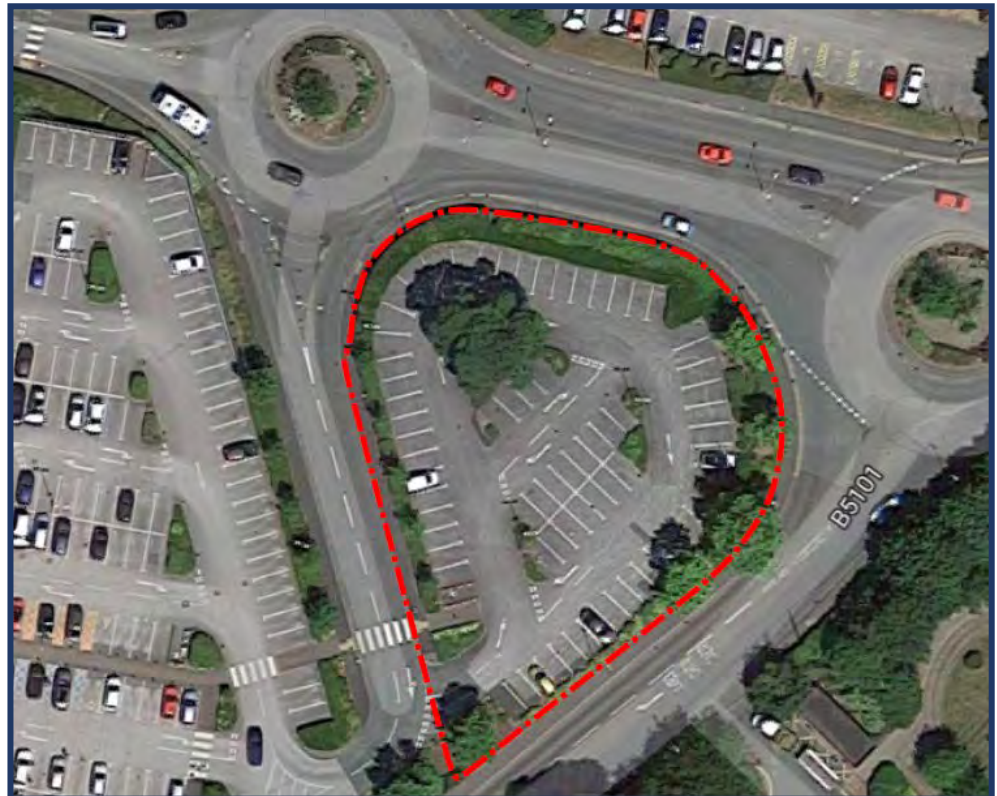


Pam Brown Associates



July 2019

Ph 1 Desk Study & Ph2 Geo-environmental Site Investigation

PLAS COCH ROAD
WREXHAM
LL11 2BA

Report Ref. 1928-19 / Final
/ Revision 1 – 31st July 2019

Pam Brown Associates



PHASE I DESK STUDY AND PHASE II GEO-ENVIRONMENTAL INVESTIGATION

PLAS COCH ROAD
WREXHAM
LL11 2BA

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Executive Summary	
Site Location and Description	The site is located off Plas Coch Road, Wrexham, LL11 2BA. National Grid Reference: 332572E, 351333N The site covers an area of 0.24ha, of irregular in shape and currently comprises an area of car parking with associated trees and soft landscaping features.
Proposed Development	McDonalds restaurant and drive thru' with areas of car parking and landscaping.
Geology	Glaciofluvial deposits comprising sand and gravel are recorded on site overlying Pennine Lower Coal Measures and Peninne Middle Coal Measures Formations (undifferentiated) described as mudstone, siltstone and sandstone. Negligible to Very Low risks have been identified in association with geological hazards on site. Eight (8No.) records of historical underground workings have been identified within 250m of the site, the nearest record relates to a colliery, 757m to the north. Ten (10No.) records of historical surface ground workings were recorded within 250m of the site boundary, the nearest record at 1m southeast related to a cutting. One (1No.) current ground working has been recorded 953m northeast associated with producing Sand. This activity is noted as being 'Ceased'.
Radon	The site is within a Radon affected area, as between 10% and 30% of the properties are above the radon action level. According to Building Research Establishment BRE211 (2015) 'Radon: Protective Measures for New Buildings', Full radon protective measures are required in the construction of new buildings or extensions.
Coal Mining	The site is recorded as being within a known coal mining affected area and inferred coal seams are noted within 500m of the site boundary. The property is within a surface area that could be affected by underground mining in two (2No.) seams of coal at 310m and 370m depth, last worked in 1921.
Mining / Mineral Abstraction	Mining for Iron Ore (bedded) has been recorded on site and mining for vein minerals has been recorded 6m east of the site. Other non-coal mining (including; clay, tin, brine and gypsum extraction) affected areas have not been identified within 1km of the site.
Hydrogeology, abstractions and discharges	The superficial deposits and bedrock have been designated as 'Secondary A' aquifers. No groundwater abstraction licenses and portable water licences were noted within 2km and the site is not within a Groundwater Source Protection Zone (GPZ).



Hydrology, abstractions and discharges	The nearest watercourse is a non-tidal inland river 417m north of the site, within the Dee Catchment Area. The River Gwenfro is recorded 1052m southwest of the site. The biological quality was measured in 2008 as Grade C ('Fairly Good') to Grade B ('Good') to at monitoring points 844m south and 1052m southwest, respectively. The chemical quality was measured in 2009 as Grade C ('Fairly Good') at 1052m southwest of the site. No active surface water abstraction licences have been recorded within 2km of the site.
Flooding Issues	The site is at 'Very Low' risk of flooding from rivers or the sea and is susceptible to groundwater flooding associated with superficial deposits.
Environmental Database	Four (4No.) current Part B permits were noted within 500m of the site, including the nearest record 103m NW for a petrol filling station. One (1No.) Category 3 or 4 Radioactive Substances licence was recorded 241m southeast for disposal of radioactive waste and keeping and use of radioactive materials. Two (2No.) discharge consents were identified at 413m and 454m south, for unspecified discharges, with their status noted as 'expired'. One (1No.) pollution incident was noted within 500m of the site, 315m west associated with diesel. Seven (7No.) licensed waste management facilities were recorded within 1.5km of the site. The nearest record was an EA licenced waste site 616m to the southeast.
Environmental Sensitive Sites	One (1No.) record of a Site of Specific Scientific Interest (SSSI) was noted within 2km of the site, 452m southwest of the site, recorded as the Gateway Marsh. Eight (8No.) records of Ancient Woodland are recorded within 2km of the site. The nearest is noted 1324m southwest.
Site History	From the late 1870s, the site was recorded as part of a wooded area in the east and open land in the west. By the late 1940s, a small building was recorded on the northern part of the site. By the mid-1990s, all previous features were no longer noted. By the early 2000s, the site was comprised of an area of car parking, serving a large retail park.
Scope of Ground Investigation	• Non-intrusive survey of underground services to clear exploratory locations • 4No. windowless sample boreholes • 3No. rotary open holes • TRL CPT testing at 6No. locations • Coring in 2No. locations • Chemical analysis of soils and WAC testing • Geotechnical testing • 4No. post completion monitoring visits

