



Old Mill Lane, Barnsley
Phase II Geo-Environmental Assessment
For
Aldi Stores Ltd.

Report Ref	Issue	Prepared by	Date	Reviewed by	Date
15004/SI	1	A Bradley	17.10.16	A Cooper	18.10.16

Client

Aldi Stores Ltd
Commercial Road
Goldthorpe
South Yorkshire
S63 9FA

3e Consulting Engineers Ltd
4 Calder Close
Calder Park
Wakefield
WF4 3BA

Tel : 01924 240420

**Old Mill Lane, Barnsley
Phase II Geo-Environmental Assessment**

CONTENTS

EXECUTIVE SUMMARY	i
1 INTRODUCTION	1
2 THE SITE	3
3 PHASE I GEO-ENVIRONMENTAL ASSESSMENT	4
4 METHOD OF INVESTIGATION	7
5 RESULTS OF THE INVESTIGATION	10
6 DISCUSSION	20

Drawings

- G001 Site Location Map
- G002 Exploratory Hole Location Plan

Appendices

- Appendix A Site Plan
- Appendix B Exploratory Hole Records
- Appendix C Ground Gas and Water Monitoring Records
- Appendix D Laboratory Chemical Test Certificates
- Appendix E Laboratory Geotechnical Test Certificates

Executive Summary

Site Investigation	The investigation involved: • 3 mini percussion boreholes to a maximum depth of 6.0 metres. • 3 dynamic sampling boreholes to a maximum depth of 8.9 metres. • 2 rotary open hole boreholes to a maximum depth of 30.2 metres. • Installation of five ground gas and water monitoring wells. • Contamination and geotechnical related testing. • Ground gas and water monitoring.
Current Use	The site is currently unoccupied, level and generally covered by informal granular hardstanding with discrete areas of block work walls concrete slab or tarmac hardstanding. The boundaries are marked by post and wire fencing on the east, west and south with palisade fencing to the north. Old Tannery Lane lies on embankment to the south of the site.
Environmental Setting	• Geological information indicates the site to be underlain alluvial deposits which overlie Coal Measures bedrock. • Four landfill record within 250m. • River Dearne lies 35m to south. • The underlying solid and drift strata are classed as a Secondary A aquifer. • The site is recorded to be at risk from flooding (Zone 3). • There are no licensed groundwater abstractions within 250m. • There are 9 discharge consents within 250m. • Radon protection measures are not required for future developments. • There are no Local Authority Pollution and Prevention Controls within 250m.
Ground Conditions	Ground conditions generally comprise made ground including reworked clay, gravel, cobbles and boulders of brick, concrete, black ashy gravel of various lithology's. These were proven to an average depth of 1.70m, however, within the former gas holder these were proven to 6.6m where a concrete obstruction was present. Underlying the made ground were alluvial soils, which comprised very soft to firm sandy clay with bands of sand and gravel to a maximum depth of 3.90m. Firm to stiff and stiff gravelly clay (residual soils) overlying interbedded clay, sand and cobbles of sandstone recovered as a bedded gravel were present to depths between 8.15m and 8.50m bgl. The solid Coal Measures strata comprising interbedded Mudstone, Sandstone and Siltstone with a thin band of coal (BH02 12.40-12.60m) was proven to 30.2m.
Groundwater	During the progression of the mini percussion and dynamic sampling boreholes, perched groundwater was encountered in the made ground between 1.5m and 1.9m bgl. Deeper groundwater strikes were encountered in natural soils and bedrock between 4.0m and 8.1m. The preliminary groundwater monitoring visits encountered water between 1.11m in the centre of the site and 2.83m bgl in the east.
Contamination	Information obtained during the desk study indicated a medium risk of contamination. Visual and olfactory evidence of potential Gas Works contamination was encountered in the base of the natural soils outside of the gas holder and in the base of the gas holder. Laboratory chemical analysis on the soils have identified them to be suitable to remain on site for the proposed development when compared with the relevant GAC. A single sample of made ground (TP03 at 0.30m) in the west of the site identified some elevated PAH compounds and another sample of made ground soils from (TP06 at 0.25m) identified Chrysotile fibres at 0.003%. Groundwater testing has identified that elevated concentrations of PAH, TPH, benzene, ethylbenzene, ammonia and phenol are present in the groundwater when compared against generic assessment criteria, however, these results are similar, albeit slightly higher to those recorded in the post remediation monitoring carried out by the remediation consultant. Given the results of the laboratory analysis, the risk to the wider environment is considered to be low to negligible when compared to the post remediation monitoring on the site, which we understand was approved by MBMC and the EA.

