

Report on a Ground Investigation

Location:	Land off Banks Road, Linthwaite HD7 5LP		
For:	James Bamforth		
Report No.	GES 1399-21	Report date:	June 2021

For and on behalf of **GeoEnviro Solutions Ltd**

	
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01	09/06/21	Final	DS	RL	RL
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1. Introduction

GeoEnviro Solutions (GES) was instructed by James Bamforth to conduct a Site Investigation (SI) at a site known as Land off Banks Road, Linthwaite, HD7 5LP.

The SI undertaken is as a result of recommendations made by Rogers Geotechnical Services (RGS) in our previously issued Phase 1: Environmental Desk Study Report for the site (Report Reference: C1575/21/E/2457, Issued: March 2021), with which this report should be read in conjunction. As such this report seeks to address the potential pollutant linkages identified within the Preliminary Conceptual Site Model, contained within our Phase 1: Environmental Desk Study Report.

We are content that as a result of the actual site investigation works and subsequent soil testing undertaken, as outlined within this report, we have characterised the ground conditions and consequently the potential for contamination to exist on site. These works and ensuing assessment have been detailed in this report.

The information contained in this report is intended for the use of the named client (or their approved contractors). Should any part of this report be relied on by a third party, that party does so wholly at its own risk and GES disclaims any liability to such parties. Should the purposes for which the report is used, or the proposed use of the site change, this report may no longer be valid and further use of, or reliance upon the report in those circumstances shall be at the client's sole and own risk. The passage of time may result in changes in site conditions, regulatory or other legal provisions, technology or economic conditions which could render the report inaccurate or unreliable. GES should in all such altered circumstances be commissioned to review and update this report accordingly.

2. Proposed Developments

We understand current plans for the development of the site include:

- The development of a semi-detached house with gardens and driveway.

The proposed redevelopment plans for the site, at the time of issuing this report can be reviewed within Appendix 1.

3. Physical Setting

3.1 Site Information

The site is approximately rectangular in shape and slopes relatively steeply and occupies a position off Banks road.

3.2 Geology

There are no records of superficial deposits underlying the site. Underlying the site is bedrock comprised of Millstone Grit Group, comprising mudstones, siltstones and sandstones.

3.3 Hydrogeology

As a result of the bedrock geology on site, the aquifer is designated as being a Secondary A Aquifer. This is defined as permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important source of base flow to rivers. These are generally aquifers formerly classified as minor aquifers.

3.4 Hydrology

Groundwater Vulnerability

Table 3.1 presents Environment Agency groundwater vulnerability definitions:

High Vulnerability	Areas able to easily transmit pollution to groundwater. They are likely to be characterised by high leaching soils and the absence of low permeability superficial deposits.
Medium Vulnerability	Intermediate, between high and low vulnerability.
Low Vulnerability	Areas that provide the greatest protection from pollution. They are likely to be characterised by low leaching soils and/or the presence of superficial deposits characterised by a low permeability.

Table 3.1: Groundwater Vulnerability Definitions

The groundwater vulnerability in the vicinity of the site is classified as High due to the productive bedrock aquifer and well-connected fractures underlying the site.

3.5 Contaminant Sources

On Site Sources

The following possible on-site sources have been identified from the historical study:

- None identified.

The following possible on-site sources have been identified from the Enviro + Geo Insight data:

- None identified.

Off Site Sources

The following off site sources have been identified from the historical Enviro + Geo Insight data:

- Unspecified works/factories/features within 250m of the site
- Electricity substation 61m north of the site
- Road Vehicle fuelling, service and repairs 106m southwest of the site
- Unspecified tanks 94m west of site

There are further entries present, but these are considered far enough from the site to pose no risk.

The following contaminants are potentially associated with the on-site sources:

- Heavy Metals;
- TPH and PAH;
- PCBs.

The following contaminants are potentially associated with the off-site sources.

- Heavy Metals;
- PAH and TPH;
- PCBs.

In practice, a broad contaminant screen should be analysed for in any intrusive investigation recommended to ensure that potential contaminants are not omitted.

4. Preliminary Conceptual Site Model and Risk Assessment

This presented Conceptual Site Model has been re-issued from the previous Phase 1: Desktop study (C1575/21/E/2456), to provide information regarding the possible **sources** of contamination on site, the **pathway** in which the contamination can migrate and a vulnerable **receptor** to the contamination, all of which need to be present for there to be a risk. Given the continued end use of the site the generic land use of 'residential with homegrown produce' has been applied. Consequently, the following Source – Pathway – Receptor relationships have been identified.

Table: Conceptual Site Model and Preliminary Qualitative Risk Assessment

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CONCEPTUAL SITE MODEL			PRELIMINARY RISK ASSESSMENT	
Pathways	Receptor	Linkage Present?	Risk Rating	Notes
Direct contact/dermal absorption/soil ingestion	Operative	Yes – operatives are likely to come in contact with the soil.	Moderate	There are potential on and off site sources of contamination that may have caused contamination of the site. Any on site sources of contamination could migrate to neighbouring properties. Further testing required to reach a firm conclusion.
	End User	Yes – end users are likely to come in contact with the soil.	Moderate	
	Neighbours	Yes – possible source on site and immediate neighbours are present.	Moderate	
Inhalation of Dust/Vapours	Operative	Yes – contact with soil likely during works and vapours may accumulate in enclosed spaces.	Moderate	There are potential on and off site sources of contamination that may have caused contamination of the site. Any on site sources of contamination could migrate to neighbouring properties.
	End User	Yes – vapours may accumulate in enclosed spaces.	Moderate	



	Neighbours	Yes – neighbouring properties present and possible inhalation of dust during the works.	Moderate	operatives, end users and neighbours. In the event that harmful vapours are present they may accumulate in enclosed spaces, affecting operatives, end users and neighbours. Further testing required to reach a firm conclusion.
	Operative	Yes – Gardens and soft landscaping proposed as part of new development. Site currently disused garden area.	Moderate	
Ingestion of fruit/vegetables and/or waters	End User	Yes – gardens and soft landscaping proposed as part of the new development.	Moderate	There are potential on and off site sources of contamination that may have caused contamination of the site. Further testing required to reach a firm conclusion.
	Neighbours	Yes – residential dwellings present within 250m of the proposed development.	Moderate	

Table 4.1: Preliminary Conceptual Site Model.

5. Fieldworks

5.1 Site Investigation

All SI works were completed from April 8th 2021 under the supervision of a Geo-Environmental Engineer from GES. In summary the investigation included:

- A two man team ascertained the routes of any below ground services in close proximity to the proposed exploratory hole positions, using a CAT scan and lifting up of any man hole covers. Following the CAT scan, hand dug starter pits were completed to a depth of 1.2 metres below ground level (mbgl).
- Three (3no.) windowless sampler boreholes (WS01 to WS03) were completed, by means of a competitor dart rig, to depths of 4.45mbgl, the depth being limited due to encountering high strength soils (bedrock) at shallow depth, which prevented further penetration of the underlying deposits. The locations of exploratory positions were selected relative to the historic land use and the current proposed redevelopment plans for the site.
- Borehole WS01 was undertaken at the site of a burnt area of land and garden buildings, identified from the Phase 1 Desk Study. However, some site clearance had been undertaken and no significant evidence of burning was noted to remain during the investigation.
- The windowless sampler boreholes were logged with any groundwater conditions noted and representative soil samples removed in accordance with current guidelines.
- Soil samples were removed from shallow sub surface locations, with further samples taken at depth at every 0.5mbgl or when the underlying stratum changed. Samples were subsequently placed in suitable containers including 1kg tubs and 250ml glass jars and placed in cool boxes with cool packs prior to storage within our *in-house* laboratory fridges and then subsequent forwarding to our designated laboratory for analysis.
- Standard Penetration Tests were undertaken during the drilling to provide an assessment of the strength of the underlying deposits with depth.
- Upon completion, all exploratory holes were back filled, compacted and made good to existing levels and finishes, with any surplus spoil bagged up and removed from site.

The positions of exploratory holes in relation to the existing site layout can be reviewed within Appendix 1, with borehole logs located in Appendix 2.

6. Geology and Ground Conditions

The succession has been shown to include the following:

Table 6.1: Generalised Strata Profile			
Maximum Depth m below ground level to underside of layer	Strata Type	Positions Layer	Groundwater Strikes m below ground level
1.40	Variable MADE GROUND.	All positions	None
2.70	Firm light brown mottled brown sandy gravelly CLAY. Gravel is fine to coarse angular of sandstone.	All positions	None
4.45+	Extremely weak, mottled brown micaceous MUDSTONE: Recovered as silty GRAVEL. (EXTREMELEY WEATHERED)	All positions	None

'+' denotes that the strata extended below the termination depth of the investigated positions, thus the extent of the deposit is only proven to the depths indicated.

7. Groundwater Conditions

Groundwater was not encountered during investigative works undertaken. However, it should be noted that groundwater levels are dependent upon seasonal variations and can change after periods of prolonged rainfall or drought. However, as a consequence of the anticipated depth to standing water level such seasonal variations are unlikely to have an effect on site development.