Ground Conditions	Ground conditions on site comprised Made Ground (up to 1.3m thickness) overlying interbedded sands, gravels and clays with coal (thickness 19.8m to 20.5m), Weathered Coal Measures strata (sandy clay) was encountered at depths of between 21.1m and 21.8m and Coal Measures bedrock, at depths of between 23.2m and 24.2m below existing ground level. Groundwater was not encountered in any of the exploratory holes during the fieldwork, or within standpipes during subsequent monitoring.
Environmental Assessment	None of the made ground and natural soil samples, subjected to a suite of contamination testing, presented contaminant concentrations which exceed generic assessment criteria for land under a commercial / industrial use. No asbestos fibres or asbestos containing materials were identified in those samples subjected to asbestos screening analysis. From an environmental perspective, the site is considered to pose a 'Low Risk' of harm to sensitive receptors based on the findings of the ground investigation and revised conceptual site model.
Geotechnical Assessment	Based on the ground conditions encountered and type of proposed development, strip/pad foundations will be suitable at this site taken down into the natural loose to medium dense sand a minimum of 1.0m depth. Floor slabs can be designed as ground bearing providing they are placed on the natural sand deposits. It is recommended that for foundations the Design Sulphate Class for the site, as defined in BRE Special Digest 1(2005), be taken as DS-1, and the Aggressive Chemical Environment for Concrete (ACEC) site classification be taken as AC-1s. Results of in-situ testing have given average values of CBR in the range 35% to 90% near surface. Based on the above results and ground conditions encountered, it is recommended for preliminary design purposes a CBR value = 30% is adopted for near surface granular material and a value of 2% for any near surface cohesive material.
Waste Classification	Results for the WAC-inert analysis performed in a selected number of samples suggest potential arisings may be able to be deposited in an Inert Landfill.
Ground Gas Assessment	Maximum methane and carbon dioxide concentrations recorded on site were in the order of <0.1%v/v and 4.7 %v/v, respectively. A Characteristic Situation 1 - 'Very low' risk is considered adequate for the site on a preliminary basis, for which no special precautions are required for new buildings.
Recommendations	• Use of appropriate water supply pipe work • Use of adequate PPE by construction / maintenance workers • Site workers to be vigilant of unexpected ground conditions or asbestos containing materials which may be encountered during development.

1.0 INTRODUCTION

Pam Brown Associates Ltd (PBA) have been appointed by Glanville Group to undertake a Phase I Desk Study and Phase II Geotechnical & Environmental Site Investigation at a site located off Plas Coch Road, Wrexham, LL11 2BA. The site investigation was based on the Scurr Architects drawing 'Site Feasibility Plan' Drawing No.: 7391-AEW-8903-F004 dated February 2019.

The purpose of the investigation is to provide information to assist with the design of the proposed development scheme, as well as to provide an assessment of geotechnical and environmental properties of the ground and groundwater.

The reporting process aims to characterise the site based upon the procedures identified within Environment Agency Contaminated Land Report 11 'Model Procedures for the Management of Land Contamination'. These procedures relate to 'past' contamination, and assume that legislative controls such as Pollution Prevention and Control authorisations control current potentially polluting activities. Emphasis is therefore upon historic use and the overall approach in dealing with past land contamination is one of risk management.

The Phase I Desk Study has been undertaken with the purpose of characterising the geological and environmental setting of the site by reviewing available data obtained within Groundsure Reports, including: geological, hydrological, hydrogeological, historic and Environment Agency (EA) data. The information obtained is then used to evaluate the environmental sensitivity (vulnerability) of aquatic, human and ecological systems in the site's vicinity in support of the identification and assessment of pollutant linkages.

A conceptual site model (CSM) is formulated by reviewing the environmental setting of the site, its physical characteristics and identifying historic/current potential contaminative uses to detect potential contamination sources, pathways and receptors. This is undertaken in accordance with CIRIA C552 (2001)¹ to determine whether significant harm is being caused or there is a significant possibility of such harm being caused as outlined in EPA1990: Part IIA² and further described in DEFRA (2006, 2012) statutory guidance^{3,4}. The classification of risk is obtained by combining the severity of the harm likely to arise from a given on/off site activity and the probability that harm may arise to a particular sensitive receptor.

The Phase II Geo-Environmental Investigation was undertaken to provide geotechnical data for foundation and slab design. Information was also obtained with regard to soil/groundwater quality and ground gas generation potential.

In accordance with CLR 11, the process of investigation and risk assessment is iterative, the findings of the Phase II investigation were subsequently used to review the CSM for the site and reassess risk to receptors, and ultimately confirm the potential requirement or otherwise for remedial action.

This report should be read in conjunction with the PBA 'Coal Mining Risk Assessment' July 2019, prepared for the property.

¹ Rudland, D., Lancefield, R.M., Mayel, P.N. (2001) "Contaminated land Risk Assessment: A guide to good practice. CIRIA C552. UK. pp.80.

² Environmental Protection Act 1990: Part IIA. Contaminated Land. Section 78A (ii).

³ Department of Environment, Food and Rural Affairs (2006) DEFRA Circular 01/2006 – Environmental Protection Act 1990: Part2A. September 2006. U.K.

⁴ Department of Environment, Food and Rural Affairs (2012) Environmental Protection Act 1990:Part2A – Contaminated Land Statutory Guidance. April 2012. U.K.

Limitations

The conclusions reached within this report are restricted to those that can be determined from the available data and within the inherent limitations of a discrete investigation. Conclusion and/or recommendations made in this report may be subject to amendment in the light of additional information becoming available.

The information provided by third parties is presented in good faith; however PBA cannot accept any responsibility/liabilities for the information derived from these and/or for discrepancies or inaccuracies found in the data.

The report presents the findings of the ground investigation exploratory logs, tests and monitoring results and interpretation of this data which is limited to the specific exploratory locations and scope under which the study was commissioned. As with any site, there may be differences in conditions between exploratory hole locations, the data included in the report reflects the observations made at the time of the investigation. Seasonal fluctuations may occur in groundwater and ground gas levels which may not be accounted for as part of this study. PBA cannot take responsibility for conditions that have not been revealed by the exploratory holes, or variations which may occur between them.

This report has been prepared solely for the use of Glanville Group for the specific purpose under which the investigation was commissioned. If the document is used/viewed by any other party for any other purpose than the one specified above, reference must be made to PBA to confirm its suitability for use. No responsibility will be accepted where a third party uses this report, either in part or in its entirety, unless formally re-assigned.

This report should be reviewed at all stages of construction by someone familiar with the terms and assumptions it contains. It is essential that a suitably qualified and experienced engineer be appointed for design purposes, and to supervise construction.

2.0 SITE OVERVIEW

2.1 SITE LOCATION AND DESCRIPTION

The site is located off Plas Coch Road, Wrexham approximately 1.12km northeast of Wrexham Central Train Station. An extract of the 1:50,000 Ordnance Survey map showing the general location of the site is included as Figure 1.

The approximate National Grid reference for the site is 332572E, 351333N. An aerial photograph of the site is presented below with the site boundary marked in red.



The site covers an area of approximately 0.24ha and is irregular in shape. The site comprises part of the car park, with associated trees and soft landscaping features along the perimeter.

The car park is bounded on all sides by an access road (B5101) to the surrounding Plas Coch Retail Park. The retail park extends to the north and west of the site whilst to the south and east are BBC Wales and a sports centre, respectively.

The current site layout is presented as Figure 2.

2.2 PROPOSED DEVELOPMENT

The proposed development includes the construction of a McDonalds restaurant with associated car parking and drive-thru areas. The proposed development plan is included as Figure 3.

2.3 ENVIRONMENTAL SETTING

A review of available physical and environmental information relating to the site has been undertaken including mapped references and extracts from the Groundsure GeoInsight and EnviroInsight reports (Appendices 1 and 2). A summary of the site's environmental setting and sensitivity is included in Table 1.

Table 1. Environmental Site Setting

Physical Characteristics	
Topography	The site is in a generally flat area with elevations of approximately 90 metres Above Ordnance Datum (mAOD), increasing towards the southwest to 105mAOD
Geology	The geology of the site is recorded on the British Geological Survey (BGS) 1:10,000 and 1:50,000 maps. Glaciofluvial deposits comprising sand and gravel are recorded on site overlying Pennine Lower Coal Measures and Peninne Middle Coal Measures Formations (undifferentiated) described as mudstone, siltstone and sandstone. Fourteen (14No.) records of inferred coal seams and inferred faults have been recorded within 500m of the site. The nearest is a coal seam recorded 133m west. Risks identified in association with geological hazards include: • Very low risk from collapsible deposits • Very low risk from landslide • Very low to Negligible risk from running sands • Negligible risk from compressible deposits • Negligible risk from shrinking and swelling clay ground stability hazards. • Negligible risk from ground dissolution of soluble rocks Eight (8No.) records of historical underground workings have been identified within 250m of the site including collieries, unspecified shafts, and unspecified disused mines. The nearest is a colliery 757m to the north. Ten (10No.) records of historical surface ground workings were recorded within 250m of the site boundary, including canals and cuttings. The nearest was recorded 1m southeast as a cutting. One (1No.) current ground working has been recorded 953m northeast associated with producing Sand. This activity is noted as being 'Ceased'. Mining for Iron Ore (bedded) has been recorded on site and mining for vein minerals has been recorded 6m east of the site. Other non-coal mining (including; clay, tin, brine and gypsum extraction) affected areas have not been identified within 1km of the site.
Coal Mining	The site is recorded as being within a known coal mining affected area and inferred coal seams are noted within 500m of the site boundary. A CON29M Coal Mining Report was commissioned, and is included as Appendix 3. In addition, a standalone Coal Mining Risk Assessment has been prepared for the site, which includes an assessment of the risk posed by the coal mining legacy on and around the site.