Appraisal	Remediation – At this stage, it is considered that remediation will comprise <u>remedial capping</u> in soft landscaping and the installation of a <u>hydrocarbon/carbon dioxide barrier</u> as part of the store construction. A remediation strategy will be required for the approval of the regulators. Offsite Disposal of Materials – A preliminary assessment suggests that the made ground materials, are likely to be classed as stable <u>non-reactive hazardous waste</u>. Water Supply Pipes – Our preliminary assessment indicates that <u>special precautions</u> are required with respect to water supply pipes placed within made ground. Mining – Based on the information contained in the Coal Authority Mining Report and the single borehole carried out in the south, the site is considered to be <u>stable</u> with respect to coal mining. Foundations – The made ground and the soft alluvial clay encountered are considered unsuitable as a bearing stratum using conventional shallow spread foundations due to the potential for excessive total and differential settlements. Either <u>piled foundations or vibro improvement</u> are considered suitable subject to the advice of a specialist contractor and approval of the regulators. It should be noted that based on the site investigation within the gas holder it is assumed that the gas holder base was not removed and therefore obstructions may be present within the made ground which may pose a constraint to foundations or services corridors. Floor Slabs – It is considered that a <u>piled slab</u> or <u>vibro improvement</u> will need to be adopted, particularly as the store is proposed to be situated over the infilled former gas holder. Gas precautions – Preliminary monitoring indicates elevated carbon dioxide gas to be present, therefore, <u>basic</u> gas precautions are considered necessary. A further three monitoring visits are proposed and the gas precautions will be confirm and reported in an addendum report. In addition, based on the elevated concentrations of naphthalene within the made ground at the base of the gas holder and within natural soils around the gas holder it is recommended that the gas protection measures are increased to a <u>hydrocarbon and carbon dioxide resistant barrier</u>, particularly as the likely foundations solution (either piles or stone columns) will provide a preferential pathway up to the underside of the floor slab for vapours. Drainage - Based on the presence of deep soft cohesive soils and shallow water table the use of soakaways is <u>not</u> considered feasible on the site. External Works - A CBR value of <u>2%</u> should be adopted at this stage for design on the made ground or residual soils, subject to confirmation following site clearance, proof rolling and removal of any soft spots. Sulphate attack on buried concrete – Buried concrete should be designed to BRE Special Digest 1:2005 Design Sulphate Class <u>DS-2</u> with an ACEC site classification <u>AC-2</u> for made ground and Design Sulphate Class <u>DS-1</u> with an ACEC site classification <u>AC-1</u> within natural soils.
-----------	---

1 INTRODUCTION

1.1 3e Consulting Engineers Ltd (3e) were commissioned by Aldi Stores Ltd. to carry out a geo-environmental assessment for the proposed development of land off Old Mill Lane, Barnsley, South Yorkshire. This report highlights ground related environmental and geotechnical considerations in relation to the proposed development for an Aldi store with associated car parking and landscaping, details of which are provided in **Appendix A**.

1.2 A Phase I geo-environmental assessment of the site was completed by 3e Consulting Engineers (ref: 15004 Issue 2). It is recommended that the report is read in conjunction with this assessment. The objectives of this assessment were:

- To investigate near surface soil and groundwater conditions.
- To determine the potential risks posed by any ground or groundwater contamination and provide recommendations on remedial measures to manage such risks.
- To assess the risk posed by hazardous ground gas.
- To provide advice relating to geotechnical issues associated with the site.
- To provide foundation recommendations.

1.3 Fieldwork was undertaken between 12 and 15 September 2016 and comprised three mini percussive boreholes, three dynamic sampling boreholes and two rotary open hole boreholes with associated sampling and testing.

1.4 This report presents the factual information available during this appraisal, interpretation of the data obtained and recommendations relevant to the scope of works outlined above. It has been assumed in the production of this report that the site is to be redeveloped for a commercial end use.

1.5 The comments and opinions presented in this report are based on the findings of the intrusive investigation carried out by 3e and the results of laboratory analysis. Responsibility cannot be accepted for any conditions not revealed by this investigation and which have not been taken into account by this report. Any diagram or opinion relating to site geology, contamination or other spatially variable features between or beyond investigation positions is conjectural and provided for guidance only. Confirmation of ground conditions between exploratory holes should be undertaken if deemed necessary. Evaluation of groundwater is



based on observations made at the time of the investigation and any monitoring visits, but it should be noted that levels and quality may vary due to seasonal and other effects.

1.6 This report has been prepared for the sole use of Aldi Stores Ltd. No other third party may rely upon or reproduce the contents of this report without the written approval of 3e. If any unauthorised third party comes into possession of this report, they rely on it entirely at their own risk and 3e do not owe them any Duty of Care or Skill.

2 THE SITE

Location and Description

2.1 The site, centred on National Grid Reference 435200, 407310, is located on the east of Old Mill Lane and north of Old Tannery Road in Barnsley, approximately 1km north east of the town centre as shown on **G001**.

2.2 The site is currently unoccupied, level and generally covered by informal granular hardstanding with discrete areas of block work walls, concrete slab or tarmac hardstanding. During the walkover, evidence of potential contamination sources was not observed on the surface.

2.3 The boundaries are marked by post and wire fencing on the east, west and south with palisade fencing to the north.

2.4 The adjacent land use is as follows:

- North: Car park and associated Wickes store beyond.
- South and East: Old Tannery Lane on embankment with unoccupied land and River Dearne beyond.
- East: Agricultural plant yard with other commercial and residential properties beyond.
- West: Old Mill and with on embankment with retail units beyond.

3 PHASE I GEO-ENVIRONMENTAL ASSESSMENT

3.1 A Phase I geo-environmental assessment of the site was completed by 3e Consulting Engineers (ref: 15004 Issue 2). It is recommended that the report is read in conjunction with this assessment. Relevant information from the Phase I geo-environmental assessment is summarised in the following section.