8. Visual and Olfactory Observations

With the exception of general anthropogenic material identified, no visual and/or olfactory evidence of potential contamination was noted within any soils encountered as part of the investigative works undertaken. It should also be appreciated that a partial site strip was undertaken prior to the site investigation

9. Geotechnical Laboratory Testing

9.1 Atterberg Limits and Natural Moisture Content

Two (2no.) samples from the naturally occurring deposits were submitted for determination of their Natural Moisture Content and Plasticity Index. Natural Moisture Contents of these samples were between 12% and 13%. Modified Plasticity Indices of 16% and 22% were recorded for the results. As a consequence, the deposits encountered can be generally classed as ranging being of low volume change potential, in accordance with NHBC guidelines.

All geotechnical laboratory certificates can be reviewed within Appendix 3.

9.2 Sulphates

Three (3no.) samples of the underlying naturally occurring deposits in WS01 at 2.0mbgl, WS02 at 1.0mbgl and WS03 at 3.0mbgl were submitted for assessment of water-soluble sulphate, total sulphate, pH value and total sulphur concentrations.

Water-soluble sulphate concentrations of <10mg/l to 18 were recorded, total (acid) sulphate concentrations of 0.074% to 0.23%, total sulphur concentrations of 0.081% to 0.17%, with a pH value of between 7.4 and 7.8 units. Total Potential Sulphates were up to 0.24% to 0.51%.

Reference to BRE Special Digest 1 indicates a Design Sulphate Class of DS-1. Consequently, concrete may be designed to AC-1 concrete classification.

10. Construction Consideration

The made ground and topsoil are not considered suitable for the construction of shallow foundations due to the risk of unacceptable total and differential settlement occurring under moderately light surface loading.

The investigation recorded extremely weak mudstone at shallow depth. On this basis, it is considered that foundations could include the provision of strip and spread footings. The results of this investigation indicate that extremely weak sandstone will be revealed at depths of from 1.0mbgl to 2.0mbgl. This material would possess a significant bearing capacity, probably being in excess of 200kN/m². Therefore, at a typical foundation load for a house the factor of safety against general shear failure will be high, probably exceeding 10. In addition, it is considered that nominal settlements will occur under the action of the proposed increase in load.

Should made ground or any weak zones be revealed in the excavation bases, they should be removed and replaced by suitably compacted granular soil or lean-mixed concrete. Should excavations be required to stand open for any length of time, it will be necessary to place a blinding layer of lean-mixed concrete over the sub-grade. This expedient will reduce loosening or softening of the underling soil due to both physical disturbance and the ingress of surface water.

Should seepages of groundwater be encountered it is considered that they could be dealt with using a simple form of de-watering. Such a system could include the excavation of sumps from which the water could be pumped.

The stability of the excavation faces cannot be guaranteed thus temporary support to the excavation faces may become necessary unless the foundations are constructed using trench-fill techniques. In this method the foundation trenches should be excavated, inspected and backfilled with concrete as a

continuous operation. Under no circumstances should operatives be allowed to enter unsupported excavations.

10.1 Retaining structures

It is understood that retaining structures will be constructed in the mudstone rock recorded. It is considered that traditional gravity wall could be employed. These will require checks for overall stability in the design and the mudstone deposits should provide adequate stability to suitably designed structures. As part of the works the temporary support to the Banks Road should be considered during construction.

10.2 Excavations

No Groundwater was encountered during the investigation and subsequent monitoring. However, it should be appreciated that groundwater levels are subject to seasonal variation or changes on local drainage conditions.

Groundwater is unlikely to represent a particular problem to the construction of the development at this site particularly if encountered with excavations in the sand. However, it should be recognized that slight seepages and minor water entries may combine in any long trench excavations to create a significant volume of water which may cause local problems during the construction phase. Any minor groundwater seepages or significant standing water within excavations made upon this site may be removed by using a simple form of de-watering. Such a system could include the excavation of sumps from which the water could be pumped. Advice on Groundwater Control is given in CIRIA Report No 515 – Groundwater Control Design and Practice.

The stability of the excavation faces cannot be guaranteed thus temporary support to the excavation faces may become necessary unless the foundations are constructed using trench-fill techniques. In this method the foundation trenches should be excavated, inspected and backfilled with concrete as a continuous operation. Under no circumstances should operatives be allowed to enter unsupported excavations.

Subject to space constraints, excavations could be battered back to a suitable angle of repose (typically 1:1 for a 2.00m deep excavation). Alternatively, if there is a requirement to protect nearby structures or services, appropriate supports may be required. Due to the cohesive nature of the soils encountered, it is likely that any support required could be installed following excavation. Advice on excavation support is given in CIRIA Report No 97 – Trenching Practice.

11. Contamination

11.1 Soil Testing

A total of five (5no.) samples have been analysed by Chemtest Ltd in their UKAS and MCERTS accredited laboratory-testing facility in accordance with laboratory protocol.

The testing completed comprised of a focused suite of heavy metals, speciated Total Petroleum Hydrocarbons (TPH CWG Aromatic/aliphatic split) and speciated Polycyclic Aromatic Hydrocarbons (PAH) including the more carcinogenic benzo(a)pyrene (BaP) and naphthalene, asbestos, soil organic matter (SOM) content, VOCs, sVOCs, MTBE & BTEX, cyanide, pH and sulphates.

The results of this laboratory testing have been compared to the Soil Guideline Values (SGVs) as well as the CIEH 'LQM' guideline values for inorganic and organic contaminants in soils. The proposed development of the site is intended to comprise of residential and therefore screening has been made against a land use of 'residential with homegrown produce'.

11.2 Selection of Screening Criteria

The on-site receptors for the study site are considered to be:

- Construction workers (during redevelopment of the site only);
- Future maintenance workers (following redevelopment);
- Future end users and site visitors (following redevelopment); and
- Trespassers (during redevelopment).

Risks to construction workers during the redevelopment process will be mitigated by adhering to appropriate health and safety legislation, and the wearing of appropriate personal protective equipment (PPE). During redevelopment, the site will be securely fenced to prevent trespassers from accessing the site, and good site management practices will be implemented to mitigate exposure to off-site receptors.

The potential pathways for contaminants within the soil to human health receptors following redevelopment are considered to be:

- Direct ingestion of soil and soil derived dust;
- Dermal contact with soil outside and soil derived dust inside;
- Inhalation of soil derived dust inside and outside; and
- Inhalation of soil derived vapours inside and outside.

The potential pathways for contaminants within the soil to off-site human health receptors following redevelopment are considered to be:

- Direct ingestion of soil and soil derived dust;
- Dermal contact with soil outside and soil derived dust inside;
- Inhalation of soil derived dust inside and outside; and
- Inhalation of soil derived vapours inside and outside if contamination within soil is able to migrate across the site boundary within.

In the first instance, the results of this laboratory testing have been compared to generic assessment criteria (GAC) for the residential with homegrown produce land use scenario. These incorporate the following pathways:

- Direct ingestion of soil and soil derived dust;
- Dermal contact with soil outside and soil derived dust inside;
- Inhalation of soil derived dust inside and outside; and
- Inhalation of soil derived vapours inside and outside.

Contaminants have been screened against revised LQM/CIEH S4UL criteria¹ where available. These GAC have been designed for use under planning, using Health Criteria Values based on minimal risk, and updated exposure parameters. The S4UL are intended to replace the previous LQM/CIEH GAC. The S4UL are based on the assumption of a sandy loam soil the 1.0% soil organic matter (SOM) criteria have been used, where available and appropriate, in the first instance. All soil samples were analysed for %SOM, the range was from 1.2-10.0%, and so this conservative approach is considered appropriate for initial screening.

Where no S4UL are available, the EIC/ AGS/ CL:AIRE/ GAC² have been used. The toxicological criteria within these are also based on minimal risk. It is recognised that these criteria have not recently been updated, and in particular, do not incorporate the slightly higher inhalation rates that have been used within the S4UL. However, given that they incorporate additional pathways, they are considered suitable for an initial screen. The EIC/ AGS/ CL:AIRE/ GAC are also based on a sandy loam soil and the 1% SOM criteria have been used in the first instance.

There is neither an S4UL nor a EIC/ AGS/ CL:AIRE/ GAC available for lead. In the absence of a GAC based on minimal risk, the C4SL for lead has been used. It is recognised that this is based on a “low level of toxicological concern” rather than on a minimal risk level. However, it is considered appropriate for use under planning, especially for a site where there will effectively be no pathways for inorganic metals following redevelopment.

All the GAC are based on a sandy loam soil. This is considered appropriate for use for initial screening. Although it is apparent from the laboratory soil descriptions, that the Made Ground, by its very nature is heterogeneous, and often has a significant sand/gravel component, especially at shallow depths, it is noted that many of the soil descriptions have a significant clay component at increasing depth.

¹ Nathanail et al. (2015) The LQM/CIEH S4ULs for Human Health Risk Assessment. Land Quality Press, 2015. Copyright Land Quality Management Limited reproduced with permission; Publication Number S4UL3495

² CL:AIRE (2010) The EIC/AGS/CL:AIRE Generic Assessment Criteria for Human Health Risk Assessment

All of the GAC assume unsaturated soils. However, the use of the GAC are considered to be conservative, because they assume a certain air-filled porosity and water-filled porosity.

The GAC also assume that no free phase product is present and are not intended for use in this instance. No free product was observed within soils during the site investigation.

11.3 Soil Testing Results and Screening

All metals, PAHs, and TPH CWG analytes are presented in the following tables with units in mg/kg unless otherwise stated. Other potential contaminants of concern are only shown where there is at least one result exceeding the limit of detection.