Physical Characteristics											
	The property is within a surface area that could be affected by underground mining in two (2No.) seams of coal at 310m and 370m depth, last worked in 1921. The property is not within a surface area that could be affected by present underground mining. The property is not in an area where the Coal Authority has received an application for, and is currently considering whether to grant a licence to remove or work coal by underground methods. The property is not in an area where a licence has been granted to remove or otherwise work coal using underground methods. The property is not in an area likely to be affected from any planned future underground coal mining. However, reserves of coal exist in the local area which could be worked at some time in the future. There are no recorded mine entries within, or within 20m of, the site boundary. The Coal Authority is not aware of any damage due to geological faults or other lines of weakness that have been affected by coal mining. The property is not within the boundary of past opencast coal mining methods, 200m from present opencast coal mining methods or 800m from future opencast coal mining methods. The coal authority has not received a damage notice or claim for the property or within 50m of the boundary since 31st October 1994. There is no record of mine gas, remedial works, withdrawal of support, working facilities order for the property.										
Radon	The site is within a Radon affected area, as between 10% and 30% of the properties are above the radon action level. According to Building Research Establishment BRE211 (2015) 'Radon: Protective Measures for New Buildings', Full radon protective measures are required in the construction of new buildings or extensions. A Groundsure Radon Check report was commissioned for the site, this can be consulted in Appendix 4.										
Estimated Background Soil Chemistry	<table> <tr> <td>Arsenic</td><td><15 mg/kg</td></tr> <tr> <td>Cadmium</td><td><1.8 mg/kg</td></tr> <tr> <td>Chromium</td><td>60-90 mg/kg</td></tr> <tr> <td>Nickel</td><td>15-30 mg/kg</td></tr> <tr> <td>Lead</td><td>100-200 mg/kg</td></tr> </table>	Arsenic	<15 mg/kg	Cadmium	<1.8 mg/kg	Chromium	60-90 mg/kg	Nickel	15-30 mg/kg	Lead	100-200 mg/kg
Arsenic	<15 mg/kg										
Cadmium	<1.8 mg/kg										
Chromium	60-90 mg/kg										
Nickel	15-30 mg/kg										
Lead	100-200 mg/kg										
Hydrogeology	The superficial deposits and bedrock have been designated as 'Secondary A' aquifers; this describes 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. The permeability of the superficial deposits is recorded as 'High to Very High' via intergranular flow, whilst the bedrock is recorded as having a 'Low to Moderate' permeability via fracture flow. There are no active groundwater abstraction licences, nor potable abstraction licences recorded within 2km of the site. The site is not within a Groundwater Source Protection Zone.										

Physical Characteristics		
Surface Water Hydrology	The nearest watercourse is a non-tidal inland river 417m north of the site, within the Dee Catchment Area. The River Gwenfro is recorded 1052m southwest of the site. The biological quality of the River Gwenfro was measured in 2008 as Grade C ('Fairly Good') to Grade B ('Good') to at monitoring points 844m south and 1052m southwest, respectively. The chemical quality was measured in 2009 as Grade C ('Fairly Good') at 1052m southwest of the site. No active surface water abstraction licences have been recorded within 2km of the site.	
Flood Risk	According to the Environment Agency, the site is not a flood risk area and there are no identified River and Coastal Zone 2 floodplain or Zone 3 floodplains within 250m of the site. The Environment Agency Risk of Flooding from Rivers and the Sea (RoFRaS) database indicate the site is at 'Very Low' (less than 1 in 1,000) chance of flooding in any given year. The site is in an area identified by BGS as susceptible to groundwater flooding associated with the superficial deposits. It is deemed there is a 'potential at surface' for groundwater flooding to occur based on the ground conditions.	
Nitrate Vulnerable Zone (NVZ)	There are no records of Nitrate Sensitive Areas and Nitrate Vulnerable Zones with 2km of the site.	
Designated Ecologically Significant Areas	One (1No.) record of a Site of Specific Scientific Interest (SSSI) was noted within 2km of the site, 452m southwest of the site, recorded as the Gateway Marsh. Eight (8No.) records of Ancient Woodland are recorded within 2km of the site. The nearest is noted 1324m southwest.	
Environmental Sensitivity	<u>Groundwater</u>	Low to Moderate - The site is underlain by Secondary A aquifers with low to very high permeability. The site is not within a groundwater source protection zone (SPZ) and no groundwater abstraction were noted within 2km.
	<u>Surface water</u>	Moderate - The nearest surface water receptor is located 417m north and no active surface water abstraction licenses are recorded within 2km. The chemical and biological quality of River Gwenfro was measured as Grade C in 2009 at a monitoring point 1052m southwest.
	<u>Humans</u>	Moderate - The site is located in a mixed use commercial and industrial area. The site is part of a car park serving the Plas Coch Retail Park.
	<u>Ecological systems</u>	Moderate - One record of a SSSI is noted 417m north and eight records of ancient woodland have been noted within 2km, the nearest is 1324m southwest.



2.4 REGULATORY LICENCES

The Groundsure EnviroInsight report has been reviewed to identify potentially polluting activities and enforcement mechanisms associated with the site and the surrounding area. The most relevant findings are detailed in Tables 2, 3 and 4 below.

Table 2. Regulatory Mechanisms

Licences	Name	Description	Location	Comments
Part B Activities and Enforcements	Sainsburys Petrol Filling Station	Process: Unloading of Petrol into Storage at Service Stations Status: Current Permit	103m NW	No Enforcements Notified
	Johnsons Cleaners UK Ltd	Process: Dry Cleaning Status: Current Permit	211m N	No Enforcements Notified
	Shell UK Ltd	Process: Unloading of Petrol into Storage at Service Stations Status: Current Permit	310m S	No Enforcements Notified
	Remploy Ltd, Furniture Group	Process: Timber Manufacture Status: Current Permit	493m NE	No Enforcements Notified
Category 3 or 4 Radioactive Substances	Glyndwr University Multidisciplinary Research and Innovation Centre	Type: Disposal of Radioactive Waste and Keeping and Use of Radioactive Materials	241m SE	Status: Revoked/Cancelled Permission Number: BW8569, AW1209, AW1233 Approval: 01/12/2003 & 21/01/1997 Last Updated: 01/01/2015
Licensed Discharge Consents	Wrexham Mold Road Depot	Effluent Type: Unspecified Permit Number: CM0026101 & CM0062401 Permit Version: 1 – 11	413m- 454m S	Receiving Water: Un- Named Tributary of Gwenfro Issue Date: 21/12/1964 & 16/06/1970 Revocation Date: 06/01/1993

Table 3. EA/NRW Recorded Pollution Incidents (within 500m)

Incident Date	Contaminant Details	Location	Recorded Impact
18/05/2015	Pollutant: Oils and Fuel Pollutant Description: Diesel	315m W	Water: - Land: No Impact Air: No Impact

Table 4. Waste Management Facilities (within 1500m)

