road, Goldthorpe, S63 9AA

DATE: 26/04/21

[illegible]

Remarks: Casing to 1.50m

Microdrill rotary open hole borehole to 30m

No cores recovered from borehole

No gas detected from borehole on completion

Full flush returned below 8.10m. No voids encountered.

Key:



Slotted Pipe			
--------------	--	--	--

Plain Pipe

Bentonite

Gravel Filter

O Disturbed sample

Cv Shear vane

W Water sample

S Standard Penetration Test

C Cone Penetration Test

RH1

GEOINVESTIGATE Ltd.

Your Ref. S21119

Our Ref.

RH No.2 Sheet No. 1 of 2

Location: Land at Fieldsend Road, Goldthorpe, S63 9AA

DATE: 26/04/21

[illegible]

Remarks: Casing to 2.00m

Microdrill rotary open hole borehole to 40m

No cores recovered from borehole

No gas detected from borehole on completion

No flush returns below 2.60m. No voids encountered.

Key:

Slotted Pipe

	Plain Pipe
---	------------

	Bentonite
---	-----------

 Gravel Filter

0	Disturbed sample
---	------------------

Cv Shear vane

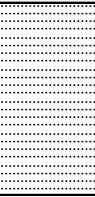
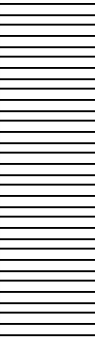
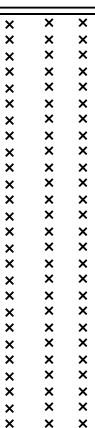
W Water sample

S Standard Penetration Test

C Cone Penetration Test

RH2

GEOINVESTIGATE Ltd.**Your Ref.** S21119**Our Ref.****RH No.1 Sheet No. 2 of 2****Location:** Land at Fieldsend Road, Goldthorpe, S63 9AA**DATE:** 26/04/21

Depth (m)	Description of Strata	Thick- ness	Legend	Gas Well	Sample	Test Type Result	Flush	Depth to Water	Depth (m)
28.50	Grey SANDSTONE interbedded with SILTSTONE	1500							27.50
33.60	Grey MUDSTONE	5100							30.00 32.50
40.0	Grey SILTSTONE	6400							35.00 37.50 40.00

Remarks: Casing to 2.00m

Microdrill rotary open hole borehole to 40m

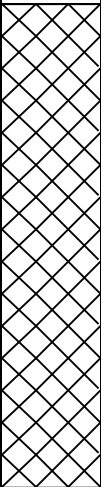
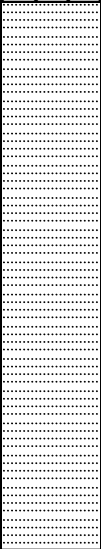
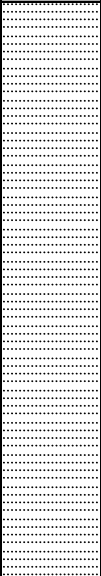
No cores recovered from borehole

No gas detected from borehole on completion

No flush returns below 2.60m. No voids encountered.

Key:
 Slotted Pipe
 Plain Pipe
 Bentonite
 Gravel Filter
O Disturbed sample**Cv** Shear vane**W** Water sample**S** Standard Penetration Test**C** Cone Penetration Test**RH2**

GEOINVESTIGATE Ltd.**Your Ref.** S21119**Our Ref.****RH No.3 Sheet No. 1 of 2****Location:** Land at Fieldsend Road, Goldthorpe, S63 9AA**DATE:** 26/04/21

Depth (m)	Description of Strata	Thick- ness	Legend	Gas Well	Sample	Test Type Result	Flush	Depth to Water	Depth (m)
7.30	TARMAC and brown DRIFT	7300					5.80m No Flush Returns		2.50 5.00 7.50
17.1	Light brown SANDSTONE	9800							10.00 12.50 15.00
	Grey SANDSTONE interbedded with SILTSTONE	7900							17.50 20.00 22.50 25.00

Remarks: Casing to 2.00m

Microdrill rotary open hole borehole to 30m

No cores recovered from borehole

No gas detected from borehole on completion

No flush returns below 5.80m. No voids encountered.

Key:
 Slotted Pipe
 Plain Pipe
 Bentonite
 Gravel Filter
O Disturbed sample**Cv** Shear vane**W** Water sample**S** Standard Penetration Test**C** Cone Penetration Test**RH3**

GEOINVESTIGATE Ltd.**Your Ref.** S21119**Our Ref.****RH No.3 Sheet No. 2 of 2****Location:** Land at Fieldsend Road, Goldthorpe, S63 9AA**DATE:** 26/04/21

Depth (m)	Description of Strata	Thick- ness	Legend	Gas Well	Sample	Test Type Result	Flush	Depth to Water	Depth (m)
26.30	Grey SANDSTONE interbedded with SILTSTONE	1300							
30.00	Grey MUDSTONE	3700							27.50
									30.00

Remarks: Casing to 2.00m

Microdrill rotary open hole borehole to 30m

No cores recovered from borehole

No gas detected from borehole on completion

No flush returns below 5.80m. No voids encountered.