All of the soil contamination laboratory analytical results are presented within **Appendix 4**.

Metalloids

Determinant	Min	Max	GAC	Number of exceedances
Arsenic	1.9	20	37*	0
Cadmium	<0.1	0.17	11*	0
Chromium total	17	35	910*	0
Chromium (VI)	<0.50	<0.50	6*	0
Copper	16	38	2400*	0
Lead	12	65	200*	0
Mercury	<0.10	0.26	40* ^a	0
Nickel	16	45	180* ^b	0
Selenium	0.39	0.56	250*	0
Zinc	52	95	3700*	0
Total Phenols	<0.1	<0.1	420*	0
Total Cyanide	<0.5	<0.5	140*	0

Table 11.1: Metalloids Soil Exceedances

*LQM/CIEH GAC for Residential with homegrown produce land use scenario based on a sandy loam soil and 1% SOM.

- Based on the inorganic mercury GAC as the conceptual site model does not suggest that other forms of mercury are likely to be present on site.
- LQM issued an update to the nickel S4ULs in August 2015 and this has been taken into account.

Organics

Determinant	Min	Max	GAC	Number of exceedances
Naphthalene	<0.1	<0.1	2.3*	0
Acenaphthylene	<0.1	<0.1	170*	0
Acenaphthene	<0.1	<0.1	210*	0
Fluorene	<0.1	<0.1	170*	0
Phenanthrene	<0.1	1.7	95*	0
Anthracene	<0.1	0.36	2400*	0
Fluoranthene	<0.1	1.1	280*	0
Pyrene	<0.1	1.4	620*	0
Benzo(a)anthracene	<0.1	0.5	7.2*	0
Chrysene	<0.1	0.57	15*	0
Benzo(b)fluoranthene	<0.1	0.52	2.6*	0
Benzo(k)fluoranthene	<0.1	0.19	77*	0
Benzo(a)pyrene	<0.1	0.40	2.2*	0
Indeno(1,2,3-cd)pyrene	<0.1	<0.1	27*	0
Dibenz(a,h)anthracene	<0.1	<0.1	0.24*	0
Benzo(ghi)perylene	<0.1	<0.1	320*	0

Table 11.2: PAH Soil Exceedances

There were no exceedances noted from the screening undertaken on PAH congeners.

Determinant	Min	Max	GAC	Number of exceedances
Aliphatic >C5 – C6	< 1.0	< 1.0	42*	0
Aliphatic >C6 - C8	< 1.0	< 1.0	100*	0
Aliphatic >C8 - C10	< 1.0	< 1.0	27*	0
Aliphatic >C10 - C12	< 1.0	< 1.0	130*	0
Aliphatic >C12 - C16	< 1.0	< 1.0	1100*	0
Aliphatic >C16 – C21	< 1.0	< 1.0	65000*	0
Aliphatic >C21 – C35	< 1.0	< 1.0	65000*	0
Aromatic >C5 - C7	< 1.0	< 1.0	70*	0
Aromatic >C7 - C8	< 1.0	< 1.0	130*	0
Aromatic >C8 - C10	< 1.0	< 1.0	34*	0

Aromatic >C10 - C12	< 1.0	< 1.0	74*	0
Aromatic >C12 - C16	< 1.0	< 1.0	140*	0
Aromatic >C16 - C21	< 1.0	44	260*	0
Aromatic >C21 - C35	< 1.0	330	1500*	0

Table 11.3: TPH CWG Aliphatic/Aromatic Soil Exceedances

* LQM/CIEH GAC Residential with Homegrown Produce land use scenario based on a sandy loam soil and 1.0% SOM. It is noted that the LQM/CIEH S4UL guidance recommends an additive approach for the TPH fraction, so that a hazard index approach is used. Based on a preliminary conservative comparison of maximum concentrations to S4ULs, no forward modelling is necessary to prove that this would still result in no exceedances at the site.

There are no exceedances noted from the screening undertaken on the respective TPH CWG bands.

Others

- The asbestos screening returned a negative result for the presence of fibrous material from all samples analysed.
- BTEX/MTBE screening returned a negative result for any congeners.

The soil contamination laboratory certificates can be reviewed within **Appendix 4**.

11.4 Gas Monitoring Results

Gas monitoring was initially carried out four occasions with an additional two visits requested with the monitoring undertake over a three-month period. These were undertaken using a Gas monitor (GA5000). Readings were taken from all three (3no.) installed window sampler boreholes.

The standpipes will be tested for the presence of methane, oxygen, carbon dioxide and hydrogen sulphide. The flow rates of the gas and barometric pressure will also be recorded. four (4no.) monitoring visits were completed, and full results can be viewed in Appendix 5.

Ground conditions were wet and moist on two occasions, with wind recorded as being light and moderate during monitoring. All the rounds of monitoring were completed during steady pressure conditions.

Oxygen concentrations range from a minimum of 14.5% to a maximum of 20.4%.

Concentration of methane has remained at 0.0% recorded in all three (3no.) boreholes.

The maximum peak concentration of carbon dioxide obtained to date is 2.6% from installation WS01 during the 4th round of monitoring completed.

Flow rates are recorded during each round of monitoring from all installations. To date, readings range from a minimum of 0.2l/hr to a maximum of 0.3l/hr. Negligible concentrations of hydrogen sulphide were returned from the rounds of monitoring undertaken. Monitoring returned concentrations at 0ppmv.

Barometric pressure ranges from a low of 985mBars during the 1st and 2nd rounds of monitoring to a high of 1006mBars attained during the 3rd round of monitoring. Visit 5 was undertaken during falling pressure from a high of around 997 the previous day.

The recorded concentrations of methane and carbon dioxide have been used to calculate a Gas Screening Value (GSV) for the gassing regime at this site. This value has been subsequently compared against CIRIA values supplied within CIRIA Document C665 *Assessing risks posed by hazardous ground gases to buildings* (2007) using Situation B for carbon dioxide and methane.

The values used represent the worst-case CO₂ and CH₄ concentrations across all installations. The maximum flow rate was 0.3l/hr and this was taken from all locations and/or monitoring visits to date.

The GSV is calculated as:

(Worst case CO₂ and CH₄ concentration / 100) x worst case flow rate = GSV

Peak Flow Rate (l/hr)	Worst Case CO ₂	CO ₂ GSV	Worst Case CH ₄	CH ₄ GSV
+0.3	2.6%	0.0078l/hr	0.0%	0.0l/hr

Table 11.4: Calculated GSV's

This GSV is a conservative estimate based on the maximum concentrations and flow rate.

It was noted that during the monitoring a slight reduction in oxygen was recorded within borehole WS01 on three occasions in May and in WS02 on one visit in May (this was peak with steady readings noted to be normal), these were then noted to recover in subsequent visits. Given the site is a back garden, it is likely that this reduction is due to vegetation and ground oxygen demand during the peak growing season, further supported by the recovery during subsequent monitoring.

12. Site Investigation Findings

12.1 Risk to Human Health

With the exception of the Made Ground identified, no visual and/or olfactory evidence of potential contamination was noted within any soils encountered during the SI works undertaken, which focussed in the proposed private garden areas and also underneath the footprint of the proposed dwellings.

Therefore, it would be reasonable to conclude that there is a negligible risk to human health receptors and is therefore considered that no remediation works should be required.

12.2 Risk to Plants and Wildlife

A negligible risk has been attributed given the concentrations of phytotoxic contaminants below elevated concentrations often below the limit of detection returned.

12.3 Risk to Site Workers

Precautions should be taken to minimise exposure of site workers during ground works through the implementation of site safety procedures and the use of suitable personal protective equipment (PPE). Such precautions should include, but not be limited to:

- Personal hygiene, washing and changing procedures;
- Availability of site welfare;
- Provision of PPE appropriate to the task; and
- Daily safety briefings and tool box talks.

All site works will be undertaken in accordance with the guidelines prepared by the Health and Safety Executive (1991) and all work will be carried out in accordance with the Principal Contractor's Health and Safety Plan.

12.4 Risk to Proposed Structures

A low risk has been attributed given the lack of hydrocarbons returned from the laboratory thus giving a low risk for potential volatilisation. Furthermore, on site there is historical development and potentially infilled land and ground workings that pose a risk for ground gas generation.

13. Updated Conceptual Site Model and Risk Assessment

The Conceptual Site Model has been re-formulated based upon the results from the SI in accordance with BS10175:2015. It aims to provide information regarding the sources of contamination and the pathways in which contamination can migrate to a vulnerable receptor, all of which need to be present for there to be a risk. This is in relation to the proposed end use being classified as 'residential with homegrown produce'. The following linkages have been identified:

Contaminant Source	Pathways	Receptor	Potential Severity	Probability of Risk	Level of Risk	Justification
On Site: Made Ground soils on site possibly containing elevated metals, other organics such as TPH, PAH, phenols, VOC and SVOCs.	Ingestion, dermal contact, inhalation of dusts/vapours	Future end users and site visitors	Medium	Unlikely	Low ●	A low level of risk is considered due to the lack of returned exceedances in samples selected for testing.
		Construction Workers	Medium	Unlikely	Low ●	A low level of risk is considered due to the lack of returned exceedances in samples selected for testing.
	Leaching through soils and migration via groundwater or soil pore moisture	Controlled Waters	Medium	Unlikely	Low ●	A low level of risk is considered due to the lack of returned exceedances in samples selected for testing.
	Permeation of water pipes	Construction materials, future end users and site visitors	Medium	Unlikely	Low ●	Hydrocarbons, especially aromatics are known to permeate plastic pipes. Provision of water supply pipes and connectors formed from proprietary "barrier pipe" materials (e.g. polyethylene-aluminium-polyethylene) may be required by the water supply company.
	Uptake	Plant and Wildlife	Medium	Unlikely	Low ●	A low risk rating has been assessed due to the limited history of potentially contaminative land uses on site.
On Site: Asbestos at/near ground surface in Made Ground soils.	Inhalation of fibres in airborne dust	Future end users and site visitors	Medium	Unlikely	Low ●	A Low risk is assessed due to the lack of any ACMs identified by testing scheduled.
		Construction Workers	Medium	Unlikely	Low ●	A Low risk is assessed due to the lack of any ACMs identified by testing scheduled.