Landfill Site	Name	Description	Location	Comments
EA Historic Landfill Sites	Holmes Plant Hire	Waste Type: Industrial Waste Licence: Yes	1025m N	Licence Holder: D S Holmes Builders Limited First Recorded: 01/01/1990 Last Recorded: 18/02/1991
	Berse Drelincourt	Waste Type: Inert Site Reference: WMBC/L34	1072m SW	Licence Holder: Mr L G Hockey First Recorded: 01/01/1981 Last Recorded: 31/12/1985
	Parciau	Waste Type: Inert, Industrial, Commercial, Household	1272m SE	Licence Holder: Wrexham Borough Council First Recorded: 01/01/1969 Last Recorded: 31/12/1972
	Stansty Gardens	Waste Type: Inert Site Reference: WMBC L/41	1358m NW	Licence Holder: Sinclair Developments Ltd First Recorded: 31/07/1983
	Rosenheath	Waste Type: Inert Site Reference: WMBC L/37	1364m NW	Licence Holder: Mr C Butler First Recorded: 31/08/1984
EA/NRW Licensed Waste Sites	Jacques Garage	Size: 25,000 tonnes Waste Licence Number: JAC001 & LP3194FV EPR Reference: LP3194FV/V002 Waste Management Licence Number: 37037 Annual Tonnage: 5000	616m-617m SE	Issue Date: 29/09/1992 Expiry Date: 24/04/2007
	T Milner & Son	Size: <25,000 tonnes Waste Licence Number: EP3194FT & THO002 EPR Reference: EP3194FT/A001 Waste Management Licence Number: 37161 Annual Tonnage: 4520	1013m-1015m N	Operator: Thomas Milner and Stephen Milner Issue Date: 31/03/1999

Potentially contaminative uses active within 250m

- Electrical Features
- Chimneys (Industrial Features)

Petrol or Fuel Sites

Two (2No.) active petrol sites were recorded within 500m of the site, 95m northwest and 324m south.

Historical Tanks

Twenty-two (22No.) records of tanks including unspecified tanks and tanks are recorded within 500m of the site boundary. The nearest was an unspecified tank recorded 97m northeast.

Historical Energy Features

Thirty-seven (37No.) records of electrical substations were recorded within 500m of the site, the nearest was located 18m to the south east.

Historical Garage and Motor Vehicle Repair Sites

Nine (9No.) records of garages were recorded within 500m of the site. The nearest was noted 301m south.

Potentially Infilled Land

Thirty-four (34No.) records of potentially infilled land were identified within 500m of the site, including cuttings, unspecified pits, ponds, unspecified heaps and unspecified ground workings. The nearest record is of cuttings 174m to the west.

3.0 REGRESSIVE MAP ANALYSIS

A series of superseded Ordnance Survey Maps, covering the period 1872 to 2014, have been reviewed to determine the development history of the site and identify any relevant activities that took place in the vicinity (Appendices 5 and 6). The maps and plans have been summarised in Table 5.

Table 5. Historic Use of the Site and Surrounding Area

Date	The Site	Surrounding Area
1872-1874	The eastern portion of the site formed part of a wooded area associated with Plas Coch (Houses). The western portion of the site was noted as open land.	• Goods Shed ~500m east • Railway ~520m east running north to south • Saw Mill and Timber Yard ~700m southeast.
1898-1899	No changes were observed to the site layout	• Locomotive Works ~540m northeast • Station associated with the railway ~520m southeast • Iron Works ~730m southeast • Fever hospital ~750m south
1909-1910	The site underwent no changes during this period.	• Two (2No.) tanks ~600 & 650m south • Goods shed was no longer recorded
1937-1939	A small building was constructed on the northern part of the site, adjacent the site boundary.	• No changes were observed to the surrounding area
1949	No changes were observed to the site layout.	• Omnibus depot ~300m south
1957-1958	The site underwent no changes during this period	• Pond ~ 90m northeast • Tank ~100m north • Builders Yard ~280m northeast
1964	No changes were observed to the site layout.	• The locomotive works and tanks 600m & 650m south were no longer noted • Works ~500m east • Iron works ~730m southeast noted as works.
1967-1968	The site underwent no changes during this period	• Electrical substation ~80m east

Date	The Site	Surrounding Area
1973-1975	The small building noted on the northern part of the site and the wooded area on the eastern portion, were no longer recorded.	• Depot ~80m north • Motorway ~150m west • Omnibus Depot ~300m south was recorded as Bus Depot • Works building ~500 east was noted as Depot • Factory ~480m northeast
1980-1985	No changes were noted to the site layout	• Electrical substation ~150m southwest • Works building 730m southeast was no longer noted
1988-1994	The site was noted as open land.	• Petrol Filling Station ~90m northwest • Electrical Substations ~30m Southeast & ~180m northeast and southwest • Depot & Factory ~600-700m southeast
2002	The site is noted as forming part of a car park.	• Retail park constructed from the site, extending ~450m north and ~150m west. • Factory ~7600-700m southeast no longer noted.
2010	No changes were noted to the site layout.	• No changes to the surrounding area were observed
2014	The site underwent no changes during this period	• The Factory ~480m northeast was no longer observed

4.0 PRELIMINARY RISK ASSESSMENT

Under the terms of the Environment Act 1995 a plausible pollutant linkage must exist to link the source to the receptors in order for an environmental risk to exist. Once these have been identified the likelihood and severity of each pollutant linkage are considered such that the scenarios of most concern can be addressed. A preliminary assessment of risk is then undertaken using a risk evaluation method, based on an EA/CIRIA scoring system^{1,5,6}, which aims to categorise the significance of risk in terms of the probability of the receptors being exposed to a given hazard (i.e. high likelihood, likely, low likelihood, unlikely) and the magnitude / severity of the environmental harm resulting from the hazard.

The risk categories are then assessed based upon the consequence vs. probability assigned to each scenario, based upon guidance originally produced by the DETR. These categories are outlined in Appendix 7. The risk assessment has been based upon the proposed future use for a fast-food restaurant.

Potential Contamination Sources

On-Site

The historic maps from the late 1870s record the eastern portion of the site to be part of a wooded area, whilst the western portion of the site to be noted as open land. By the late 1940s, a small building was recorded on the northern part of the site. By the mid 1990s, all previous features, were no longer noted. By the early 2000s, the site was developed as a car park, serving a large retail park to the north and west.

No potentially polluting activity had taken place on site, hence the most likely source of contaminants would be minor spillages / leakages of oil, fuel, hydraulic fluids, antifreeze etc., from vehicles using the car park.

Off-site

The main off-site activity with the potential to cause contamination on-site would be the Petrol Filling Station ~90m northwest, built in the 1990s.

Potential pollutants associated with the Petrol Filling Station include metals, inorganic chemicals, asbestos, phenols, acetone, oil/fuel, aromatic hydrocarbons, PCBs and organolead compounds.

Other possible nearby sources of contamination within 250m of the site include the Electrical Substations and tanks.

The following table identifies the potential pollutant pathways based on the CIRIA guidance¹ based on the potential contamination of soils and groundwater beneath the site.

⁵ Environment Agency (2004) Environmental Risk Management and Strategic Environmental Assessment Guidance Note. Version 6. pp 1-5.

⁶ DEFRA (2002) Guidelines for Environmental Risk Assessment and Management. Available at: <http://www.defra.gov.uk/environment/risk/eramguide/index.htm>


Table 6. Potential Pollutant Pathways

Pathway	Receptor	Harm	Likelihood	RISK
Direct contact, ingestion and Inhalation of contaminated-dust/soil	Site Users	Medium	Likely – Whilst hardstanding surfaces are present, an area to the centre of the site is proposed to be retained as landscaping due to the presence of a tree with a Tree Protection Order (TPO)	M
Ingestion and Inhalation of contaminated dust/soil	Adjacent users	Medium	Likely – area of soft landscaping proposed to be retained in the centre of the site.	M
Direct contact, ingestion and inhalation of contaminated dust/soil during any groundworks	Construction/ Maintenance Workers	Medium	Likely – Ground workers would excavate into the near surface materials allowing for exposure to potentially contaminated materials.	M
Surface runoff of contaminated water	Inland river (417m N) River Gwenfro (1052m SW)	Medium	Low – It is anticipated that a surface water drainage scheme would be implemented as part of the new development which would capture any surface water run-off.	L/M
Lateral migration of near surface groundwater			Low – due to distance of the inland river from the site	L/M
Vertical mobilisation of contaminants through the soil profile	Secondary A aquifers	Medium	Likely– due to soft landscaping being retained allowing for infiltration to occur.	M
Migration of vapours/gases into building/service runs and subsequent inhalation/explosion	Future site users	Medium	Likely – gases can collect in service runs which also provide pathways into the building.	M
	Construction/ maintenance workers			
Direct contact	Buildings and buried services	Medium	Likely – organic compounds, sulphates, low pH in the soils could impact water pipes/attenuation structures / buried concrete.	M
Plant uptake of leachable contaminants/direct contact	Vegetation / soft landscaping	Medium	Likely – assuming the retention of soft landscaping and tree with TPO.	M

KEY

M – Moderate

L/M – Low to Moderate

L - Low

Based on the highest level of risk estimated, it is considered a **Low to Moderate** risk that harm could arise to sensitive receptors given the contaminative issues which could be present on site as a result of historic off-site activities.