Key:

Slotted Pipe

Plain Pipe

Bentonite

Gravel Filter

O Disturbed sample**Cv** Shear vane**W** Water sample**S** Standard Penetration Test**C** Cone Penetration Test**RH3**

APPENDIX 2

Chemtech Analytical Test Report

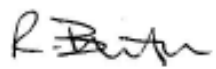


ANALYTICAL TEST REPORT

Contract no: 94935
Contract name: Proposed Dwellings - Fieldsend Road, Goldthorpe, S63 9AA
Client reference: G21119
Clients name: Geo Investigate
Clients address: Units 3a & 4 Terry Dicken Industrial Estate
Ellerbeck Way, Stokesley
North Yorkshire
TS9 7AE
Samples received: 31 March 2021
Analysis started: 31 March 2021
Analysis completed: 09 April 2021
Report issued: 09 April 2021

Notes: Opinions and interpretations expressed herein are outside the UKAS accreditation scope.
Unless otherwise stated, Chemtech Environmental Ltd was not responsible for sampling.
All testing carried out at Unit 6 Parkhead, Stanley, DH9 7YB, except for subcontracted testing.
Methods, procedures and performance data are available on request.
Results reported herein relate only to the material supplied to the laboratory.
This report shall not be reproduced except in full, without prior written approval.
Samples will be disposed of 6 weeks from initial receipt unless otherwise instructed.

Key: U UKAS accredited test
M MCERTS & UKAS accredited test
\$ Test carried out by an approved subcontractor
I/S Insufficient sample to carry out test
N/S Sample not suitable for testing
NAD No Asbestos Detected

Approved by: 
Rachael Burton
Customer Support Squad Leader

Chemtech Environmental Limited

SAMPLE INFORMATION

MCERTS (Soils):

Soil descriptions are only intended to provide a log of sample matrices with respect to MCERTS validation. They are not intended as full geological descriptions. MCERTS accreditation applies for sand, clay and loam/topsoil, or combinations of these whether these are derived from naturally occurring soils or from made ground, as long as these materials constitute the major part of the sample. Other materials such as concrete, gravel and brick are not accredited if they comprise the major part of the sample.

All results are reported on a dry basis. Samples dried at no more than 30°C in a drying cabinet.

Analytical results are inclusive of stones.

Lab ref	Sample id	Depth (m)	Sample description	Material removed	% Removed	% Moisture
94935-1	BH1	0.50	Clayey Sand with Gravel	-	-	14.3
94935-2	BH3	1.00	Sand with Gravel	-	-	10.8
94935-3	BH4	0.50	Sand with Gravel	-	-	12.2
94935-4	BH4	2.50	Sand with Gravel	-	-	7.6
94935-5	BH5	0.30	Sand with Gravel	-	-	5.7
94935-6	BH5	0.50	Sand with Gravel	-	-	11.1

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SOILS

Lab number			94935-1	94935-2	94935-3	94935-4	94935-5	94935-6
Sample id			BH1	BH3	BH4	BH4	BH5	BH5
Depth (m)			0.50	1.00	0.50	2.50	0.30	0.50
Date sampled			29/03/2021	29/03/2021	29/03/2021	29/03/2021	29/03/2021	29/03/2021
Test	Method	Units						
Arsenic (total)	CE127 ^H	mg/kg As	48	24	22	6.5	<1	20
Boron (water soluble)	CE063	mg/kg B	3.1	5.2	3.3	5.0	<0.5	2.8
Cadmium (total)	CE127 ^H	mg/kg Cd	<0.2	0.2	<0.2	<0.2	0.7	<0.2
Chromium (total)	CE127 ^H	mg/kg Cr	25	26	20	36	10	21
Chromium (III)	CE208	mg/kg CrIII	25	26	20	36	10	21
Chromium (VI)	CE146	mg/kg CrVI	<1	<1	<1	<1	<1	<1
Copper (total)	CE127 ^H	mg/kg Cu	56	54	46	33	4.0	61
Lead (total)	CE127 ^H	mg/kg Pb	38	29	24	19	12	29
Mercury (total)	CE127 ^H	mg/kg Hg	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Nickel (total)	CE127 ^H	mg/kg Ni	31	40	21	43	3.0	32
Selenium (total)	CE127 ^H	mg/kg Se	3.0	2.4	2.4	1.7	<0.3	3.9
Zinc (total)	CE127 ^H	mg/kg Zn	86	78	35	56	59	38
pH	CE004 ^H	units	5.3	6.9	6.6	6.8	9.1	8.4
Sulphate (2:1 water soluble)	CE061	mg/l SO ₄	199	630	414	957	29	88
Sulphide	CE079	mg/kg S ²⁻	<10	<10	<10	<10	<10	<10
Cyanide (free)	CE077	mg/kg CN	<1	<1	<1	<1	<1	<1
Cyanide (total)	CE077	mg/kg CN	<1	<1	<1	<1	<1	<1
Thiocyanate	CE145 ^H	mg/kg SCN	<1	<1	<1	<1	<1	<1
Phenols (total)	CE078	mg/kg PhOH	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Total Organic Carbon (TOC)	CE197	% w/w C	32.4	21.5	39.8	7.1	0.8	37.9
Estimate of OMC (calculated from TOC)	CE197	% w/w	55.9	37.0	68.7	12.2	1.3	65.4
PAH								
Acenaphthene	CE087 ^H	mg/kg	<0.02	0.02	<0.02	0.03	<0.02	<0.02
Acenaphthylene	CE087 ^H	mg/kg	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Anthracene	CE087 ^U	mg/kg	0.03	0.05	0.04	0.03	<0.02	0.04
Benzo(a)anthracene	CE087 ^U	mg/kg	0.04	0.04	0.04	0.04	<0.02	0.03
Benzo(a)pyrene	CE087 ^U	mg/kg	0.03	0.04	0.02	0.04	<0.02	0.02
Benzo(b)fluoranthene	CE087 ^H	mg/kg	0.04	0.06	0.04	0.06	0.07	0.04
Benzo(ghi)perylene	CE087 ^H	mg/kg	<0.02	0.03	<0.02	0.03	0.02	<0.02
Benzo(k)fluoranthene	CE087 ^H	mg/kg	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
Chrysene	CE087 ^H	mg/kg	0.04	0.05	0.04	0.05	0.06	0.04
Dibenz(ah)anthracene	CE087 ^H	mg/kg	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Fluoranthene	CE087 ^H	mg/kg	0.09	0.09	0.07	0.09	0.04	0.06
Fluorene	CE087 ^U	mg/kg	0.02	<0.02	<0.02	0.05	<0.02	0.03
Indeno(123cd)pyrene	CE087 ^H	mg/kg	<0.02	0.03	<0.02	0.03	<0.02	<0.02
Naphthalene	CE087 ^H	mg/kg	0.80	1.00	1.10	0.85	<0.02	1.06
Phenanthrene	CE087 ^H	mg/kg	0.36	0.30	0.27	0.32	0.06	0.25
Pyrene	CE087 ^H	mg/kg	0.09	0.11	0.09	0.10	0.08	0.07
PAH (total of USEPA 16)	CE087	mg/kg	1.54	1.83	1.71	1.72	<0.34	1.63