On Site: Ground Gases (CH ₄ , CO ₂) from on-site Made Ground.	Gas migration and build up within buildings (explosion/asphyxiation risk)	Future end users and building structures.	Low	Unlikely	Low ●	A low risk rating has been assessed given limited made ground and no nearby landfills present. Current guidance indicates that Made Ground is generally classified as low risk in terms of potential for gas generation.
Off Site: Historical land uses and activities, Made Ground/infilled material possibly containing elevated metals, other inorganics, TPH, PAH, PCBs, phenols, VOC and SVOCs.	Leaching through soils and migration via groundwater or soil pore moisture	Future end users and site visitors	Medium	Unlikely	Low ●	A low level of risk is considered due to the lack of returned exceedances in samples selected for testing.
	Ingestion, dermal contact, inhalation of dusts/vapours	Future end users and site visitors	Medium	Unlikely	Low ●	A low level of risk is considered due to the lack of returned exceedances in samples selected for testing.
Off Site: Ground Gases (CH ₄ , CO ₂ , H ₂ S) from off-site historical landfilling activities.	Gas migration and build up within buildings (explosion/asphyxiation risk)	Future end users and building structures.	Low	Unlikely	Low ●	Given the lack of generating sources on and off site and monitoring undertaken the risk from ground gas is considered low.

Table 12.1: Updated Conceptual Site Model.

14. Recommendations

In view of the above it is considered that there is a low risk to the end user and no further action is required.

14.1 Watching Brief and Discovery Strategy

A watching brief should be maintained by the Main Contractor at all times during the groundworks stage. Should any unforeseen contamination, such as oils or soils/groundwater with an unusual colour or odour, be encountered during groundworks then the following procedure should be implemented:

- Work to cease in that area to prevent exposure to ground workers and potential contaminants being spread around;
- Notify a Geo-Environmental Consultant, to attend site and sample material;
- Notify the Environmental Health Department / Contaminated Land Officer(s) of the Local Planning Authority.

If the nature and extent of the contamination is unmanageable under the procedure set out above, then a suitable management, mitigation or remediation procedure will be agreed with the CLO. However, this is considered unlikely at this particular site.

14.2 Asbestos

Although screening has revealed no asbestos to be present within the samples analysed from exploratory holes undertaken, it cannot be guaranteed that asbestos is not present within the soils across the remainder of the site. Consequently, we would recommend that a watching brief be adopted with regards to the site for the potential of finding any Asbestos Containing Materials (ACMs). If any ACMs are identified these need to be dealt with accordingly in relation to the Hazardous Waste Regulations 2005.

14.3 Services

If new services will be installed as part of the redevelopment of the site, we would recommend the local water board be contacted to determine their specification for the type of pipework which should be used on this site.

All services and in particular potable water supply pipework should comprise of material that is resistant to attack and degradation to chemical attack.

Further information can be found within the published guidance for the '*Selection of Water Supply Pipes to be used in Brownfield Sites*', issued in January 2011 by the UK Water Industry Research (UKWIR),

this supersedes the Water Regulations Advisory Scheme (WRAS) Information and Guidance Note – *'Laying Pipes in Contaminated Land'* which has been withdrawn.

14.4 Surface Water

It should be noted that the Environment Agency does not recommend that soakaways be placed within Made Ground, potentially contaminative land or in ground previously identified as contaminated.

14.6 Gas Protection Measures

Based on the maximum calculated GSV of 0.0078l/hr to date, the site can be characterised by Table 8.6 of CIRIA C665 for classification A, characteristic situation 1 and as 'very low risk'. Based on this data, the indication is that there is no indication of an active gas regime identified and consequently, no special precautions are required for gas protective measures.

15. Limitations

GES have prepared this report with all reasonable skill, care and diligence. The work undertaken to provide the basis of this report comprised a study of available documented information from a variety of sources.

The opinions given in this report have been dictated by the finite data on which are they based and are relevant only to the purpose for which the report was commissioned.

Information reviewed should not be considered exhaustive and has accepted in good faith as providing true and representative data with respect to site conditions. Should additional information become available which may influence the opinion expressed in this report, GES reserves the right to review such information and, if warranted, to alter the opinions accordingly.

It should be noted that any risks identified in this report are perceived risks based on the information reviewed.

The recommendations contained in this report represent our professional opinions. These opinions were arrived at in accordance with currently accepted industry practices at this time and as such is not a guarantee that the study site is free of hazardous conditions.

This report has been prepared solely for the use of the named client and may not be relied upon by other parties without written consent from GES. GES disclaims any responsibility to the client and others in respect of any matters outside the agreed scope of the work.

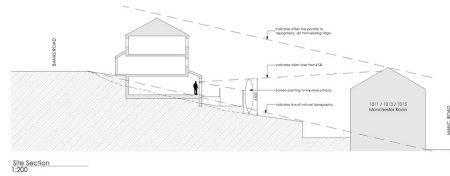
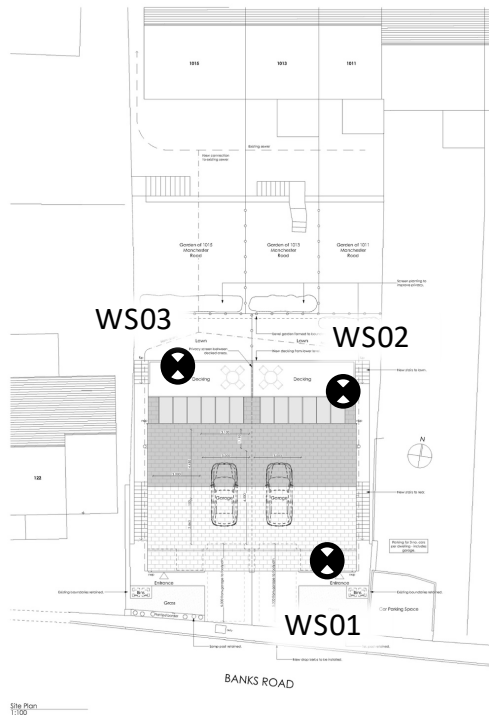
16. References

- British Standards Institution (1990) BS1377: *British standard methods of test for soils for civil engineering purposes*, B.S.I., London.
- British Standards Institution (2015) BS5930: *Code of practice for site investigations*, B.S.I., London.

Appendix 1

Site Location and Exploratory Hole Plan

General Notes:
This drawing is a preliminary drawing and is for information purposes only. It is not to be used for construction or any other purpose without the written consent of the author. All dimensions are in metres and are based on the best available information. The author is not responsible for any errors or omissions or for any consequences arising from the use of this drawing.



Author	Checked	Drawn	Scale
BA			
Project	Client	Contract	Contract
Land Off Banks Road, Linthwaite, Yorkshire			
Location	Site Plan / Location Plan / Site Section	Planning	Planning

Author	Checked	Drawn	Scale
BA			
Project	Client	Contract	Contract
Land Off Banks Road, Linthwaite, Yorkshire			
Location	Site Plan / Location Plan / Site Section	Planning	Planning

BA Barnford Architectural Ltd.
01753 600000
www.barnfordarchitectural.co.uk
info@barnfordarchitectural.co.uk

Title: **Investigation Location Plan**



Site Name:
Land Off Banks Road, Linthwaite

Job No:
GES 1399-21

Appendix 2

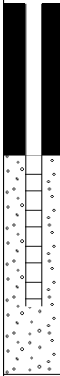
Borehole Logs

[illegible]

Remarks	
No Groundwater encountered. Refusal encountered at 2.45mbgl. Monitoring well installed to 2.00mbgl.	