Assuming a worst-case scenario and in accordance with a '**Moderate**' risk classification (CIRIA 522)¹, 'it is possible that harm could arise to a designated receptor from an identified hazard. However, it is either relatively unlikely that any such harm would be severe, or if any harm were to occur it is more likely that the harm would be relatively mild.

Investigation (if not already undertaken) is normally required to clarify the risk and to determine the potential liability. Some remedial works may be required in the longer term'.

Site investigation works are recommended to assess ground conditions on site from an environmental perspective, aiming to identify potential contaminative issues in soil, groundwater and concentrations of ground gases/vapours. The investigation should be combined with a geotechnical assessment of underlying materials on-site and to facilitate the design of building foundations and pavements.



PHASE II – GEOTECHNICAL & ENVIRONMENTAL SITE INVESTIGATION

5.0 PHASE II – GEOTECHNICAL & ENVIRONMENTAL SITE INVESTIGATION

5.1 GENERAL

On instructions from the Client (Glanville Group) and in order to address the findings of the Phase I Desk Study, a ground investigation was designed based on the methodology provided in CLR11 (2004) 'Model Procedures for the Assessment of Land Contamination' and undertaken in accordance with BS5930 (2015) 'Code of Practice for Site Investigations', Eurocodes 7, BS10175:2011+A2:2017 (2011) 'Investigation of Potentially Contaminated Sites – Code of Practice' and the requirements of the client and engineers (unless otherwise stated).

The site investigation works were commissioned with the following objectives:

Geotechnical

- To carry out an assessment of the geotechnical characteristics of the near surface made ground and natural materials.
- To provide ground density data (TRL results) through the use of in-situ testing to support the design process.
- To advise on suitable foundation strata and bearing properties with data for foundation and floor slab design.
- To provide indicative pavement design comment.
- To provide a preliminary indication of infiltration rates.
- Investigate the potential for shallow coal workings beneath the site.

Environmental

- To assess the environmental quality of the materials on site and reassess the CSM, using site specific data.
- To monitor ground gas & groundwater levels on site.
- To assess the quality of the underlying groundwater.
- To identify on a preliminary basis if remedial works are required to mitigate unacceptable risks posed by identified levels of contamination.

The fieldwork was carried out on the 11th June 2019 and included the excavation of four (4No.) Windowless sample boreholes to a maximum depth of 5.0m below ground level (bgl) with associated geotechnical testing, three (3No.) rotary open boreholes to 30.0m bgl, six (6No.) TRL's to a maximum depth of 1.0m bgl and two (2No.) core samples.

All exploratory hole locations were scanned for buried services using a Cable Avoidance Tool (CAT) and Ground Penetrating Radar (GPR). All exploratory locations were subsequently hand dug to 1.2m bgl or natural material.

Equipment brought onto site was inspected by PBA personnel prior to commencement of the investigation and confirmed as being in a clean, safe and tidy condition free of any leaks of fuel, hydraulic, engine and gear oil.

The logging of soils and rocks was undertaken in accordance with BS5930:2015 except where superseded by the soil and rock description methodology in BS EN14688-1(2002), BS EN14688-2(2004) and BS EN14689-1(2003).

5.2 WINDOWLESS SAMPLE BOREHOLES

Four (4No.) windowless sample holes (WS1-WS4) were excavated to depths of between 4.9-5.0m below existing ground level (bgl). WS1 was terminated at 4.9m bgl due to a machine refusal.

A plan showing the location of the exploratory borehole is included as Figure 4. The borehole logs are included in Appendix 8.

The exploratory locations were positioned with the following aims:

- Provide a greater understanding of the geological sequence at shallow depth underlying the site including the thickness of made ground within the proposed building footprint and retain samples for further geotechnical testing.
- Provide preliminary data to aid in foundation design.
- Investigate and obtain information regarding the quality of the soils across the wider area and identify potential contamination.
- Facilitate installation of groundwater/gas monitoring wells.
- Accessibility/ongoing operations.
- Avoidance of assumed and identified underground services by the utility clearance contractor and plans provided by the client.

Dynamic probing was undertaken adjacent to each of the windowless sample boreholes prior to the main phase of borehole excavation. In addition, TRL probing was carried out in six (6No.) locations across the site.

The exploratory locations were positioned with the aim to assess the ground conditions across the proposed building footprint to facilitate the foundation design, provide coverage of other areas of the site from a contaminative perspective as well as provide supplementary data for the external pavement design.

Following completion of the in-situ probing the boreholes were excavated using an Archway Competitor 130 windowless sampling rig. Windowless sampling comprises advancing 1.0m steel samplers in to the ground using the tracked windowless sampling rig. Samplers are advanced in to the ground by means of a 63.5kg weight being mechanically lifted and permitted to freefall 750mm on to an anvil connected by steel rods to the top of the sampler. When advanced its full length the sampler is recovered using the hydraulic-powered ram mounted on the mast of the rig or by using an auxiliary jacking system. Removable plastic liners contained within each sampler, ranging from 89mm to 37mm internal diameter, permit a continuous profile of the soil to be described and sampled for subsequent testing.

A PBA engineer was present on site full time to examine and supervise the excavations. The recovered core liners were split, photographed, logged and sub-sampled for environmental purposes prior to being sealed and clearly labelled. These were transported to the drilling Contractor to enable subsequent sampling and testing for geotechnical purposes. Samples obtained were representative of made ground and natural materials encountered, and where visual or olfactory contamination was identified. Samples were

subsequently sent for further laboratory examination, chemical and geotechnical analysis at UKAS accredited laboratories.

The logs including descriptions of the strata encountered can be consulted in Appendix 7. The soil profile and other significant features were recorded based on the cores abstracted from each exploratory hole. Groundwater observations were made during the investigation works (where possible). These observations relate to the time of the investigation only, and do not necessarily reflect seasonal fluctuations.

On completion, 50mm HDPE standpipes were installed in three (3No.) of the exploratory locations (WS1, WS2, WS4) to allow for subsequent gas and groundwater monitoring. Additional detail on installation depth and response zones is provided in Section 5.7.

5.3 ROTARY OPEN-HOLE DRILLING

A total of three (3No.) boreholes (designated RH1 – RH3) were progressed using a track-mounted rotary rig to a depth of 30.0m below existing ground level.

Work was undertaken in accordance with the Coal Authority's Permit Reference 18143, dated 31st May 2019 and BS 5930:2015 and BS 1377:2016 and in general accordance with the methodologies identified in CIRIA SP32. All excavations, in-situ testing and logging was conducted/supervised by PBA.

Borehole drilling was commenced by means of Rotary Open Hole drilling to 30.0m bgl to investigate the potential for worked coal seams to be present beneath the site.

The boreholes were drilled using rotary open hole methods, producing a 115mm nominal diameter hole. Water was used as the flushing medium. Details of ground water conditions were noted where possible however the use of water flush generally limits the accuracy of water level data.

Once 30.0m bgl had been reached, the boreholes were backfilled on completion with cement bentonite grout.

On completion samples recovered from the site were taken to a UKAS Accredited Laboratory for further examination and geotechnical testing. Details of the depths and types of samples recovered are indicated on the attached log sheets.

The details regarding the type and depth of each sample recovered are provided on the borehole logs included as Appendix 8. The samples collected were sent to a UKAS Accredited laboratory to be scheduled for a suite of chemical and geotechnical testing as described in Sections 5.8 and 5.9.