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SOILS

Lab number			94935-1	94935-2	94935-3	94935-4	94935-5	94935-6
Sample id			BH1	BH3	BH4	BH4	BH5	BH5
Depth (m)			0.50	1.00	0.50	2.50	0.30	0.50
Date sampled			29/03/2021	29/03/2021	29/03/2021	29/03/2021	29/03/2021	29/03/2021
Test	Method	Units						
TPH								
VPH Aromatic (>EC5-EC7)	CE067	mg/kg	<0.01	<0.01	<0.01	-	<0.01	<0.01
VPH Aromatic (>EC7-EC8)	CE067	mg/kg	<0.01	<0.01	<0.01	-	<0.01	0.02
VPH Aromatic (>EC8-EC10)	CE067	mg/kg	<0.01	0.01	<0.01	-	<0.01	0.02
EPH Aromatic (>EC10-EC12)	CE068	mg/kg	<1	2	2	-	<1	2
EPH Aromatic (>EC12-EC16)	CE068	mg/kg	<1	<1	<1	-	<1	<1
EPH Aromatic (>EC16-EC21)	CE068	mg/kg	<1	<1	<1	-	<1	<1
EPH Aromatic (>EC21-EC35)	CE068	mg/kg	<1	<1	<1	-	<1	<1
EPH Aromatic (>EC35-EC44)	CE068	mg/kg	<1	<1	<1	-	<1	<1
VPH Aliphatic (>C5-C6)	CE067	mg/kg	<0.1	<0.1	<0.1	-	<0.1	<0.1
VPH Aliphatic (>C6-C8)	CE067	mg/kg	0.1	<0.1	<0.1	-	<0.1	<0.1
VPH Aliphatic (>C8-C10)	CE067	mg/kg	<0.1	<0.1	<0.1	-	<0.1	<0.1
EPH Aliphatic (>C10-C12)	CE068	mg/kg	11	5	7	-	<4	9
EPH Aliphatic (>C12-C16)	CE068	mg/kg	46	28	32	-	<4	35
EPH Aliphatic (>C16-C35)	CE068	mg/kg	199	124	138	-	149	127
EPH Aliphatic (>C35-C44)	CE068	mg/kg	25	17	14	-	98	13
PCB								
PCB Congener 28	CE137 ^M	mg/kg	-	-	-	-	<0.004	-
PCB Congener 52	CE137 ^M	mg/kg	-	-	-	-	<0.004	-
PCB Congener 101	CE137 ^M	mg/kg	-	-	-	-	<0.008	-
PCB Congener 118	CE137 ^M	mg/kg	-	-	-	-	<0.006	-
PCB Congener 138	CE137 ^M	mg/kg	-	-	-	-	<0.006	-
PCB Congener 153	CE137 ^M	mg/kg	-	-	-	-	<0.009	-
PCB Congener 180	CE137 ^M	mg/kg	-	-	-	-	<0.008	-
PCB (total of ICES 7)	CE137 ^M	mg/kg	-	-	-	-	<0.045	-
Subcontracted analysis								
Asbestos (qualitative)	\$	-	NAD	NAD	NAD	-	NAD	-