Site History

3.2 In summary, the site is indicated to have been occupied by a gas works since the end of the 19th century, which extended across the entire site and the land adjacent to the east, west and south. The gas works was redeveloped as a depot in the 1960s, which lasted until its removal in the last ten years. The surrounding area has supported a paper mill, saw mill, tannery and collieries, since the late 1800's.

Geology and Mining

3.3 The published geological map of the area (Barnsley, Sheet 87) indicates the site to be underlain by Alluvium, which could comprise clay, silt sand or gravel. Previous investigations prior to the site remediation generally encountered soft clay beneath the made ground to depths of about 4m but up to 6.3m in the south of the site. The soft clays were underlain by firm clays beneath the entire site with gravel at depths in excess of 6m in a number of boreholes. The site is underlain by Kent's Rock sandstone unit of the Late Carboniferous. The Kent's Rock is underlain by the Kent's Thin Coal which is indicated up to 1.9m thick locally.

3.4 No made ground is recorded on published maps, however, previous investigations prior to the site remediation generally encountered between 1.2m and 4.5m, with deeper fill encountered in the SE part of the site. Within the former gas holder greater than 6.5m of made ground was encountered.

3.5 The Coal Authority record workings beneath the site in 4 seams of coal between 120m and 410m depth. The Coal Authority also believes that the site is in an area where coal exists at or close to the surface, which may have been worked at some time in the past.

3.6 No mine entries are recorded on or within 20m of the site boundary. It should be noted that other unrecorded mine entries may be present and there are collieries and a drift

mines noted within 500m of the site. However, no evidence of mine entries was noted in the validation reports of the site remediation, which included the excavation of a significant proportion of the made ground on site.

Watercourses and Groundwater

3.7 The nearest surface water feature is the River Dearne some 35m to the south.

3.8 The site is indicated to lie within a flood plain considered to be at risk of flooding (Zones 3). A separate Flood Risk Assessment has been prepared by 3e in October 2016, which discussed the flood risk in much greater detail.

3.9 The underlying solid strata and drift deposits are classified as a Secondary A Aquifer. There is a Yorkshire Water surface water abstraction some 369m NW from an unnamed stream and a groundwater abstraction from Star Paper Mill 416m to NE.

3.10 There are nine discharge consents within 250m, mostly for Yorkshire Water storm water overflows into the River Dearne.

Landfill Sites, Pollution Controls and Industrial Land Use

3.11 Four historical landfills are recorded within 250m, the closest of which is some 48m south west of the site for inert waste in the SW portion of the former gas works on the opposite bank of the River Dearne.

3.12 The site was a registered waste transfer sites between 1993 and 2000.

3.13 One active petrol filling station is recorded within 250m of the site. This is recorded to be approximately 229m SW of the site at the Asda supermarket on the opposing side of the River Dearne.

Conceptual Site Model

3.14 The proposed development comprises of a commercial food store with associated parking and soft landscaping on the site. The desk study assessment concluded the main risks were from the former site use as a remediated gas works, imported made ground and

potentially untreated areas of the former gas works off site to the north under the existing Wickes store car park (based on a review of historical maps and available reports).

3.15 The assessment indicates that the risk to human health from the contamination can be largely mitigated by use of appropriate PPE during construction and by the use of hardstanding or soil capping throughout the proposed development to break any latent pollution pathway. Additionally, the construction of the store will likely require a hydrocarbon vapour barrier to mitigate against the presence of elevated naphthalene in the soils.

3.16 Overall the assessment indicates a medium environmental risk until proven otherwise.

Ground Gas Risk Assessment

3.17 No Radon protection measures are required in the construction of new dwellings.

3.18 The preliminary ground gas risk assessment identifies that there is a low to medium risk to the development from ground gas due to the made ground, nearby landfill, potential shallow coal mining and the presence of potential alluvium beneath the site.

Site Remedial Works

3.19 It is our understanding that the site remediation was designed to make the site suitable for a commercial end use based on the guidance at the time of remediation. Therefore there would not appear to be a requirement to provide a remedial soil capping layer for the site, however, in order to provide growing media for soft landscaped areas, some topsoil will need to be imported. The imported soils will need to be validated prior to placement in order to ensure the materials are suitable for use.

4 METHOD OF INVESTIGATION

Scope of Works

4.1 The intrusive works were designed in accordance with the findings and recommendations of the Phase I Desk Study Report and comprised three mini percussion boreholes (maximum depth of 6.0m), three dynamic sampling boreholes (maximum depth of 8.5m) and two rotary open hole boreholes (to a maximum depth of 30.2m).

4.2 Fieldwork was carried out in general accordance with BS5930:2015, 'Code of Practice for Site Investigations'. Strata logging is generally compliant with BS EN ISO 14688:2002 and 2004 and BS EN ISO 14689:2003. All depths recorded are taken from below existing ground level. Detailed descriptions of strata and groundwater observations made during investigation works, together with samples recovered, are presented on the exploratory hole records in **Appendix B** and the exploratory hole locations are shown on **Drawing G002**.