5.4 HARDSTANDING CORING

Two (2No.) locations specified by Glanville Group were cored using standalone rotary coring equipment to determine the composition of the hardstanding surfaces within the entry and exit routes of the proposed McDonalds restaurant. The locations of the coring positions are indicated on Figure 4. Details of the composition of the hardstanding are discussed in Section 6.5.

5.5 IN-SITU GEOTECHNICAL TESTING

5.5.1 TRL Hand Held Dynamic Cone Penetrometer Testing (CBR Testing)

The density (expressed as California Bearing Ratio (CBR)) of near surface materials was examined using a hand held dynamic cone penetrometer (TRL Probe).

A total of six (6No.) tests were undertaken within areas of proposed external hardstanding as shown on the proposed development layout (Figure 3). The locations of the test positions are shown on Figure 4.

Each test was undertaken from the existing ground surface, and was performed using an 8kg weight, dropping from a height of 575mm and driving a 20mm diameter, 60° cone into the sub-soil. The blow counts are recorded against penetration achieved and the results are plotted graphically. The CBR value of the various layers was then obtained from a graph showing DCP-CBR relationship as described by Kleyn and Van Heerden⁷ (1983). Test result certificates are included in Appendix 9.

5.5.2 Dynamic Cone Penetrometer Testing (Dynamic Probing)

Dynamic probing was undertaken adjacent to each of the window sample borehole locations, after completion of windowless sampling. Probing was carried out from the surface to max depths of 5.0m bgl using the same Archway Competitor 130 Dynamic Sampling rig as was used to undertake the window sampling element.

The dynamic probe locations are shown on Figure 4, and the logs/results are included in Appendix 9.

The probing was carried out in general accordance with BSEN ISO22476-2. The test involves the use of a chain-driven trip hammer to drive a solid steel penetrometer tipped with a 90°, cast iron cone, into the ground at a rate of between 15 and 30 blows per minute. The resistance of the ground to each 100mm increment of penetration is recorded, and referred to as DPN₁₀₀.

'Super Heavy' Dynamic Probing (DPSH) was employed at the site, which involved the use of a 50.5mm diameter cone, driven by a weight of 63.5kg falling over a distance of 750mm.

The driving of the probe was undertaken continuously as far as was practicable.

5.6 PERMEABILITY TESTING

A falling head test was conducted in WS1 on the 25th June 2019, undertaken in accordance with BS5930:1999 Part 25.4.3 Variable Head Test. The test was conducted by pouring approximately 40 litres of water into the exploratory location and recording the time taken for the volume of water to drain into the surrounding material. The test duration lasted 50 minutes.

⁷ Kleyn & Van Heerd (1983) 'Using DCP Soundings to Optimize Pavement Rehabilitation' Paper submitted for Annual Transportation Convention, Johannesburg. Report LS/83 Materials Branch, Transvaal Roads Department, Pretoria, South Africa.

5.7 INSTRUMENTATION AND MONITORING

On completion, monitoring wells were installed in three (3No.) exploratory locations to allow subsequent monitoring of ground gas and groundwater levels.

Details of the installations are summarised in Table 7 and are also included within the borehole logs (Appendix 8).

Table 7. Installation details

Exploratory Hole	Standpipe Response zone (mbgl)
WS1	0.9-4.9
WS2	1.0-3.0
WS4	1.0-3.0

5.8 CHEMICAL LABORATORY TESTING

Twelve (12No.) soil samples were taken from exploratory locations representative of both made ground and natural materials. Samples were stored within appropriate glass and plastic containers and kept within cool boxes at approximately 4°C. The samples were sent within a 48hr-period to a UKAS accredited laboratory to be subject to a suite of contamination testing based on current site use and field observations. The tests undertaken comprised the following:

- Metal and metalloid suite, including arsenic, boron, cyanide and ammonia
- Petroleum hydrocarbons with aliphatic/aromatic speciation by CWG methodology
- Speciated polyaromatic hydrocarbons (PAHs)
- Speciated Cyanide – Complex, total and thiocyanate
- Sulphate, sulphide and sulphur
- Organic matter content
- Total phenols
- Soil pH
- Asbestos Screen - 7No. samples
- Waste Acceptance Criteria – Inert – (3No.)

Certificates for the chemical analysis of soil samples are presented in Appendix 10.

5.9 GEOTECHNICAL LABORATORY TESTING

A programme of laboratory testing was carried out on samples taken from the strata encountered to assist in classification and to determine the engineering properties of the solid and superficial strata underlying the site. The testing was carried out at a UKAS accredited laboratory operated by Murray Rix. The test procedures used were generally in accordance with the methods described in BS1377:1990 unless otherwise stated. Details of the specific tests carried out are provided in Table 8.

Table 8. Geotechnical Testing Schedule

Test	Standard	No.
Sulphate content of 2:1 soil:water extract	BS1377:1990 Part 3, Clause 5	3
pH Value	BS1377:1990 Part 3, Clause 9	3
Particle size distribution (wet sieve)	BS1377:1990 Part 2, Clause 9.2	4

The results of the laboratory geotechnical tests are included in Appendix 12 and are discussed in Section 7.0.



6.0 GROUND CONDITIONS ENCOUNTERED

6.1 GENERAL

On the basis of published geological information and the findings of the investigation the strata encountered in the exploratory holes included:

- Made Ground
- Glaciofluvial Deposits
- Coal Measures Bedrock

The depths of the various materials encountered in each of the exploratory holes are summarised in the following table. Ground conditions encountered are discussed below.

Table 9. Summary of Ground Conditions Encountered

Hole	Depth to stratum (m)						
	MADE GROUND				GLACIOFLUVIAL DEPOSITS		
	Tarmac	Sub-base	Clayey gravelly SAND	Sandy/gravelly CLAY	Clayey/gravelly SAND	Sandy CLAY	Sandy GRAVEL
RH1	GL – 0.1	0.1 – 0.5		0.5 – 1.3	1.3 – 15.2	15.2 – 19.3	19.2 – 21.1
RH2	GL – 0.1	0.1 – 0.5		0.5 – 1.3	1.3 – 4.8	16.0 – 20.0	4.8 – 16.0 20.0 – 21.8
RH3	GL – 0.1	0.1 – 0.4		0.4 – 1.1	1.1 – 8.8	8.8 – 19.6	19.6 – 21.3
WS1	GL – 0.09	0.09 – 0.26	0.26 – 0.65	0.65 – 0.9	0.9 – 1.0 1.7 – 2.2 2.85 – 3.5	1.0 – 1.7 2.2 – 2.85	3.5 – 4.9
WS2	GL – 0.13	0.13 – 0.35	0.35 – 0.8		0.8 – 1.55 1.58 – 3.2 3.4 – 5.0		1.58 – 1.9 3.2 – 3.4
WS3	GL – 0.09	0.09 – 0.4	0.4 – 0.5		0.5 – 5.0		
WS4	GL – 0.12	0.12 – 0.4	0.4 – 0.5		0.45 – 2.8 2.84 – 4.0	4.0 – 5.0	2.8 – 2.84

Hole	Depth to stratum (m)		Groundwater
	COAL MEASURES STRATA		
	Grey brown sandy CLAY	Grey red SANDSTONE	
RH1	21.1 – 24.2	24.2 – 30.0	-
RH2	21.8 – 23.8	23.8 – 30.0	-
RH3	21.3 – 23.2	23.2 – 30.0	-
WS1			Dry
WS2			Dry
WS3			Dry
WS4			Dry

Reference should also be made to the exploratory hole records (Appendix 8) for further detail on the nature and depth of the strata observed in each exploratory hole.

Made Ground

Asphalt was encountered in all locations from existing ground level to 0.09-0.12m bgl.

Made Ground was encountered beneath the asphalt, between 0.09-1.3m bgl, beneath which was sub-base, described grey slightly clayey/silty sandy gravel of basalt and limestone, followed by variable made ground layers of brownish grey, dark brown slightly silty on occasions, slightly clayey to clayey, gravelly to very gravelly sand/sandy gravel. Sand is fine to coarse, gravel is angular to subrounded, fine to coarse of sandstone, light igneous rock and fine coal fragments.

Material recovered from the rotary boreholes was recorded as stone fill over sand ash fill / sand and brick gravel fill.