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PREPARED LEACHATES

Lab number			94935-4L	94935-5L
Sample id			BH4	BH5
Depth (m)			2.50	0.30
Test	Method	Units		
Arsenic (dissolved)	CE128 ^U	µg/l As	0.12	0.29
Boron (dissolved)	CE128 ^U	µg/l B	213	17
Cadmium (dissolved)	CE128 ^U	µg/l Cd	<0.07	<0.07
Chromium (dissolved)	CE128 ^U	µg/l Cr	<0.2	<0.2
Copper (dissolved)	CE128 ^U	µg/l Cu	0.6	0.8
Lead (dissolved)	CE128 ^U	µg/l Pb	<0.2	<0.2
Mercury (dissolved)	CE128 ^U	µg/l Hg	<0.008	<0.008
Nickel (dissolved)	CE128 ^U	µg/l Ni	7.8	0.5
Selenium (dissolved)	CE128 ^U	µg/l Se	2.62	0.29
Zinc (dissolved)	CE128 ^U	µg/l Zn	3	<1
pH	CE213 ^U	units	8.3	8.4
Sulphate	CE049 ^U	mg/l SO ₄	206	<1.7
Sulphur (dissolved)	CE128 ^U	mg/l S	66.9	4.8
Sulphide	CE079	µg/l S ²⁻		
Cyanide (free)	CE147	µg/l CN	<20	<20
Cyanide (total)	CE147	µg/l CN	<20	<20
Thiocyanate	CE014	µg/l SCN	<200	320.3
Phenols (total)	CE148	µg/l PhOH	<10	<10
PAH				
Acenaphthene	CE051	µg/l	1.3	0.8
Acenaphthylene	CE051	µg/l	<0.1	<0.1
Anthracene	CE051	µg/l	<0.1	<0.1
Benzo(a)anthracene	CE051	µg/l	<0.1	<0.1
Benzo(a)pyrene	CE051	µg/l	<0.1	<0.1
Benzo(b)fluoranthene	CE051	µg/l	<0.1	<0.1
Benzo(ghi)perylene	CE051	µg/l	<0.1	<0.1
Benzo(k)fluoranthene	CE051	µg/l	<0.1	<0.1
Chrysene	CE051	µg/l	<0.1	<0.1
Dibenz(ah)anthracene	CE051	µg/l	<0.1	<0.1
Fluoranthene	CE051	µg/l	<0.1	<0.1
Fluorene	CE051	µg/l	1.2	0.9
Indeno(123cd)pyrene	CE051	µg/l	<0.1	<0.1
Naphthalene	CE051	µg/l	<0.1	<0.1
Phenanthrene	CE051	µg/l	0.1	<0.1
Pyrene	CE051	µg/l	<0.1	<0.1
PAH (total of USEPA 16)	CE051	µg/l	2.6	1.7