4.3 The boreholes were sunk in order to determine the soil profile and to allow ground gas and groundwater monitoring wells to be installed. Disturbed samples were recovered as appropriate for soil descriptions and laboratory testing. Standard penetration tests (SPT/CPT) were carried out to provide an assessment of the in situ strength and density of the made ground and natural deposits present below the site.

4.4 The gas/groundwater monitoring wells, comprising slotted 19mm and 50mm diameter HDPE pipe set within a granular filter, were installed in five boreholes (WS01 to WS02, BH02 and BH03) to a maximum depth of 9.0m bgl. The wells were sealed at surface using bentonite and either a lockable cover was fitted at the surface or standing proud of the surface. To date, the wells have been monitored on three occasions for methane, carbon dioxide and oxygen using a portable infra-red gas monitor. The rate of gas flow from the boreholes was also recorded using a portable flow meter and the groundwater levels were recorded using a portable dip meter. The results of the ground gas monitoring are presented in **Appendix C**.

Laboratory Chemical Testing

4.5 Selected samples recovered from the site were tested for potential contaminants of concern based on the findings of the conceptual site model. A total of eight samples of made ground and two natural soils were screened for a selection of the following determinands:

- Arsenic
- Cadmium
- Chromium
- Lead
- Mercury
- Nickel
- Selenium
- Copper
- Zinc
- Boron (water soluble)
- Soil Organic Matter (SOM)
- Water soluble sulphate
- Speciated polycyclic aromatic hydrocarbons (PAH)
- TPH (Aliphatic/Aromatic banding)
- MTBE & BTEX

4.6 In addition, nine samples of made ground were screened for the presence of asbestos and six samples of natural deposits were scheduled for water soluble sulphate and pH determinations to assess the potential for sulphate attack on buried concrete.

4.7 Where Gas Works waste contamination was suspected in deep natural soils, additional testing for total cyanide, total ammonia and phenols.

Groundwater Analysis

4.8 In order to assess the potential risk to the water environment, groundwater samples were obtained from the two groundwater monitoring wells, installed within BH2 and BH3 on 29 September 2016.

4.9 The two samples of groundwater recovered were screened for the following determinands:

- Speciated polyaromatic hydrocarbons (PAH)
- TPH (Aliphatic/Aromatic banding)
- MTBE & BTEX
- Ammonia
- Total Cyanide
- Total Phenols
- pH

4.10 The analyses were carried out at an MCERTS registered and UKAS accredited laboratory. The results of the chemical testing are provided in **Appendix D**.

Laboratory Geotechnical Testing

Classification Tests

4.11 Five samples of cohesive alluvial soils were scheduled for Atterberg limits determinations for classification purposes. The samples were obtained from between 1.6m and 5.0m bgl.

4.12 The results of the geotechnical testing are presented in **Appendix E**.

5 RESULTS OF THE INVESTIGATION

Soil Profile

5.1 Detailed descriptions of the materials encountered together with observations of groundwater behaviour, the results of in situ testing and sampling information are given on the exploratory hole records included as **Appendix B**.

Average Depth to Top of Strata (Thickness Range)	Description
Ground Level (1.1m – 2.35m), within the former gas holder MG was proven to 6.6m bgl	Made ground: Reworked clay, gravel, cobbles and boulders of brick, concrete, black ashy gravel of various lithologies.
1.7m (Recorded thicknesses of 0.4m to 3.9m)	Alluvial Soils: Very soft to firm sandy clay with bands of sand and gravel.
6.0m (Recorded thicknesses between 3.3m and 3.5m).	Residual Soils: Firm to stiff and stiff gravelly clay overlying interbedded clay, sand and cobbles of sandstone or coarse sandstone recovered as a bedded gravel.
6.0m (Base not proven). Max depth encountered 30.2m.	Coal Measures: Interbedded Mudstone, Sandstone and Siltstone with a thin band of coal.

5.2 The SPTs completed within the made ground materials recorded SPT 'N' values between N3 and N48, on average these soils had an SPT 'N' value of N18 (Medium dense). The superficial deposits have recorded SPT 'N' values, between N5 and N16, on average these soils had an SPT 'N' value of N8 (loose or soft to firm). The underlying residual soils and weathered mudstone bedrock have recorded SPT 'N' values, between N12 and N50, on average these soils had an SPT 'N' value of N30 (stiff to very stiff).

Groundwater

5.3 During the progression of the mini percussion and dynamic sampling boreholes, perched groundwater was encountered in the made ground between 1.5m and 1.9m bgl. Deeper groundwater strikes were encountered in natural soils and bedrock between 4.0m and 8.1m.

5.4 The preliminary groundwater monitoring visits encountered water between 1.11m in the centre of the site and 2.83m bgl in the east.

5.5 The results of the groundwater monitoring are presented in **Appendix C**.

5.6 It should be noted that groundwater levels vary seasonally and that a higher water table than recorded could occur.

Physical Evidence of Contamination

5.7 Potential contamination associated with the former gas works was identified in both soils and groundwater in all three deep dynamic sampling boreholes. This was both visual and olfactory evidence of contamination was encountered within the deeper made ground materials (particularly immediately below a puddle clay layer and above the obstruction encountered in the former gas holder) and in residual soils.