Glaciofluvial Deposits

Glaciofluvial deposits were encountered in all exploratory location beneath the made ground and proven to depth of 21.1-21.8m bgl, the Glaciofluvial Deposits comprised a series of predominantly sands and gravels near surface. Sandy clay was encountered in RH1, RH2, RH3 WS1 and WS4 at depths of between 1.0m (WS1) and 16.0m (RH3). In places gravel of coal was encountered within the Glaciofluvial Deposits encountered was highly variable across the site.

WS1

Superficial material encountered between 0.9-2.2m bgl generally consisted of orangey brown slightly gravelly SAND/ sandy gravelly CLAY.

Stiff CLAY was encountered from 2.2-2.85m bgl.

Material encountered from 2.85-4.9m bgl was generally described as Brown clayey slightly gravelly SAND/ sandy GRAVEL.

WS2, WS3 & WS4

Superficial material encountered from 0.45-5.0m bgl generally comprised orangey brown/ brown gravelly SAND & greyish black/brown GRAVEL. Sand is fine to coarse. Gravel is angular to subrounded of coal and sandstone.

Occasional gravels of coal were encountered within the superficial material during the investigation.

No olfactory or visual signs of contamination were identified within the natural soil/rock.

Coal measures

Coal Measures strata was encountered in RH1, RH2 and RH3 only at depths of between 21.1m and 21.8m below existing ground level and proven to a maximum depth of 30.0m.

The coal measures strata comprised a weathered zone of sandy clay (thickness 1.9m to 3.1m) overlying grey/red sandstone bedrock.

Coal seams were not encountered in any of boreholes RH1, RH2 or RH3.

6.2 GROUNDWATER

No groundwater was encountered during the site investigation or the subsequent monitoring visits.

6.3 GROUND GAS MONITORING

Four (4No.) ground gas monitoring visits were undertaken between 18th June – 30th July 2019. Atmospheric pressures during the monitoring period were recorded as 0998mb – 1010mb.

The results are summarised in Table 10 below and copies of the monitoring certificates are provided in Appendix 11.

Table 10. Summary of Ground Gas Monitoring Results

Exploratory Hole	WS1	WS2	WS4
Max CH ₄ (% Vol)	<0.1	<0.1	<0.1
Max CO ₂ (% Vol)	4.7	2.9	3.1
Min O ₂ (% Vol)	17.1	16.8	16.4
Max Gas Flow (l/hr)	<0.1	<0.1	<0.1

Methane was recorded at concentrations below levels of detection during the monitoring visit. Carbon dioxide concentrations ranged between 1.1%vol and 4.7%vol. Oxygen concentrations were recorded between 16.4%vol and 18.9%vol. Peak Volatile Organic Compound (VOC) readings were recorded in the range 1.1 to 8.7ppm.

Recorded gas flow rates were below instrument levels of detection (<0.1l/hr).

Based on the guidance in BS 8485:2015⁸, a preliminary calculation of the hazardous gas flow rate (Q_{hg}) has been undertaken based on the maximum concentration of a hazardous gas observed on site, in this instance carbon dioxide, as no methane has been recorded above the limits of detection. The preliminary Q_{hg} estimate is provided below:

$$Q_{hg} \text{ (WS1)} = 0.1 \times 4.7 / 100 = 0.0047 \text{ l/hr}$$

The findings of the site investigation would suggest a worst case Q_{hg} of 0.0047 l/hr for the site, which would suggest a Characteristic Situation 1 (CS1) - 'Very Low Risk' would be an appropriate classification, with regard to new developments, according to BS8485:2015.

Details provided by the client about the proposed development suggest the building type as per Table 3 of the BS8485:2015 would be 'Type C', as it would comprise a commercial premise with small to large room sizes.

Based on the assumption that development will have central building management control and with the information available to date, the gas protection score for the site would be '0', predicated by a 'CS1' designation, combined with building type C and determined using Table 4 of the BS guidance. Based on this, specific gas protection measures are therefore unlikely to be required for the proposed development.

⁸ BS8485:2015 'Code of practice for the design of protective measures for methane and carbon dioxide ground gases for new buildings'.

6.4 SOIL INFILTRATION TESTING (FALLING HEAD TESTS)

The falling head permeability test undertaken in the standpipe in WS1 has given an indicative permeability value = 3.97×10^{-5} m/s, suggesting the ground over the depth of the test has low to medium permeability.

The results of the test and derived infiltration rates can be consulted in Appendix 13.

It should be noted that these tests constituted an initial assessment of the infiltration potential of the natural materials on site and should only be regarded as indicative. It is strongly recommended that soakaway tests are conducted in accordance with BRE365 guidance, if the use of soakaways is being considered for the development plans. The test shall be undertaken in the specific location and depth where the soakaway will be located in order to confirm the use of soakaways as a viable alternative.

6.5 HARDSTANDING CORING

The composition of cores taken from two (2No.) locations has been summarised in the table below:

Table 11. Summary of ground conditions in Surface Cores

Location	Depth	Description
Core 1	GL-45mm	Surface Course: 3-10mm aggregate, 4mm average. Subangular of limestone. Matrix Supported.
	45-120mm	Binder course: 1-25mm aggregate, average 7-8mm. Subangular of limestone. Clast supported with a rough base.
Core 2	GL-25mm	Surface course: 1-2mm aggregate. Subangular of limestone. Matrix supported.
	25-45mm	Binder course: 1-25mm aggregate, average 10mm. Subangular of limestone. Clast supported with a rough base.



7.0 LABORATORY TESTING AND ANALYSIS

7.1 SUMMARY OF IN-SITU TRL PROBE RESULTS

The results of in-situ TRL Dynamic Cone Penetrometer testing (equivalent CBRs) are provided in Appendix 9. The location of each test position is shown in Figure 4.

Results of in situ CBR testing have given average values of CBR in the range 35% to 90% over depths from immediately beneath tarmac to 0.9m depth.

7.2 SUMMARY OF LABORATORY GEOTECHNICAL TEST RESULTS

A summary of the Laboratory geotechnical testing is included in the table below. The results are discussed in Section 8.0.

Table 12. Summary of Laboratory Geotechnical Test Results

Hole	Depth (m)	Stratum	Classification				Chemical	
			Moisture Content (%)	PSD Gravel (%)	PSD Sand (%)	PSD Silt/Clay (%)	pH	Sulphate BRE (water sol 2:1)
WS1	1.7 – 2.2	CLAY	9.3	21	26	53	7.0	0.19 g/l
WS1	0.8 – 1.3	SAND	2.5	35	50	15	7.0	0.25 g/l
WS3	2.3 – 3.6	SAND	11	16	68	16		
WS4	1.45 – 1.8	SAND	9.4	16	68	16	7.1	0.17 g/l

8.0 ENGINEERING PROPERTIES OF MATERIALS ENCOUNTERED

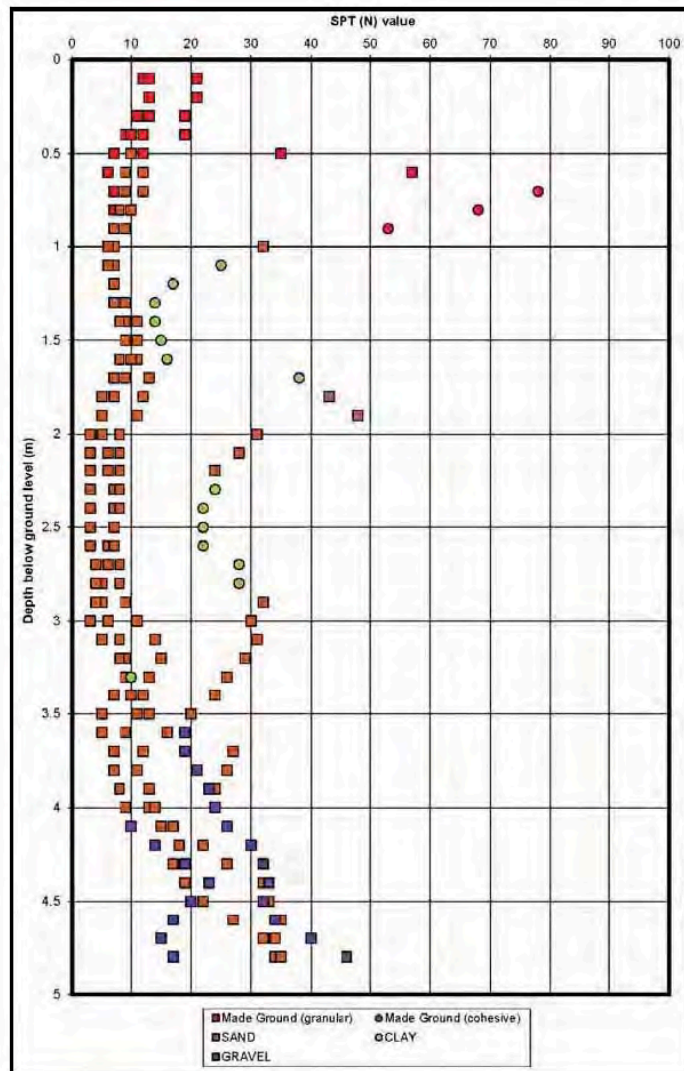
The following sections discuss the engineering and chemical properties of the strata encountered, based on results of in situ testing and laboratory testing obtained during this investigation.