Percussion Drilling Log

Project Name: Land off Banks Road		Client: James Bamforth		Date: 06/05/2021	
Location: Linthwaite, HD7 5LP		Contractor:			
Project No. : 1399-21		Crew Name:		Drilling Equipment:	
Borehole Number WS02	Hole Type WLS	Level	Logged By	Scale 1:50	Page Number Sheet 1 of 1

Well	Water Strikes	Sample and In Situ Testing			Depth (m)	Level (m)	Legend	Stratum Description				
		Depth (m)	Type	Results								
		0.00 - 0.30	D		0.30			MADE GROUND: Dark brown, silty sandy gravelly CLAY. Gravel is fine to coarse of brick and mixed lihology.				
		0.30 - 1.00	D									
		1.00 - 1.45	SPTL	N=32 (7,8/8,8,8,8)	1.00			Firm to stiff, light brown mottled brown silty very gravelly CLAY. Gravel is fine to coarse angular of mudstone.	1			
		1.00 - 2.00	S									
		1.20	SPT				Extremely weak, mottled brown micaceous MUDSTONE: Recovered as silty GRAVEL. (EXTREMELEY WEATHERED)	2				
		2.00 - 2.45	SPTL									
		2.00	S									
			SPT									
		End of Borehole at 2.450m							3			
									4			
									5			
									6			
									7			
									8			
									9			
									10			

Hole Diameter		Casing Diameter		Chiselling				Inclination and Orientation			
Depth Base	Diameter	Depth Base	Diameter	Depth Top	Depth Base	Duration	Tool	Depth Top	Depth Base	Inclination	Orientation

Remarks No Groundwater encountered. Refusal encountered at 2.45mbgl. Monitoring well installed to 2.00mbgl.										
--	--	--	--	--	--	--	--	--	--	---

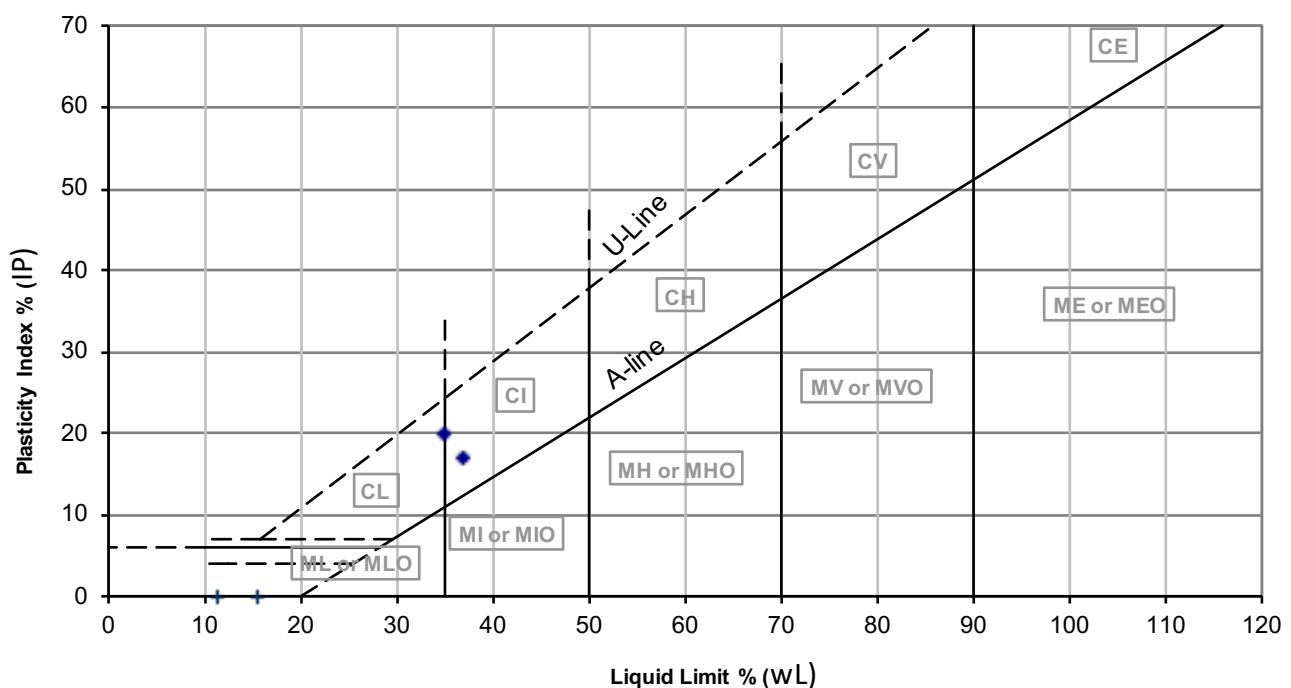
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Appendix 3

Geotechnical Laboratory Results

Interpretation of Moisture Content, Liquid and Plastic Limits

Location	Depth (m)	Moisture Content (w) (%)	Liquid Limit (w _L) (%)	Plastic Limit (w _P) (%)	Plasticity Index (I _P) (%)	Retained by 425mm (%)	Modified (w) (w') (%)	Modified (I _P) (I' _P) (%)	Liquidity/ Consistency (I _L) (%) (I _C) (%)		Casagrande Class	N.H.B.C Class (%)
WS01	1.00	12	37	20	17	4	13	16	-0.5	1.5	C I	LOW
WS03	2.00	13	35	15	20	2	13	20	-0.1	1.1	C I	LOW



Appendix 4

Soil Contamination Laboratory Results



2183

Final Report

Report No.: 21-17753-1
Initial Date of Issue: 02-Jun-2021
Client Borehole Solutions North Ltd
Client Address: Unit 7 , Springvale Works
Brookfoot lane
Brighouse
HD62RA
Contact(s): dan@boreholesolutions.com
Project Land off Banks Road, Linthwaite
Quotation No.:
Order No.: 1399-21
No. of Samples: 8
Turnaround (Wkdays): 5
Date Approved: 02-Jun-2021

Date Received: 26-May-2021

Date Instructed: 26-May-2021

Results Due: 02-Jun-2021

Approved By:



Details: Glynn Harvey, Technical Manager

Results - Soil

Project: Land off Banks Road, Linthwaite

Client: Borehole Solutions North Ltd	Chemtest Job No.:				21-17753	21-17753	21-17753	21-17753	21-17753	21-17753	21-17753	21-17753
Quotation No.:	Chemtest Sample ID.:				1208732	1208733	1208734	1208735	1208736	1208737	1208738	1208739
Order No.: 1399-21	Client Sample Ref.:				D1	D2	D3	ES1	ES2	ES3	ES4	ES5
	Client Sample ID.:				D1	D2	D3	ES1	ES2	ES3	ES4	ES5
	Sample Location:				WS01	WS02	WS03	WS01	WS02	WS02	WS03	WS03
	Sample Type:				SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL
	Top Depth (m):				2	1	3	0.15	0.3	2	1	3.5
	Bottom Depth (m):				2	1	3	0.15	0.3	2	1	3.5
	Date Sampled:				18-May-2021	18-May-2021	18-May-2021	18-May-2021	18-May-2021	18-May-2021	18-May-2021	18-May-2021
	Time Sampled:				12:00	12:00	12:00	12:00	12:00	12:00	12:00	12:00
	Asbestos Lab:							DURHAM	DURHAM	DURHAM	DURHAM	DURHAM
Determinand	Accred.	SOP	Units	LOD								
ACM Type	U	2192		N/A				-	-	-	-	-
Asbestos Identification	U	2192		N/A				No Asbestos Detected	No Asbestos Detected	No Asbestos Detected	No Asbestos Detected	No Asbestos Detected
ACM Detection Stage	U	2192		N/A				-	-	-	-	-
Moisture	N	2030	%	0.020	12	14	14	17	15	12	24	13
pH	U	2010		4.0	7.4	7.4	7.8	7.4	7.5	6.4	7.7	7.8
Sulphate (2:1 Water Soluble) as SO4	U	2120	g/l	0.010	0.018	0.013	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Sulphate (2:1 Water Soluble) as SO4 mg/l	U	2120	mg/l	10.000	18	13	< 10					
Total Sulphur	U	2175	%	0.010	0.15	0.081	0.17					
Cyanide (Total)	U	2300	mg/kg	0.50				< 0.50	< 0.50	< 0.50	< 0.50	< 0.50
Sulphate (Total)	U	2430	%	0.010	0.23	0.074	0.23					
Arsenic	U	2450	mg/kg	1.0				8.0	2.4	1.9	20	4.6
Cadmium	U	2450	mg/kg	0.10				0.17	0.16	0.10	< 0.10	0.12
Chromium	U	2450	mg/kg	1.0				35	17	21	25	22
Copper	U	2450	mg/kg	0.50				28	16	21	38	26
Mercury	U	2450	mg/kg	0.10				0.12	< 0.10	< 0.10	0.26	< 0.10
Nickel	U	2450	mg/kg	0.50				20	16	30	18	45
Lead	U	2450	mg/kg	0.50				50	20	12	65	29
Selenium	U	2450	mg/kg	0.20				0.45	0.39	0.55	0.56	0.41
Zinc	U	2450	mg/kg	0.50				63	94	73	52	95
Chromium (Hexavalent)	N	2490	mg/kg	0.50				< 0.50	< 0.50	< 0.50	< 0.50	< 0.50
Organic Matter	U	2625	%	0.40				1.6	1.6	2.9	7.9	2.1
Aliphatic TPH >C5-C6	N	2680	mg/kg	1.0				< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Aliphatic TPH >C6-C8	N	2680	mg/kg	1.0				< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Aliphatic TPH >C8-C10	U	2680	mg/kg	1.0				< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Aliphatic TPH >C10-C12	U	2680	mg/kg	1.0				< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Aliphatic TPH >C12-C16	U	2680	mg/kg	1.0				< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Aliphatic TPH >C16-C21	U	2680	mg/kg	1.0				< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Aliphatic TPH >C21-C35	U	2680	mg/kg	1.0				< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Aliphatic TPH >C35-C44	N	2680	mg/kg	1.0				< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Total Aliphatic Hydrocarbons	N	2680	mg/kg	5.0				< 5.0	< 5.0	< 5.0	< 5.0	< 5.0
Aromatic TPH >C5-C7	N	2680	mg/kg	1.0				< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Aromatic TPH >C7-C8	N	2680	mg/kg	1.0				< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Aromatic TPH >C8-C10	U	2680	mg/kg	1.0				< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Aromatic TPH >C10-C12	U	2680	mg/kg	1.0				< 1.0	< 1.0	< 1.0	< 1.0	< 1.0