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METHOD DETAILS

METHOD	SOILS	METHOD SUMMARY	SAMPLE	STATUS	LOD	UNITS
CE127	Arsenic (total)	Aqua regia digest, ICP-MS	Dry	M	1	mg/kg As
CE063	Boron (water soluble)	Hot water extract, ICP-OES	Dry		0.5	mg/kg B
CE127	Cadmium (total)	Aqua regia digest, ICP-MS	Dry	M	0.2	mg/kg Cd
CE127	Chromium (total)	Aqua regia digest, ICP-MS	Dry	M	1	mg/kg Cr
CE208	Chromium (III)	Calculation: Cr (total) - Cr (VI)	Dry		1	mg/kg CrIII
CE146	Chromium (VI)	Acid extraction, Colorimetry	Dry		1	mg/kg CrVI
CE127	Copper (total)	Aqua regia digest, ICP-MS	Dry	M	1	mg/kg Cu
CE127	Lead (total)	Aqua regia digest, ICP-MS	Dry	M	1	mg/kg Pb
CE127	Mercury (total)	Aqua regia digest, ICP-MS	Dry	M	0.5	mg/kg Hg
CE127	Nickel (total)	Aqua regia digest, ICP-MS	Dry	M	1	mg/kg Ni
CE127	Selenium (total)	Aqua regia digest, ICP-MS	Dry	M	0.3	mg/kg Se
CE127	Zinc (total)	Aqua regia digest, ICP-MS	Dry	M	5	mg/kg Zn
CE004	pH	Based on BS 1377, pH Meter	As received	M	-	units
CE061	Sulphate (2:1 water soluble)	Aqueous extraction, ICP-OES	Dry		10	mg/l SO ₄
CE079	Sulphide	Extraction, Continuous Flow Colorimetry	As received		10	mg/kg S ²⁻
CE077	Cyanide (free)	Extraction, Continuous Flow Colorimetry	As received		1	mg/kg CN
CE077	Cyanide (total)	Extraction, Continuous Flow Colorimetry	As received		1	mg/kg CN
CE145	Thiocyanate	Weak acid extraction, Colorimetry	Dry	M	1	mg/kg SCN
CE078	Phenols (total)	Extraction, Continuous Flow Colorimetry	As received		0.5	mg/kg PhOH
CE197	Total Organic Carbon (TOC)	Carbon Analyser	Dry		0.1	% w/w C
CE197	Estimate of OMC (calculated from TOC)	Calculation from Total Organic Carbon	Dry		0.1	% w/w
CE087	Acenaphthene	Solvent extraction, GC-MS	As received	M	0.02	mg/kg
CE087	Acenaphthylene	Solvent extraction, GC-MS	As received	M	0.02	mg/kg
CE087	Anthracene	Solvent extraction, GC-MS	As received	U	0.02	mg/kg
CE087	Benzo(a)anthracene	Solvent extraction, GC-MS	As received	U	0.02	mg/kg
CE087	Benzo(a)pyrene	Solvent extraction, GC-MS	As received	U	0.02	mg/kg
CE087	Benzo(b)fluoranthene	Solvent extraction, GC-MS	As received	M	0.02	mg/kg
CE087	Benzo(ghi)perylene	Solvent extraction, GC-MS	As received	M	0.02	mg/kg
CE087	Benzo(k)fluoranthene	Solvent extraction, GC-MS	As received	M	0.03	mg/kg
CE087	Chrysene	Solvent extraction, GC-MS	As received	M	0.03	mg/kg
CE087	Dibenz(ah)anthracene	Solvent extraction, GC-MS	As received	M	0.02	mg/kg
CE087	Fluoranthene	Solvent extraction, GC-MS	As received	M	0.02	mg/kg
CE087	Fluorene	Solvent extraction, GC-MS	As received	U	0.02	mg/kg
CE087	Indeno(123cd)pyrene	Solvent extraction, GC-MS	As received	M	0.02	mg/kg
CE087	Naphthalene	Solvent extraction, GC-MS	As received	M	0.02	mg/kg
CE087	Phenanthrene	Solvent extraction, GC-MS	As received	M	0.02	mg/kg
CE087	Pyrene	Solvent extraction, GC-MS	As received	M	0.02	mg/kg
CE087	PAH (total of USEPA 16)	Solvent extraction, GC-MS	As received		0.34	mg/kg
CE067	VPH Aromatic (>EC5-EC7)	Headspace GC-FID	As received		0.01	mg/kg
CE067	VPH Aromatic (>EC7-EC8)	Headspace GC-FID	As received		0.01	mg/kg
CE067	VPH Aromatic (>EC8-EC10)	Headspace GC-FID	As received		0.01	mg/kg
CE068	EPH Aromatic (>EC10-EC12)	Solvent extraction, GC-FID	As received		1	mg/kg
CE068	EPH Aromatic (>EC12-EC16)	Solvent extraction, GC-FID	As received		1	mg/kg
CE068	EPH Aromatic (>EC16-EC21)	Solvent extraction, GC-FID	As received		1	mg/kg

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METHOD DETAILS

METHOD	SOILS	METHOD SUMMARY	SAMPLE	STATUS	LOD	UNITS
CE068	EPH Aromatic (>EC21-EC35)	Solvent extraction, GC-FID	As received		1	mg/kg
CE068	EPH Aromatic (>EC35-EC44)	Solvent extraction, GC-FID	As received		1	mg/kg
CE067	VPH Aliphatic (>C5-C6)	Headspace GC-FID	As received		0.1	mg/kg
CE067	VPH Aliphatic (>C6-C8)	Headspace GC-FID	As received		0.1	mg/kg
CE067	VPH Aliphatic (>C8-C10)	Headspace GC-FID	As received		0.1	mg/kg
CE068	EPH Aliphatic (>C10-C12)	Solvent extraction, GC-FID	As received		4	mg/kg
CE068	EPH Aliphatic (>C12-C16)	Solvent extraction, GC-FID	As received		4	mg/kg
CE068	EPH Aliphatic (>C16-C35)	Solvent extraction, GC-FID	As received		4	mg/kg
CE068	EPH Aliphatic (>C35-C44)	Solvent extraction, GC-FID	As received		10	mg/kg
CE137	PCB Congener 28	Solvent extraction, GC-MS	As received	M	0.004	mg/kg
CE137	PCB Congener 52	Solvent extraction, GC-MS	As received	M	0.004	mg/kg
CE137	PCB Congener 101	Solvent extraction, GC-MS	As received	M	0.008	mg/kg
CE137	PCB Congener 118	Solvent extraction, GC-MS	As received	M	0.006	mg/kg
CE137	PCB Congener 138	Solvent extraction, GC-MS	As received	M	0.006	mg/kg
CE137	PCB Congener 153	Solvent extraction, GC-MS	As received	M	0.009	mg/kg
CE137	PCB Congener 180	Solvent extraction, GC-MS	As received	M	0.008	mg/kg
CE137	PCB (total of ICES 7)	Solvent extraction, GC-MS	As received	M	0.045	mg/kg
\$	Asbestos (qualitative)	HSG 248, Microscopy	Dry	U	-	-