Contamination Related Testing

5.8 The results of the contamination related testing undertaken on eight samples of made ground and two samples of natural soils are included as **Appendix D**. Generally, the results have been assessed using the LQM/CIEH Suitable for Use Levels (S4ULs) for Human Health Risk Assessment (Copyright Land Quality Management Limited reproduced with permission; Publication Number S4UL3170; All rights reserved).

5.9 Where no S4UL is available, reference is made to published CLEA Soil Guidelines Values (SGVs) for standard land uses, or generic levels derived using the CLEA model (v1.06). For the purpose of this report, all S4ULs or SGVs will be referred to as Generic Assessment Criteria (GAC).

5.10 With respect to the assessment of the site, as the site is proposed to be developed with an Aldi store, therefore, the most appropriate values are considered to be the GACs for a commercial end use. Based on the laboratory results, an SOM of 1% has been used in the assessment. A summary of the contamination related testing is presented as follows.

Metals and Inorganics

Determinand	Maximum conc. mg/kg	Minimum conc. mg/kg	No of Samples Tested	Generic Assessment Criteria (GAC) ⁽¹⁾ mg/kg	No of Samples Exceeding GAC
Arsenic	27	2	10	640	0
Boron	1.7	<0.5	10	240000	0
Cadmium	1.3	<0.2	10	190	0
Chromium (III)	111	13	10	8600	0
Lead	466	6.9	10	2330 ⁽²⁾	0
Mercury	<0.5	-	10	1100	0
Selenium	1.5	<0.3	10	12000	0
Copper	40	1.8	10	68000	0
Nickel	36	2.7	10	980	0
Zinc	135	19	10	730000	0

Hydrocarbons

Determinand	Maximum conc. mg/kg	Minimum conc. mg/kg	No of Samples Tested	Generic Assessment Criteria (GAC) ⁽¹⁾ mg/kg	No of Samples Exceeding GAC
<u>Speciated PAH</u>					
Naphthalene	108.68	0.04	10	190	0
Acenaphthylene	25.82	0.08	10	83000	0
Acenaphthene	20.26	0.01	10	84000	0
Fluorene	29.47	0.02	10	63000	0
Phenanthrene	72.09	0.29	10	22000	0
Anthracene	24.03	0.12	10	520000	0
Fluoranthene	99.08	0.51	10	23000	0
Pyrene	79.80	0.46	10	54000	0
Benzo(a)anthracene	42.84	0.29	10	170	0
Chrysene	30.41	0.26	10	350	0
Benzo(b)fluoranthene	42.87	0.39	10	44	0
Benzo(k)fluoranthene	17.95	0.17	10	1200	0
Benzo(a)pyrene	38.48	0.39	10	35	1
Indeno(1,2,3-cd)pyrene	29.10	0.29	10	500	0
Dibenz(a,h)anthracene	6.06	0.04	10	3.5	1
Benzo(g,h,i)perylene	19.80	0.24	10	3900	0
<u>Speciated TPH</u>					
Aromatic TPH C ₅ -C ₇	0.18	<0.01	10	3200	0
Aromatic TPH C ₇ -C ₈	0.27	<0.01	10	7800	0
Aromatic TPH C ₈ -C ₁₀	10	<0.01	10	2000	0
Aromatic TPH C ₁₀ -C ₁₂	109	<1	10	9700	0
Aromatic TPH C ₁₂ -C ₁₆	46	<1	10	59000	0
Aromatic TPH C ₁₆ -C ₂₁	288	1	10	1600000	0
Aromatic TPH C ₂₁ -C ₃₅	208	2	10	1600000	0
Aromatic TPH C ₃₅ -C ₄₄	20	<1	10	26000	0
Aliphatic TPH C ₅ -C ₆	<0.1	-	10	56000	0
Aliphatic TPH C ₆ -C ₈	0.5	<0.1	10	3500	0
Aliphatic TPH C ₈ -C ₁₀	22	<0.1	10	16000	0
Aliphatic TPH C ₁₀ -C ₁₂	529	<4	10	36000	0
Aliphatic TPH C ₁₂ -C ₁₆	1016	<4	10	28000	0
Aliphatic TPH C ₁₆ -C ₃₅	1769	20	10	28000	0
Aliphatic TPH C ₃₅ -C ₄₄	451	18	10	28000	0

Notes

- (1) LQM/CIEH S4UL for a commercial end use unless otherwise stated
(2) CLEA soil guideline value for a commercial end use (Version 1.0 beta).

5.11 Of the determinands tested one sample of made ground (TP3 at 0.30m) recorded elevated PAH determinands (Benzo(a)pyrene and Dibenzo(a,h)anthracene) above the relevant GAC.

Asbestos

5.12 One of the nine samples of made ground screened for asbestos fibres identified chrysotile fibres at 0.003% (TP06 at 0.25m).

Phytotoxic Contaminants

5.13 To assess the potential risks to plants in areas of soft landscaping the results of the soil screening have also been assessed with respect to plant phytotoxicity, as summarised in the following table.