Results - Soil

Project: Land off Banks Road, Linthwaite

Client: Borehole Solutions North Ltd	Chemtest Job No.:				21-17753	21-17753	21-17753	21-17753	21-17753	21-17753	21-17753	21-17753	21-17753
Quotation No.:	Chemtest Sample ID.:				1208732	1208733	1208734	1208735	1208736	1208737	1208738	1208739	1208739
Order No.: 1399-21	Client Sample Ref.:				D1	D2	D3	ES1	ES2	ES3	ES4	ES5	ES5
	Client Sample ID.:				D1	D2	D3	ES1	ES2	ES3	ES4	ES5	ES5
	Sample Location:				WS01	WS02	WS03	WS01	WS02	WS02	WS03	WS03	WS03
	Sample Type:				SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL
	Top Depth (m):				2	1	3	0.15	0.3	2	1	3.5	3.5
	Bottom Depth (m):				2	1	3	0.15	0.3	2	1	3.5	3.5
	Date Sampled:				18-May-2021	18-May-2021	18-May-2021	18-May-2021	18-May-2021	18-May-2021	18-May-2021	18-May-2021	18-May-2021
	Time Sampled:				12:00	12:00	12:00	12:00	12:00	12:00	12:00	12:00	12:00
	Asbestos Lab:							DURHAM	DURHAM	DURHAM	DURHAM	DURHAM	DURHAM
Determinand	Accred.	SOP	Units	LOD									
Aromatic TPH >C12-C16	U	2680	mg/kg	1.0				< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Aromatic TPH >C16-C21	U	2680	mg/kg	1.0				< 1.0	< 1.0	< 1.0	44	< 1.0	< 1.0
Aromatic TPH >C21-C35	U	2680	mg/kg	1.0				< 1.0	< 1.0	< 1.0	330	< 1.0	< 1.0
Aromatic TPH >C35-C44	N	2680	mg/kg	1.0				< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Total Aromatic Hydrocarbons	N	2680	mg/kg	5.0				< 5.0	< 5.0	< 5.0	370	< 5.0	< 5.0
Total Petroleum Hydrocarbons	N	2680	mg/kg	10.0				< 10	< 10	< 10	370	< 10	< 10
Naphthalene	U	2700	mg/kg	0.10				< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Acenaphthylene	U	2700	mg/kg	0.10				< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Acenaphthene	U	2700	mg/kg	0.10				< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Fluorene	U	2700	mg/kg	0.10				< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Phenanthrene	U	2700	mg/kg	0.10				< 0.10	< 0.10	< 0.10	1.7	< 0.10	< 0.10
Anthracene	U	2700	mg/kg	0.10				< 0.10	< 0.10	< 0.10	0.36	< 0.10	< 0.10
Fluoranthene	U	2700	mg/kg	0.10				< 0.10	< 0.10	< 0.10	1.1	0.94	0.94
Pyrene	U	2700	mg/kg	0.10				< 0.10	< 0.10	< 0.10	1.4	0.95	0.95
Benzo[a]anthracene	U	2700	mg/kg	0.10				< 0.10	< 0.10	< 0.10	< 0.10	0.50	0.50
Chrysene	U	2700	mg/kg	0.10				< 0.10	< 0.10	< 0.10	< 0.10	0.57	0.57
Benzo[b]fluoranthene	U	2700	mg/kg	0.10				< 0.10	< 0.10	< 0.10	< 0.10	0.52	0.52
Benzo[k]fluoranthene	U	2700	mg/kg	0.10				< 0.10	< 0.10	< 0.10	< 0.10	0.19	0.19
Benzo[a]pyrene	U	2700	mg/kg	0.10				< 0.10	< 0.10	< 0.10	< 0.10	0.40	0.40
Indeno(1,2,3-c,d)Pyrene	U	2700	mg/kg	0.10				< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Dibenz(a,h)Anthracene	U	2700	mg/kg	0.10				< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Benzo[g,h,i]perylene	U	2700	mg/kg	0.10				< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Total Of 16 PAH's	U	2700	mg/kg	2.0				< 2.0	< 2.0	< 2.0	4.6	4.1	4.1
Benzene	U	2760	µg/kg	1.0				< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Toluene	U	2760	µg/kg	1.0				< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Ethylbenzene	U	2760	µg/kg	1.0				1.4	< 1.0	2.0	< 1.0	< 1.0	< 1.0
m & p-Xylene	U	2760	µg/kg	1.0				< 1.0	< 1.0	8.9	< 1.0	< 1.0	< 1.0
o-Xylene	U	2760	µg/kg	1.0				1.3	< 1.0	7.3	< 1.0	< 1.0	< 1.0
Methyl Tert-Butyl Ether	U	2760	µg/kg	1.0				< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Total Phenols	U	2920	mg/kg	0.10				< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10

Test Methods

SOP	Title	Parameters included	Method summary
2010	pH Value of Soils	pH	pH Meter
2030	Moisture and Stone Content of Soils(Requirement of MCERTS)	Moisture content	Determination of moisture content of soil as a percentage of its as received mass obtained at <37°C.
2040	Soil Description(Requirement of MCERTS)	Soil description	As received soil is described based upon BS5930
2120	Water Soluble Boron, Sulphate, Magnesium & Chromium	Boron; Sulphate; Magnesium; Chromium	Aqueous extraction / ICP-OES
2175	Total Sulphur in Soils	Total Sulphur	Determined by high temperature combustion under oxygen, using an Eltra elemental analyser.
2192	Asbestos	Asbestos	Polarised light microscopy / Gravimetry
2300	Cyanides & Thiocyanate in Soils	Free (or easy liberatable) Cyanide; total Cyanide; complex Cyanide; Thiocyanate	Alkaline extraction followed by colorimetric determination using Automated Flow Injection Analyser.
2430	Total Sulphate in soils	Total Sulphate	Acid digestion followed by determination of sulphate in extract by ICP-OES.
2450	Acid Soluble Metals in Soils	Metals, including: Arsenic; Barium; Beryllium; Cadmium; Chromium; Cobalt; Copper; Lead; Manganese; Mercury; Molybdenum; Nickel; Selenium; Vanadium; Zinc	Acid digestion followed by determination of metals in extract by ICP-MS.
2490	Hexavalent Chromium in Soils	Chromium [VI]	Soil extracts are prepared by extracting dried and ground soil samples into boiling water. Chromium [VI] is determined by 'Aquakem 600' Discrete Analyser using 1,5-diphenylcarbazide.
2625	Total Organic Carbon in Soils	Total organic Carbon (TOC)	Determined by high temperature combustion under oxygen, using an Eltra elemental analyser.
2680	TPH A/A Split	Aliphatics: >C5–C6, >C6–C8,>C8–C10, >C10–C12, >C12–C16, >C16–C21, >C21–C35, >C35– C44Aromatics: >C5–C7, >C7–C8, >C8– C10, >C10–C12, >C12–C16, >C16– C21, >C21– C35, >C35– C44	Dichloromethane extraction / GCxGC FID detection
2700	Speciated Polynuclear Aromatic Hydrocarbons (PAH) in Soil by GC-FID	Acenaphthene; Acenaphthylene; Anthracene; Benzo[a]Anthracene; Benzo[a]Pyrene; Benzo[b]Fluoranthene; Benzo[ghi]Perylene; Benzo[k]Fluoranthene; Chrysene; Dibenzo[ah]Anthracene; Fluoranthene; Fluorene; Indeno[123cd]Pyrene; Naphthalene; Phenanthrene; Pyrene	Dichloromethane extraction / GC-FID (GC-FID detection is non-selective and can be subject to interference from co-eluting compounds)
2760	Volatile Organic Compounds (VOCs) in Soils by Headspace GC-MS	Volatile organic compounds, including BTEX and halogenated Aliphatic/Aromatics.(cf. USEPA Method 8260)*please refer to UKAS schedule	Automated headspace gas chromatographic (GC) analysis of a soil sample, as received, with mass spectrometric (MS) detection of volatile organic compounds.
2920	Phenols in Soils by HPLC	Phenolic compounds including Resorcinol, Phenol, Methylphenols, Dimethylphenols, 1-Naphthol and TrimethylphenolsNote: chlorophenols are excluded.	60:40 methanol/water mixture extraction, followed by HPLC determination using electrochemical detection.