Chemtech Environmental Limited

METHOD DETAILS

METHOD	PREPARED LEACHATES	METHOD SUMMARY	STATUS	LOD	UNITS
CE002	Leachate preparation (EA)	L:S 10:1		-	-
CE128	Arsenic (dissolved)	ICP-MS	U	0.06	µg/l As
CE128	Boron (dissolved)	ICP-MS	U	8	µg/l B
CE128	Cadmium (dissolved)	ICP-MS	U	0.07	µg/l Cd
CE128	Chromium (dissolved)	ICP-MS	U	0.2	µg/l Cr
CE128	Copper (dissolved)	ICP-MS	U	0.4	µg/l Cu
CE128	Lead (dissolved)	ICP-MS	U	0.2	µg/l Pb
CE128	Mercury (dissolved)	ICP-MS	U	0.008	µg/l Hg
CE128	Nickel (dissolved)	ICP-MS	U	0.5	µg/l Ni
CE128	Selenium (dissolved)	ICP-MS	U	0.07	µg/l Se
CE128	Zinc (dissolved)	ICP-MS	U	1	µg/l Zn
CE213	pH	Based on BS 1377, pH Meter	U	-	units
CE049	Sulphate	Ion Chromatography	U	1.7	mg/l SO ₄
CE128	Sulphur (dissolved)	ICP-MS	U	0.2	mg/l S
CE079	Sulphide	Continuous Flow Colorimetry		100	µg/l S ₂ -
CE147	Cyanide (free)	Continuous Flow Colorimetry		20	µg/l CN
CE147	Cyanide (total)	Continuous Flow Colorimetry		20	µg/l CN
CE014	Thiocyanate	Colorimetry		200	µg/l SCN
CE148	Phenols (total)	Continuous Flow Colorimetry		10	µg/l PhOH
CE051	Acenaphthene	Solvent extraction, GC-MS		0.1	µg/l
CE051	Acenaphthylene	Solvent extraction, GC-MS		0.1	µg/l
CE051	Anthracene	Solvent extraction, GC-MS		0.1	µg/l
CE051	Benzo(a)anthracene	Solvent extraction, GC-MS		0.1	µg/l
CE051	Benzo(a)pyrene	Solvent extraction, GC-MS		0.1	µg/l
CE051	Benzo(b)fluoranthene	Solvent extraction, GC-MS		0.1	µg/l
CE051	Benzo(ghi)perylene	Solvent extraction, GC-MS		0.1	µg/l
CE051	Benzo(k)fluoranthene	Solvent extraction, GC-MS		0.1	µg/l
CE051	Chrysene	Solvent extraction, GC-MS		0.1	µg/l
CE051	Dibenz(ah)anthracene	Solvent extraction, GC-MS		0.1	µg/l
CE051	Fluoranthene	Solvent extraction, GC-MS		0.1	µg/l
CE051	Fluorene	Solvent extraction, GC-MS		0.1	µg/l
CE051	Indeno(123cd)pyrene	Solvent extraction, GC-MS		0.1	µg/l
CE051	Naphthalene	Solvent extraction, GC-MS		0.1	µg/l
CE051	Phenanthrene	Solvent extraction, GC-MS		0.1	µg/l
CE051	Pyrene	Solvent extraction, GC-MS		0.1	µg/l
CE051	PAH (total of USEPA 16)	Solvent extraction, GC-MS		1.6	µg/l

Chemtech Environmental Limited

DEVIATING SAMPLE INFORMATION

Comments

Sample deviation is determined in accordance with the UKAS note "Guidance on Deviating Samples" and based on reference standards and laboratory trials.

For samples identified as deviating, test result(s) may be compromised and may not be representative of the sample at the time of sampling.

Chemtech Environmental Ltd cannot be held responsible for the integrity of sample(s) received if Chemtech Environmental Ltd did not undertake the sampling. Such samples may be deviating.

Key

N	No (not deviating sample)
Y	Yes (deviating sample)
NSD	Sampling date not provided
NST	Sampling time not provided (waters only)
EHT	Sample exceeded holding time(s)
IC	Sample not received in appropriate containers
HP	Headspace present in sample container
NCF	Sample not chemically fixed (where appropriate)
OR	Other (specify)

Lab ref	Sample id	Depth (m)	Deviating	Tests (Reason for deviation)
94935-1	BH1	0.50	N	
94935-2	BH3	1.00	N	
94935-3	BH4	0.50	N	
94935-4	BH4	2.50	N	
94935-5	BH5	0.30	N	
94935-6	BH5	0.50	N	

APPENDIX 3
FULL SET OF GAS MONITORING RESULTS &
ADDITIONAL NOTES ON GAS CLASSIFICATION
AND MITIGATION OPTIONS

New guidance published in BS 8485: 2015 has indicated a new system of design and implementation of gas protection measures. The new guidance works to identify the risk to a site using the sensitivity of the receptors and the risk associated with potential sources of hazardous ground gas. The most applicable building type for this site is inferred to be Type A as shown in table 3 below.

Table 2: Building types for site classification as per BS 8485:2015

	High Risk		Medium Risk	Low Risk
	Type A Building	Type B Building	Type C Building	Type D Building
Ownership	Private	Private or commercial/public, possible multiple	Commercial/public	Commercial/public
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

Building type highlighted blue considered most applicable to current study site.