Plant Phytotoxicity						
Determinand	Soil pH range	Minimum conc. (mg/kg)	Maximum conc. (mg/kg)	Maximum Permissible Concentration of PTE⁽¹⁾ in Soil (dependent upon soil pH range) (mg/kg)⁽²⁾		
				pH<6.0	pH 6.0-7.0	pH>7.0
Zinc	6.6-10.9	19	135	<200	<200	<300
Copper		1.8	40	<100	<135	<200
Nickel		2.7	36	<60	<75	<110

Notes

(1) PTE – Phytotoxic Element

(2) BS3882:2007 & DoE Code of Practice for Agricultural use of Sewage Sludge, 1996

5.14 From review of the individual test results, it can be seen that there is no perceived risk of plant phytotoxicity based on the concentrations recorded within the made ground.

Sulphate and pH Determinations

5.15 Within the made ground, water soluble sulphate concentrations ranged between 173mg/l and 1836mg/l with pH values between 6.4 and 10.9. These indicate a general BRE Special Digest 1:2005 Design Sulphate Class DS-2 with an ACEC site classification AC-2, and concrete should be designed accordingly.

5.16 Within the natural soils, water soluble sulphate concentrations ranged between 47mg/l and 619mg/l with pH values between 6.2 and 11.4. These indicate a general BRE Special Digest 1:2005 Design Sulphate Class DS-1 with an ACEC site classification AC-1, and concrete should be designed accordingly.

Waste Classification

5.17 Waste classification testing has not been carried out, however, based on the presence of slightly elevated total organic carbon, mineral oils and PAHs the made ground soils should be classified as stable non-reactive hazardous waste in a non-hazardous landfill.

Groundwater Contamination Assessment

5.18 In order to assess the chemical nature of the underlying groundwater and potential risk to the wider environment, groundwater samples recovered during monitoring of two groundwater monitoring wells were scheduled for chemical analysis with a summary of the results provided in the following table.

GROUNDWATER					
Determinand	Minimum conc. µg/l	Maximum conc. µg/l	No of Samples Tested	Generic Assessment Criteria (GAC) µg/l ⁽¹⁾	No of Samples Exceeding GAC
Speciated PAH's					
Naphthalene	9.1	179.6	2	2.4 ⁽²⁾	2
Acenaphthylene	1.3	5.8	2	0.1	2
Acenaphthene	0.2	14	2	0.1	2
Fluorene	0.7	6.6	2	0.1	2
Phenanthrene	1.4	19.1	2	0.1	2
Anthracene	0.7	7.9	2	0.4 ⁽²⁾	2
Fluoranthene	0.7	6.7	2	1 ⁽²⁾	1
Pyrene	0.8	8.4	2	0.1	2
Benzo(a)anthracene	<0.1	5.4	2	0.1	1
Chrysene	0.7	4.5	2	0.1	2
Benzo(b)fluoranthene	<0.1	1.5	2	0.1	1
Benzo(k)fluoranthene	<0.1	1.2	2	0.1	1
Benzo(a)pyrene	<0.1	2.9	2	0.1 ⁽²⁾	1
Indeno(123cd)perylene	<0.1	0.8	2	0.1	1
Dibenz(ah)anthracene	<0.1	-	2	0.1	0
Benzo(ghi)perylene	<0.1	0.7	2	0.1	1
Speciated TPH's					
Aromatic TPH C ₅ -C ₇	9	2492	2	10	1
Aromatic TPH C ₇ -C ₈	<1	39	2	10	1
Aromatic TPH C ₈ -C ₁₀	16	748	2	10	2
Aromatic TPH C ₁₀ -C ₁₂	10	180	2	10	1
Aromatic TPH C ₁₂ -C ₁₆	3	20	2	10	1
Aromatic TPH C ₁₆ -C ₂₁	4	49	2	10	1
Aromatic TPH C ₂₁ -C ₃₅	<1	16	2	10	1
Aromatic TPH C ₃₅ -C ₄₄	<1	-	2	10	0
Aliphatic TPH C ₅ -C ₆	3	8	2	10	0
Aliphatic TPH C ₆ -C ₈	25	26	2	10	2
Aliphatic TPH C ₈ -C ₁₀	45	455	2	10	2
Aliphatic TPH C ₁₀ -C ₁₂	25	474	2	10	1
Aliphatic TPH C ₁₂ -C ₁₆	32	617	2	10	2
Aliphatic TPH C ₁₆ -C ₃₅	9	635	2	10	1
Aliphatic TPH C ₃₅ -C ₄₄	<1	21	2	10	1
BTEX					
Benzene	9	2492	2	50 ⁽²⁾	2
Toluene	<1	39	2	700 ⁽³⁾	0
Ethylbenzene	7	404	2	300 ⁽³⁾	1
m & p-Xylene	5	165	2	500 ⁽³⁾	0
o-Xylene	4	179	2	500 ⁽³⁾	0
Other					
MTBE	<2	-	2	14 ⁽³⁾	0
Ammonia	503	3883	2	15 ⁽²⁾	2
Cyanide*	<20	-	2	50	0
Phenols	<10	-	2	7.7 ⁽⁴⁾	2

Notes

(1) UK Drinking Water Standard for Petroleum Hydrocarbons

(2) EQS Inland Surface Waters

(3) Resource Protection Value (RPV)

(4) US EPA National Primary Drinking Water Regulations (Secondary Drinking Water Legislation)

* = sample in wrong container and not fixed

5.19 From the results of the groundwater analysis, elevated concentrations of PAH, TPH, benzene, ethylbenzene, ammonia and phenol contamination were identified within the shallow groundwater at the locations of BH2 and BH3 when compared to the available generic assessment criteria.