Report Information

Key

U	UKAS accredited
M	MCERTS and UKAS accredited
N	Unaccredited
S	This analysis has been subcontracted to a UKAS accredited laboratory that is accredited for this analysis
SN	This analysis has been subcontracted to a UKAS accredited laboratory that is not accredited for this analysis
T	This analysis has been subcontracted to an unaccredited laboratory
I/S	Insufficient Sample
U/S	Unsuitable Sample
N/E	not evaluated
<	"less than"
>	"greater than"
SOP	Standard operating procedure
LOD	Limit of detection

Comments or interpretations are beyond the scope of UKAS accreditation

The results relate only to the items tested

Uncertainty of measurement for the determinands tested are available upon request

None of the results in this report have been recovery corrected

All results are expressed on a dry weight basis

The following tests were analysed on samples as received and the results subsequently corrected to a dry weight basis TPH, BTEX, VOCs, SVOCs, PCBs, Phenols

For all other tests the samples were dried at < 37°C prior to analysis

All Asbestos testing is performed at the indicated laboratory

Issue numbers are sequential starting with 1 all subsequent reports are incremented by 1

Sample Deviation Codes

- A - Date of sampling not supplied
- B - Sample age exceeds stability time (sampling to extraction)
- C - Sample not received in appropriate containers
- D - Broken Container
- E - Insufficient Sample (Applies to LOI in Trommel Fines Only)

Sample Retention and Disposal

All soil samples will be retained for a period of 45 days from the date of receipt

All water samples will be retained for 14 days from the date of receipt

Charges may apply to extended sample storage

If you require extended retention of samples, please email your requirements to:

customerservices@chemtest.com

Appendix 5

Gas Monitoring Results

Ground Gas and Groundwater Monitoring Record Sheet

JOB DETAILS:

Land off Banks Road

Client:

James Bamforth

Site:

Linthwaite

Date:

13.05.2021

Job No:

1399-21

Visit No:

1 of 6

Operator:

Sue Ellis

Project Manager:

DS

Monitoring Point	GAS CONCENTRATIONS												VOLATILES		FLOW DATA				Worst-credible GSVs		WELL AND WATER DATA						Comments
	Methane (%v/v)		%LEL		Carbon dioxide (%v/v)		Carbon monoxide (ppmv)		Hydrogen sulphide (ppmv)		Oxygen (%v/v)		PID Peak (ppm)	Product thickness (mm)	Flow rate (l/hr)		Differential borehole Pressure (Pa)	Time for flow to equalise (secs)	Methane (l/hr)	CO2 (l/hr)	Water level (mbgl)	Depth of well (m)	Reduced level (mAOD)	Water level (mAOD)	Response Zone		
	Peak	Steady	Peak	Steady	Peak	Steady	Peak	Steady	Peak	Steady	Min.	Steady			Peak	Steady											
WS01	0.0	0.0			1.5	1.5	2	1	0	0	16.3	16.3			0.2	0.2			0	0.003	ND	2.00		DRY			
WS02	0.0	0.0			1.4	1.4	2	0	0	0	18.2	18.3			0.2	0.2			0	0.0028	ND	2.00		DRY			
WS03	0.0	0.0			1.9	1.9	1	1	0	0	18.3	18.4			0.2	0.2			0	0.0038	ND	4.00		DRY			
																		0	0								
																		0	0								
																		0	0								
																		0	0								
																		0	0								
																		0	0								
																		0	0								
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																		0	0								
																		0	0								
																		0	0								
																		0	0								
																		0	0								
																		0	0								
Max	0.0	0.0	ND	ND	1.9	1.9	2	1	0	0	18.3	18.4	ND	ND	0.2	0.2	ND	NA	0.0000	0.0038	DRY	4.00	NR	NR			
Min	0.0	0.0	0.0	0.0	1.4	1.4	1	0	0	0	16.3	16.3	0.0	0.0	0.2	0.2	0.0	0	0.0000	0.0000	0.00	2.00	0.00	0.00			

ND - Not detected

NR - Not recorded

NA - Non applicable

NB:

Where no flow (ND) recorded, GSVs are calculated using equipment limit of detection (0.1l/hr). Where negative flows recorded, these are converted to positive values for calculation of GSVs.

Worst-possible GSVs

00.0038

MG - Made ground

NAT - Natural

C - Cohesive

G - Granular

METEOROLOGICAL AND SITE INFORMATION:

(Select correct box with X or enter data, as applicable)

State of ground:

Dry

Moist

☒

Wet

Snow

Frozen

Wind:

Calm

Light

☒

Moderate

Strong

Cloud cover:

None

Slight

☒

Cloudy

Overcast

Precipitation:

None

Slight

☒

Moderate

Heavy

Time monitoring performed:

09:15

Start

10:15

End

Barometric pressure (mbar):

985

Start

985

End

Pressure trend (Daily):

Falling

☒

Steady

Rising

Source:

Wunderground

Air Temperature (Deg. C):

10

Before

10

After

Page 1 of 1

Ground Gas and Groundwater Monitoring Record Sheet

JOB DETAILS:

Land off Banks Road

Client:

James Bamforth

Site:

Linthwaite

Date:

19.5.21

Job No:

1399-21

Visit No:

2 of 6

Operator:

SE

Project Manager:

DS

Monitoring Point	GAS CONCENTRATIONS												VOLATILES		FLOW DATA				Worst-credible GSVs		WELL AND WATER DATA						Comments
	Methane (%v/v)		%LEL		Carbon dioxide (%v/v)		Carbon monoxide (ppmv)		Hydrogen sulphide (ppmv)		Oxygen (%v/v)		PID Peak (ppm)	Product thickness (mm)	Flow rate (l/hr)		Differential borehole Pressure (Pa)	Time for flow to equalise (secs)	Methane (l/hr)	CO2 (l/hr)	Water level (mbgl)	Depth of well (m)	Reduced level (mAOD)	Water level (mAOD)	Response Zone		
	Peak	Steady	Peak	Steady	Peak	Steady	Peak	Steady	Peak	Steady	Min.	Steady			Peak	Steady											
WS01	0.0	0.0			2.1	2.0	0	0	0	0	15.8	15.6			0.2	0.2			0	0.004	ND	2.00		Dry			
WS02	0.0	0.0			0.9	0.9	0	0	0	0	19.3	19.3			0.3	0.3			0	0.0027	ND	2.00		Dry			
WS03	0.0	0.0			1.1	1.1	0	0	0	0	19.0	19.0			0.3	0.3			0	0.0033	ND	4.00		Dry			
																			0	0							
																			0	0							
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																			0	0							
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																			0	0							
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																			0	0							
Max	0.0	0.0	ND	ND	2.1	2.0	0	0	0	0	19.3	19.3	ND	ND	0.3	0.3	ND	NA	0.0000	0.0040	DRY	4.00	NR	NR			
Min	0.0	0.0	0.0	0.0	0.9	0.9	0	0	0	0	15.8	15.6	0.0	0.0	0.2	0.2	0.0	0	0.0000	0.0000	0.00	2.00	0.00	0.00			

ND - Not detected

NR - Not recorded

NA - Non applicable

Worst-possible GSVs

00.0063

NB:

Where no flow (ND) recorded, GSVs are calculated using equipment limit of detection (0.1l/hr). Where negative flows recorded, these are converted to positive values for calculation of GSVs.

MG - Made ground

NAT - Natural

C - Cohesive

G - Granular

METEOROLOGICAL AND SITE INFORMATION:

(Select correct box with X or enter data, as applicable)

State of ground:

Dry

x

Moist

Wet

Snow

Frozen

Wind:

Calm

x

Light

Moderate

Strong

Cloud cover:

None

Slight

x

Cloudy

Overcast

Precipitation:

None

x

Slight

Moderate

Heavy

Time monitoring performed:

14:00

Start

15:00

End

Barometric pressure (mbar):

985

Start

985

End

Pressure trend (Daily):

Falling

x

Steady

Rising

Source:

Wunderground

Air Temperature (Deg. C):

11

Before

11

After

JOB DETAILS: Land off Banks Road
Client: James Bamforth
Site: Linthwaite
Date: 28.5.21

Job No: 1399-21
Visit No: 3 of 6
Operator: SE

Monitoring Point	GAS CONCENTRATIONS												VOLATILES		FLOW DATA				Worst-credible GSVs		WELL AND WATER DATA						Comments
	Methane (%v/v)		%LEL		Carbon dioxide (%v/v)		Carbon monoxide (ppmv)		Hydrogen sulphide (ppmv)		Oxygen (%v/v)		PID Peak (ppm)	Product thickness (mm)	Flow rate (l/hr)		Differential borehole Pressure (Pa)	Time for flow to equalise (secs)	Methane (l/hr)	CO2 (l/hr)	Water level (mbgl)	Depth of well (m)	Reduced level (mAOD)	Water level (mAOD)	Response Zone		
	Peak	Steady	Peak	Steady	Peak	Steady	Peak	Steady	Peak	Steady	Min.	Steady															
	Peak	Steady	Peak	Steady	Peak	Steady	Peak	Steady	Peak	Steady	Min.	Steady															
WS01	0.0	0.0			2.0	2.0	0	0	0	0	15.4	15.4			0.2	0.2			0	0.004	ND	2.00			Dry		
WS02	0.0	0.0			1.0	0.9	0	0	0	0	19.7	19.7			0.3	0.3			0	0.0027	ND	2.00			Dry		
WS03	0.0	0.0			1.2	1.1	0	0	0	0	19.8	19.8			0.3	0.3			0	0.0033	ND	4.00			Dry		
																			0	0							
																			0	0							
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																			0	0							
Max	0.0	0.0	ND	ND	2.0	2.0	0	0	0	0	19.8	19.8	ND	ND	0.3	0.3	ND	NA	0.0000	0.0040	DRY	4.00	NR	NR			
Min	0.0	0.0	0.0	0.0	1.0	0.9	0	0	0	0	15.4	15.4	0.0	0.0	0.2	0.2	0.0	0	0.0000	0.0000	0.00	2.00	0.00	0.00			