Using the building types listed in Table 2 above, BS 8485:2015 has incorporated a scoring system dependent on building type and the characteristic situation of the site in order to select the appropriate measures for hazardous gas protection. This provides a Gas protection Score (assigned using Table 3 below).

Once the required gas protection score has been determined, various potential protective measures can be considered for inclusion in the proposed structures, each of which have their own gas protection score. These measures can be combined and their gas protection scores summed to match or exceed the required gas protection score determined by Table 3. These measures include structural barriers, ventilation measures and gas resistant membranes which are graded separately within the points system. In order to ensure sufficient measures are in place; one measure is normally selected from each category (see tables for gas protection).

Table 3: Gas Protection Scoring by CS Level and Building Type

Characteristic Situation	Minimum gas protection score (points)			
	High Risk		Medium Risk	Low Risk
	Type A Building	Type B Building	Type C Building	Type D Building
CS1	0	0	0	0
CS2	3.5	3.5	2.5	1.5
CS3	4.5	4	3	2.5
CS4	6.5	5.5	4.5	3.5
CS5		6.5	5.5	4.5
CS6			7.5	6.5

Table A: Gas Protection Scores – 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 minimum) should be installed in all gas protection measures systems. If the layer has a low permeability 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 the 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 Figure B.6 and Figure B.7, respectively. The ventilation effectiveness of different media depends on a number of different factors including the transmissivity of the medium, the width of the building, the side ventilation spacing and type and the 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 to 2.5	This system relies on continued serviceability of the pumps, therefore alarm and response systems should be in place. There should be robust management systems in place to ensure the continued maintenance of the system, including pumps and vents. Active ventilation should always be designed to meet at least “good performance”, as described in Annex B.
(d) Active positive pressurization by the creation of a blanket of external fresh air beneath the building floor slab by pumps supplying air to points across the central footprint of the building into a permeable layer, usually formed of a thin geocomposite blanket	1.5 to 2.5	This system relies on continued operation of the pumps, therefore alarm and response systems should be in place. The score assigned should be based on the efficient “coverage” of the building footprint and the redundancy of the system. Active ventilation should always be designed to meet at least “good performance”.
(e) Ventilated car park (floor slab of occupied part of the building under consideration is underlain by a basement or undercroft car park)	4	Assumes that the car park is vented to deal with car exhaust fumes, designed to <i>Buildings Regulations 2000, Approved Document F</i> [9].

Table B: Gas Protection Scores – Structural Barriers

Floor and substructure design (see Annex A)	Score
Precast suspended segmental subfloor (i.e. beam and block)	0
Cast in situ ground-bearing floor slab (with only 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	1 or 1.5
Basement floor and walls conforming to BS 8102:2009, Grade 2 waterproofing ^{C)}	2
Basement floor and walls conforming to BS 8102:2009, Grade 3 waterproofing ^{C)}	2.5
A) The scores are conditional on breaches of floor slabs, etc., being effectively sealed. B) To achieve a score of 1.5 the raft or suspended slab should be well reinforced to control cracking and have minimal penetrations cast in (see A.2.2.2). C) The score is conditional on the waterproofing not being based on the use of a geosynthetic clay liner waterproofing product (see C.3 , Note 4).	

Table C: Gas Protection Score – Gas Resistant Membranes

Protection element/system	Score	Comments
Gas resistant membrane meeting all of the following criteria: • sufficiently impervious to the gases with a methane gas transmission rate <40.0 ml/day/m²/atm (average) for sheet and joints (tested in accordance with BS ISO 15105-1 manometric method); • 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. settlement if placed below a floor slab); • sufficiently strong to withstand the installation process and following trades until covered (e.g. penetration from steel fibres in fibre reinforced concrete, penetration of reinforcement ties, tearing due to working above it, dropping tools, etc); • capable, after installation, of providing a complete barrier to the entry of the relevant gas; and verified in accordance with CIRIA C735 [N1]	2	The performance of 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 0.4 mm thickness (equivalent to 370 g/m ² for polyethelene) reinforced membrane (virgin polymer) meets the performance criteria in Table 7 (see C.3). If a membrane is installed that does not meet all the criteria in column 1 then the score is zero.

Table D: Gas protection measures for low-rise housing development based upon NHBC Traffic Light system

Traffic Light Classification	Protection measures required
Green	Negligible gas regime identified and gas protection measures are not considered necessary.
Amber 1	Low to intermediate gas regime identified, which requires low – level gas protection measures, comprising a membrane and ventilated sub-floor void to create a permeability contrast to limit the ingress of gas into buildings. Gas protection measures should be prescribed as per BRE Report 414. Ventilation of sub – floor void should facilitate a minimum of one complete volume change per 24 hours.
Amber 2	Intermediate to high gas regime identified, which requires high – level gas protection measures, comprising a membrane and ventilated sub-floor void to create a permeability contrast to limit the ingress of gas into buildings. Gas protection measures should be prescribed as per BRE Report 414. Gas membranes should always be fitted by a specialist contractor. As with Amber 1, Ventilation of sub – floor void should facilitate a minimum of one complete volume change per 24 hours. Certification that these measures have been installed correctly should be provided.
Red	High gas regime identified. It is considered that standard residential housing would not be normally acceptable without a further gas risk assessment and/or possible remedial mitigation measures to reduce and/or remove the source of gas.