5.20 Following further review, the most significantly elevated concentrations were recorded within BH2 and BH3, sunk hydraulically down-gradient of the on-site former gas holder.

5.21 Based upon the findings of the combined this investigation, the elevated levels of TPH and PAH contamination recorded within the groundwater samples screened from BH2 and BH3 are considered to be similar to the post remediation validation sampling carried out by the remediation consultant. In view of the fact that contaminated groundwater is already present at rockhead levels, piling is considered to have limited additional impact on the mobilisation of contamination into the underlying aquifer and lateral movement to the adjacent watercourse.

Modified Conceptual Site Model

Sources of Contamination

5.22 From the information gathered during the desk study and the site investigation the potential sources of contamination are from former site use as a gas works, however, this site has been remediated. Additional sources of contamination may be associated with imported made ground soils and off site gas works features that may not have been remediated.

5.23 Visual and olfactory evidence of potential gas works related contamination was encountered at depth within the made ground or natural soils in and around the former gas holder, however, chemical analysis identified that the soils do not exceed the relevant criteria for the proposed commercial development. The olfactory evidence is associated with the higher naphthalene concentrations recorded within these soils.

5.24 Analysis of the groundwater identified concentrations of PAH and TPH compounds are at similar levels to those identified in post remediation validation sampling carried out by the remediation consultant.

Pathways

- Dust and vapour inhalation
- Direct contact with made ground soils
- Vertical and lateral migration of groundwater
- Vertical gas migration

Receptors

- Staff and customers
- Construction site works
- Public
- Controlled waters
- Confined spaces

Pollutant Linkage Assessment

5.25 A qualitative risk assessment has been made of the likelihood of any pollutant linkage operating and its potential significance, as summarised in the following table:

Contamination source	Potential receptors	Pathway	Linkage complete and possible mitigation
<i>On site</i>			
Former Gas Works and imported made ground: Hydrocarbons and asbestos fibres.	Humans: Site workers	Direct contact, ingestion, dust inhalation	Yes, can be removed by the use of an appropriately designed site construction management plan, appropriate PPE and limited exposure.
	Humans: End users	Direct contact, ingestion, dust and vapour inhalation	Unlikely, the majority of site will be beneath hardcover which would break pathway. In areas of landscaping a remediation capping may be required.
	Controlled waters	Vertical and lateral migration	Yes, however, the concentration of contaminants within groundwater are similar to those accepted by regulators previously as part of the remediation validation works
<i>Off site</i>			
Former Gas Works Potential hydrocarbon contamination	Humans: End users	Direct contact, ingestion, dust and vapour inhalation	Unlikely, the majority of site will be beneath hardcover which would currently break pathway.
	Controlled waters	Vertical and lateral migration	Yes, however, the concentration of contaminants within groundwater on site are similar to those accepted by regulators previously.
Ground Gas	Humans: health risk Buildings: explosion	Vertical migration into buildings and confined spaces	The presence of ground gas has been identified which represents a potential risk to the future end users. As part of the development, it is deemed prudent to incorporate a hydrocarbon vapour barrier in to any buildings.

5.26 Contamination considered to be associated with the former gas works may pose a low risk to the wider environment, subject to discussions with the Local Authority and Environment Agency. In addition, the made ground on site pose and low risk to end users, but as new soft landscaping is proposed, this would act as remedial capping if import soils are used.

Geotechnical Related Testing

5.27 The results of the geotechnical testing are presented in **Appendix E**.

Classification Tests

5.28 Five samples of cohesive alluvial soils were scheduled for Atterberg limits determinations. The samples were obtained from between 1.6m and 5.0m bgl.

5.29 The cohesive alluvial soils recorded modified plasticity indices between 13.3% and 35.3% which indicates low to medium volume change potential.

Gas Monitoring

5.30 The results of the preliminary ground gas monitoring carried out on 14 and 29 September and 14 October 2016 are summarised in the following table:

Location	CH ₄ (% v/v)	CO ₂ (% v/v)	O ₂ (% v/v)	Maximum Flow (l/hr)	Barometric Pressure (mb)	Maximum GSV* (l/hr)	
						CO ₂	CH ₄
WS01	0.0	10.4-12.3	6.3-9.6	0.0	1007-1016	<0.07	<0.07
WS02	0.0-0.1	0.0	0.3-17.1	0.0			
WS03	0.0	0.5-1.1	18.1-20.1	0.0			
BH02	0.1	1.3-3.3	15.5-17.3	0.0	1007-1008	<0.07	<0.07
BH03	0.0	0.0-0.1	21.0-21.1	0.0			

* CIRIA 665 Gas Screening Value

5.31 Methane was recorded at low levels and carbon dioxide is present at levels in excess of 5% and zero flow being recorded during the monitoring. This equates to a CIRIA Gas Screening Value (GSV) less than <0.07l/hr, indicative of a CIRIA 665 site Characteristic Situation 2, where basic precautions are required. Monitoring is ongoing and the conclusions are subject to amendment until completion of the monitoring period.