MG - Made ground
NAT - Natural
C - Cohesive
G - Granular

Page 1 of 1

Ground Gas and Groundwater Monitoring Record Sheet

JOB DETAILS:

Land off Banks Road

Client:

James Bamforth

Site:

Linthwaite

Date:

3.6.21

Job No:

1399-21

Visit No:

4 of 6

Operator:

SE

Project Manager:

DS

Monitoring Point	GAS CONCENTRATIONS												VOLATILES		FLOW DATA				Worst-credible GSVs		WELL AND WATER DATA						Comments
	Methane (%v/v)		%LEL		Carbon dioxide (%v/v)		Carbon monoxide (ppmv)		Hydrogen sulphide (ppmv)		Oxygen (%v/v)		PID Peak (ppm)	Product thickness (mm)	Flow rate (l/hr)		Differential borehole Pressure (Pa)	Time for flow to equalise (secs)	Methane (l/hr)	CO2 (l/hr)	Water level (mbgl)	Depth of well (m)	Reduced level (mAOD)	Water level (mAOD)	Response Zone		
	Peak	Steady	Peak	Steady	Peak	Steady	Peak	Steady	Peak	Steady	Min.	Steady															
WS01	0.0	0.0			2.6	2.6	0	1	0	0	14.5	14.5			0.2	0.2			0	0.0052	ND	2.00		Dry			
WS02	0.0	0.0			2.3	0.6	0	0	0	0	14.6	19.9			0.2	0.2			0	0.0012	ND	2.00		Dry			
WS03	0.0	0.0			1.1	1.1	0	0	0	0	19.9	19.8			0.3	0.3			0	0.0033	ND	4.00		Dry			
																			0	0							
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																			0	0							
Max	0.0	0.0	ND	ND	2.6	2.6	0	1	0	0	19.9	19.9	ND	ND	0.3	0.3	ND	NA	0.0000	0.0052	DRY	4.00	NR	NR			
Min	0.0	0.0	0.0	0.0	1.1	0.6	0	0	0	0	14.5	14.5	0.0	0.0	0.2	0.2	0.0	0	0.0000	0.0000	0.00	2.00	0.00	0.00			
ND - Not detected NR - Not recorded																			Worst-possible GSVs		MG - Made ground NAT - Natural						
																			0 0.0078								

NB: Where no flow (ND) recorded, GSVs are calculated using equipment limit of detection (0.1l/hr). Where negative flows recorded, these are converted to positive values for calculation of GSVs.

METEOROLOGICAL AND SITE INFORMATION:

(Select correct box with X or enter data, as applicable)

State of ground:

X

Dry

Moist

Wet

Snow

Frozen

Wind:

Calm

X

Light

Moderate

Strong

Cloud cover:

X

None

Slight

Cloudy

Overcast

Precipitation:

X

None

Slight

Moderate

Heavy

Time monitoring performed:

08:30

Start

End

Barometric pressure (mbar):

999

Start

999

End

Pressure trend (Daily):

Falling

X

Steady

Rising

Source:

Wunderground

Air Temperature (Deg. C):

12

Before

12

After

Ground Gas and Groundwater Monitoring Record Sheet

JOB DETAILS:

Land off Banks Road

Client:

James Bamforth

Site:

Linthwaite

Date:

25.06.2021

Job No:

1399-21

Visit No:

5 of 6

Operator:

RL/SE

Project Manager:

DS

Monitoring Point	GAS CONCENTRATIONS												VOLATILES		FLOW DATA				Worst-credible GSVs		WELL AND WATER DATA						Comments
	Methane (%v/v)		%LEL		Carbon dioxide (%v/v)		Carbon monoxide (ppmv)		Hydrogen sulphide (ppmv)		Oxygen (%v/v)		PID Peak (ppm)	Product thickness (mm)	Flow rate (l/hr)		Differential borehole Pressure (Pa)	Time for flow to equalise (secs)	Methane (l/hr)	CO2 (l/hr)	Water level (mbgl)	Depth of well (m)	Reduced level (mAOD)	Water level (mAOD)	Response Zone		
	Peak	Steady	Peak	Steady	Peak	Steady	Peak	Steady	Peak	Steady	Min.	Steady			Peak	Steady											
WS01	0.0	0.0	0.0	0.0	1.4	1.4	0	0	0	0	19.1	19.1			0.3	0.3			0	0.0042	ND	2.00		DRY			
WS02	0.0	0.0	0.0	0.0	1.2	0.9	0	0	0	0	19.2	20.4			0.2	0.2			0	0.0018	ND	2.00		DRY			
WS03	0.0	0.0	0.0	0.0	1.1	0.4	0	0	0	0	19.2	20.1			0.2	0.2			0	0.0008	ND	4.00		DRY			
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																			0	0							
Max	0.0	0.0	0.0	0.0	1.4	1.4	0	0	0	0	19.2	20.4	ND	ND	0.3	0.3	ND	NA	0.0000	0.0042	DRY	4.00	NR	NR			
Min	0.0	0.0	0.0	0.0	1.1	0.4	0	0	0	0	19.1	19.1	0.0	0.0	0.2	0.2	0.0	0	0.0000	0.0000	0.00	2.00	0.00	0.00			

ND - Not detected

NR - Not recorded

NA - Non applicable

Worst-possible GSVs

00.00000.0042

NB:

Where no flow (ND) recorded, GSVs are calculated using equipment limit of detection (0.1l/hr). Where negative flows recorded, these are converted to positive values for calculation of GSVs.

MG - Made ground

NAT - Natural

C - Cohesive

G - Granular

METEOROLOGICAL AND SITE INFORMATION:

(Select correct box with X or enter data, as applicable)

State of ground:

Dry

Moist

X

Wet

Snow

Frozen

Wind:

X

Calm

Light

Moderate

Strong

Cloud cover:

None

Slight

X

Cloudy

Overcast

Precipitation:

None

Slight

X

Moderate

Heavy

Time monitoring performed:

09:30

Start

10:30

End

Barometric pressure (mbar):

991

Start

991

End

Pressure trend (Daily):

X

Falling

Steady

Rising

Source:

Wunderground

Air Temperature (Deg. C):

10

Before

10

After

Ground Gas and Groundwater Monitoring Record Sheet

JOB DETAILS:

Land off Banks Road

Client:

James Bamforth

Site:

Linthwaite

Date:

13.7.21

Job No:

1399-21

Visit No:

6

of

6

Operator:

RL/SE

Project Manager:

DS

Monitoring Point	GAS CONCENTRATIONS												VOLATILES		FLOW DATA				Worst-credible GSVs		WELL AND WATER DATA						Comments
	Methane (%v/v)		%LEL		Carbon dioxide (%v/v)		Carbon monoxide (ppmv)		Hydrogen sulphide (ppmv)		Oxygen (%v/v)		PID Peak (ppm)	Product thickness (mm)	Flow rate (l/hr)		Differential borehole Pressure (Pa)	Time for flow to equalise (secs)	Methane (l/hr)	CO2 (l/hr)	Water level (mbgl)	Depth of well (m)	Reduced level (mAOD)	Water level (mAOD)	Response Zone		
	Peak	Steady	Peak	Steady	Peak	Steady	Peak	Steady	Peak	Steady	Min.	Steady			Peak	Steady											
WS01	0.0	0.0	0.0	0.0	1.5	1.5	0	0	0	0	18.5	18.5			0.2	0.2			0	0.003	ND	2.00		Dry			
WS02	0.0	0.0	0.0	0.0	1.3	0.8	0	0	0	0	18.5	19.8			0.2	0.2			0	0.0016	ND	2.00		Dry			
WS03	0.0	0.0	0.0	0.0	0.8	0.8	0	0	0	0	18.3	19.4			0.2	0.2			0	0.0016	ND	4.00		Dry			
																			0	0							
																			0	0							
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Max	0.0	0.0	0.0	0.0	1.5	1.5	0	0	0	0	18.5	19.8	ND	ND	0.2	0.2	ND	NA	0.0000	0.0030	DRY	4.00	NR	NR			
Min	0.0	0.0	0.0	0.0	0.8	0.8	0	0	0	0	18.3	18.5	0.0	0.0	0.2	0.2	0.0	0	0.0000	0.0000	0.00	2.00	0.00	0.00			

ND - Not detected

NR - Not recorded

NA - Non applicable

Worst-possible GSVs

00.003

NB:

Where no flow (ND) recorded, GSVs are calculated using equipment limit of detection (0.1l/hr). Where negative flows recorded, these are converted to positive values for calculation of GSVs.

MG - Made ground

NAT - Natural

C - Cohesive

G - Granular

METEOROLOGICAL AND SITE INFORMATION:

(Select correct box with X or enter data, as applicable)

State of ground:

Dry

X

Moist

Wet

Wind:

Calm

X

Light

Moderate

Strong

Cloud cover:

None

X

Slight

Cloudy

Overcast

Precipitation:

None

X

Slight

Moderate

Heavy

Time monitoring performed:

15:05

Start

15:30

End

Barometric pressure (mbar):

989

Start

989

End

Pressure trend (Daily):

Falling

X

Steady

Rising

Source:

Wunderground

Air Temperature (Deg. C):

16

Before

16

After