*Table is for illustration only; please see BRE 414 for more information on designing appropriate measures. (BRE 414 - Protective measures for housing on gas-contaminated land)

FULL SEET OF GAS MONITORING RESULTS FOR THE SITE

Job Number G21119
 Client Bliss Investment Properites Ltd
 Site Land at Fieldsend Road, Goldthorpe S63 9AA
 Instrument GFM 406 + 410

Key
 WL Water Logged
 BDL Below Detectable Levels
 NB No Bung
 WD/I Well destroyed / inaccessible

Monitoring Personal	A	Date	06/04/2021	Weather	SUN	Temperature	5°C	Starting Pressure	998 (RISING)			
Monitoring Point	Well condition	Flow range (l/hr)	Atmospheric Pressure (mb)	Methane % (v/v)	Methane % LEL	Carbon dioxide % (v/v)	Oxygen % (v/v)	Water Level (mbgl)	Depth of Well (m)	Volume of gas in well (m ³)	Hydrogen Suphide (ppm)	Carbon Monoxide (ppm)
1		<0.1	998	<0.1		1.2	18.6					
4		<0.1	998	<0.1		0.7	19.3					
5		<0.1	998	<0.1		0.0	20.0					

Monitoring Personal	A	Date	13/04/2021	Weather	SUN	Temperature	8°C	Starting Pressure	1018 (RISING)			
Monitoring Point	Well condition	Flow range (l/hr)	Atmospheric Pressure (mb)	Methane % (v/v)	Methane % LEL	Carbon dioxide % (v/v)	Oxygen % (v/v)	Water Level (mbgl)	Depth of Well (m)	Volume of gas in well (m ³)	Hydrogen Suphide (ppm)	Carbon Monoxide (ppm)
1		<0.1	1018	<0.1		4.9	10.9					
4		<0.1	1018	<0.1		2.1	17.0					
5		<0.1	1018	<0.1		0.1	20.3					

Monitoring Personal	A	Date	20/04/2021	Weather	SUN	Temperature	12°C	Starting Pressure	999 (FALLING)			
Monitoring Point	Well condition	Flow range (l/hr)	Atmospheric Pressure (mb)	Methane % (v/v)	Methane % LEL	Carbon dioxide % (v/v)	Oxygen % (v/v)	Water Level (mbgl)	Depth of Well (m)	Volume of gas in well (m ³)	Hydrogen Suphide (ppm)	Carbon Monoxide (ppm)
1		<0.1	999	<0.1		6.2	8.1					
4		<0.1	999	<0.1		7.0	10.6					
5		<0.1	999	<0.1		0.4	19.9					

Monitoring Personal	A	Date 10/05/2021		Weather	OVERCAST	Temperature 14°C		Starting Pressure 990 (RISING)				
Monitoring Point	Well condition	Flow range (l/hr)	Atmospheric Pressure (mb)	Methane % (v/v)	Methane % LEL	Carbon dioxide % (v/v)	Oxygen % (v/v)	Water Level (mbgl)	Depth of Well (m)	Volume of gas in well (m ³)	Hydrogen Sulphide (ppm)	Carbon Monoxide (ppm)
1		<0.1	990	0.2		4.1	15.9					
4		<0.1	990	0.2		9.6	6.9					
5		<0.1	990	0.2		4.8	10.9					

Monitoring Personal	SH	Date 17/05/2021		Weather	CLOUDY	Temperature 10°C		Starting Pressure 992 (FALLING)				
Monitoring Point	Well condition	Flow range (l/hr)	Atmospheric Pressure (mb)	Methane % (v/v)	Methane % LEL	Carbon dioxide % (v/v)	Oxygen % (v/v)	Water Level (mbgl)	Depth of Well (m)	Volume of gas in well (m ³)	Hydrogen Sulphide (ppm)	Carbon Monoxide (ppm)
1		<0.1	992	<0.1		4.3	16.1				<1	<1
4		<0.1	992	<0.1		8.1	13.2				<1	<1
5		<0.1	991	<0.1		0.8	20.0				<1	<1

Monitoring Personal	B	Date 26/05/2021		Weather	RAIN	Temperature 12°C		Starting Pressure 995 (RISING)				
Monitoring Point	Well condition	Flow range (l/hr)	Atmospheric Pressure (mb)	Methane % (v/v)	Methane % LEL	Carbon dioxide % (v/v)	Oxygen % (v/v)	Water Level (mbgl)	Depth of Well (m)	Volume of gas in well (m ³)	Hydrogen Sulphide (ppm)	Carbon Monoxide (ppm)
1		<0.1	995	<0.1		6.0	14.3				<1	<1
4		<0.1	995	<0.1		10.1	6.3				<1	<1
5		<0.1	995	<0.1		0.2	19.7				<1	<1