6 DISCUSSION

6.1 Development proposals include the construction of a new Aldi store with associated car parking, hard and soft landscaping. This investigation was carried out primarily to provide geotechnical information with respect to foundations for the proposed developments. Contamination related testing has been carried out but only to provide a preliminary assessment to outline potential constraints on the development.

Contamination Assessment

6.2 Information obtained during the desk study indicated a medium risk of contamination. Visual and olfactory evidence of potential gas works contamination was encountered in the base of the natural soils outside of the gas holder and in the base of the gas holder. Laboratory chemical analysis on the soils has identified them to be suitable to remain on site for the proposed development when compared with the relevant human health GAC.

6.3 A single sample of made ground (TP03 at 0.30m) in the west of the site identified some elevated PAH compounds and a sample of made ground from beneath the proposed store recorded Chrysotile asbestos fibres at 0.003%.

6.4 Groundwater testing has identified that elevated concentrations of PAH, TPH, benzene, ethylbenzene, ammonia and phenol are present in the groundwater against generic assessment criteria, however, these results are similar, albeit slightly higher to those recorded in the post remediation validation monitoring carried out by the remediation consultant.

6.5 Given the results of the laboratory analysis, the risk to the wider environment is considered to be low when compared to the post remediation validation monitoring on the site which we understand was previously approved by BMBC and the EA.

Remediation

6.6 At this stage, it is considered that remediation will comprise remedial capping in soft landscaping and the installation of a hydrocarbon/carbon dioxide barrier is incorporated in the construction of the proposed store and suitably validated.

6.7 A remediation strategy will be required for the approval of the regulators, which would control the import and validation soils used as capping in soft landscaped areas.

Disposal of Materials

6.8 Waste classification testing has not been carried out, however, chemical test results suggest that the made ground can be classified as being stable non-reactive hazardous waste.

6.9 Where offsite disposal of waste soils is required, the results of the investigation should be made available to the waste carrier/receiver in order to determine the waste classification, costs for disposal and the requirement for further testing. Sufficient time should be allowed in the site programme to effectively segregate soils based on material type, including the time allowed for any further laboratory classification analysis as required.

Water Supply Pipes

6.10 UKWIR analysis has not been undertaken as part of this assessment. It is recommended that the results of the assessment are provided to the water supply company so that the correct pipe material can be selected. Our preliminary assessment indicates that basic special precautions are required with respect to water supply pipes placed within made ground or natural soils.

Mining Assessment

6.11 Based on the information contained in the Coal Authority Mining Report and the single borehole carried out in the south, the site is considered to be stable with respect to coal mining.

Foundations and Floor Slabs

6.12 The proposed development includes an Aldi store.

6.13 Based on the presence of variable depths and deposits of made ground underlain by alluvial soft clay. Made ground and the soft alluvial clay are considered unsuitable as a bearing stratum using conventional shallow spread foundations due to the potential for excessive total and differential settlements. Either piled foundations or vibro improvement are

considered suitable, subject to the advice of a specialist contractor and approval of the regulators. It should be noted that the site remediation did not remove all the structures (gas holder base) and therefore obstructions may be present within the made ground which may pose a constraint to foundations or services corridors.

6.14 It is considered that a piled suspended slab or vibro treatment to allow a ground bearing floor slab will need to be adopted, particularly as the store is proposed to be situated over the infilled gas holder.

External Works

6.15 A CBR value of 2% should be adopted at this stage for design on the made ground or superficial deposits, subject to confirmation following site clearance, proof rolling and removal of any soft spots.

6.16 It is recommended that in-situ plate load tests are carried out to verify the CBR at formation level.

Gas Protection Measures

6.17 Radon protection measures are not required for the proposed development.

6.18 Preliminary monitoring indicates carbon dioxide gas to be present, therefore need for gas precautions are considered necessary. A further three monitoring visits are proposed and the gas precautions will be confirm and reported in an addendum report.

6.19 In addition, based on the elevated concentrations of naphthalene within the made ground at the base of the gas holder and within natural soils around the gas holder it is recommended that the gas protection measures are increased to a hydrocarbon vapour barrier, particularly as the likely foundations solution (either piles or stone columns) will provide a preferential pathway up to the underside of the floor slab.

Surface Water Disposal

6.20 In view of the presence of deep made ground, soft cohesive soils and shallow water table the use of soakaways is not considered feasible on the site for the disposal of surface water and an alternative solution will be required.

Excavations and Dewatering

6.21 If man entry is proposed into excavations, the use of support to excavation sides will be required, in line with health and safety guidelines.

6.22 Significant groundwater ingress into shallow excavations is not anticipated within the made ground and natural soils.

Sulphate Attack on Buried Concrete

6.23 The results of the chemical analyses indicate a BRE Special Digest 1:2005 Design Sulphate Class DS-2 with an ACEC classification AC-2 within made ground materials and Design Sulphate Class DS-1 with an ACEC classification AC-1 within natural soils; buried concrete should be designed accordingly.