Laboratory testing on clay and the derivation of design parameters for clay has not been carried out due to shallow depth clay only being encountered in a single exploratory location (WS1) which is farthest away from the development layout footprint (as per Figures 3 and 4).

8.1 MADE GROUND

SPT N values are variable and range from 6 to >50 which the Made Ground is loose to very dense where granular and very stiff where cohesive.

SPT v Depth Plot



8.2 GLACIO-FLUVIAL DEPOSITS

Laboratory particle size distribution (PSD) tests suggest the samples tested are predominantly sand with varying amounts of silt/clay and gravel.

SPT N values range from 3 to 48 which suggest the Glaciofluvial Deposits are loose to dense where granular and firm to stiff where cohesive.

It is recommended that for assessing ultimate bearing capacities, where the lower values are critical, the lower quartile value of N values is used. For assessing settlements average ground conditions will give a more realistic value of settlements, and the average of N values should be used.

A summary on N Value results and derived design values is presented in Table 13 below.

Table 13. Summary of N Values and Design Values

Depth	Range of N Values	Lower Quartile N Value	Average N Value	Angle of shearing resistance (ϕ)	Comments
1.0m	6 – 32	7	11	29.0°	Sand is loose to dense
1.5m	8 – 11	8	9	29.3°	Sand is loose to medium dense
2.0m	5 – 48	6	17	28.6°	Sand is loose to dense
*Based on the correlation by Peck, Hanson and Thronburn ⁽¹⁹⁷⁴⁾ and using Lower Quartile N Value.					

Laboratory tests have given values of Water Soluble Sulphate in the range 10mg/l to 350mg/l and pH Values in the range 7.0 to 8.8.

9.0 GEOTECHNICAL ASSESSMENT

9.1 DEVELOPMENT PROPOSALS

It is proposed to construct a new McDonalds restaurant with associated infrastructure on the south-western part of the site. Details of the proposed development are included as Figure 3. At the time of writing this report, anticipated structural loadings were not known.

9.2 GROUND CONDITIONS ENCOUNTERED

The exploratory holes have encountered variable Made Ground (up to 1.3m thickness) overlying interbedded sands, gravels and clays with coal (thickness 19.8m to 20.5m), Weathered Coal Measures strata (sandy clay) was encountered at depths of between 21.1m and 21.8m and Coal Measures bedrock at depths of between 23.2m and 24.2m below existing ground level.

Underground man-made obstructions were not encountered in any of the exploratory holes.

Groundwater was not encountered in any of the exploratory holes during the fieldwork, or within standpipes during subsequent monitoring. Significant levels of land gas have not been encountered.

9.3 RISKS POSED BY COAL MINING

Evidence of mining such as voids, coal seams, broken ground, loss of drilling flush was not encountered in any of the boreholes.

Coal dust and gravel was encountered in parts, throughout the Glaciofluvial Deposits, however these are not considered economically viable to have been worked at any time in the past.

It is therefore considered, based on the findings of the boreholes, the risk posed by shallow depth coal mining features beneath the site is low.

A Coal Mining Risk Assessment has been prepared to specifically assess this element and should be read in conjunction with this report.

9.4 FOUNDATIONS

Conventional strip/pad foundations will be suitable at this site, subject to anticipated structural loadings and tolerance of structure to settlement.

Strip/pad foundations should be taken down a minimum depth of 1.0m and placed in the natural loose to medium dense sand. If any made ground, particularly soft or loose material is encountered at foundation level this should either be excavated and replaced with suitable granular fill, or the foundation extended to suitable strata. It is essential foundations are placed in materials of similar bearing and consolidation characteristics.

Table 14 summarises anticipated allowable bearing pressures for strip and pad foundations placed at different depths in the natural loose to medium dense sand. The bearing capacities are calculated based on Hansen's⁽¹⁹⁷⁸⁾ method and assuming a factor of safety against bearing capacity failure of 3. Ground water is assumed to be at 5.0m depth.

Table 14. Summary of Allowable Bearing Pressures

Foundation Depth (m bgl)	Founding Stratum	Design Value	Foundation Type	Foundation Size	Allowable Bearing Pressure
1.0m	Sand	$\phi = 29.0^\circ$	Strip	0.40m	150kN/m ²
				0.90m	155kN/m ²
			Pad	1.0m x 1.0m	210kN/m ²
				2.0m x 2.0m	220kN/m ²
1.5m	Sand	$\phi = 29.3^\circ$	Strip	0.40m	225kN/m ²
				0.90m	235kN/m ²
			Pad	1.0m x 1.0m	330kN/m ²
				2.0m x 2.0m	330kN/m ²
2.0	Sand	$\phi = 28.6^\circ$	Strip	0.40m	280kN/m ²
				0.90m	285kN/m ²
			Pad	1.0m x 1.0m	400kN/m ²
				2.0m x 2.0m	400kN/m ²

The following table summarises anticipated settlements of strip and pad foundations, using design parameters discussed in Section 8. For the purposes of the calculations, the structural loading has been assumed as equal to the allowable bearing pressure above (to give a worse-case scenario).

Table 15. Summary of Anticipated Settlements

Foundation Depth	Strata	Foundation Details			Immediate Settlement (mm)		
		Type	Size	Loading	Lower Limit	Upper Limit	Best Estimate
1.0m	SAND	Strip	0.40m	150kN/m ²	<5	20-25	5-10
			0.90m	155kN/m ²	5 – 10	35-40	10-15
		Pad	1.0m x 1.0m	210kN/m ²	5 – 10	35-40	10-15
			2.0m x 2.0m	220kN/m ²	5 – 10	60-65	20-25
1.5m	SAND	Strip	0.40m	225kN/m ²	5 – 10	40-45	10-15
			0.90m	235kN/m ²	10 – 15	80-85	25-30
		Pad	1.0m x 1.0m	330kN/m ²	10 – 15	75-80	20-25
			2.0m x 2.0m	330kN/m ²	15 – 20	125-130	35-40
2.0m	SAND	Strip	0.40m	280kN/m ²	<5	15-20	5-10
			0.90m	285kN/m ²	5 – 10	30-35	10-15
		Pad	1.0m x 1.0m	400kN/m ²	5 – 10	30-35	10-15
			2.0m x 2.0m	400kN/m ²	10 – 15	50-55	20-15

Settlements for other bearing pressures may be estimated on a pro-rata basis but bearing pressures should not exceed the allowable net bearing pressure based on ultimate bearing capacity.

Floor slabs can be designed as ground bearing providing they are placed on the natural sand deposits.

A shallow depth thickened edge raft foundation may also be suitable at this site, depending on size of building footprint and also the practicality of adequately reinforcing the raft so it acts as a rigid structure. If a raft foundation is to be considered additional in situ testing, such as plate bearing tests should be carried out to confirm loads the shallow depth Made Ground can take and associated settlements at those loadings.

All foundation excavations should be inspected by a suitable qualified engineer to prove that the founding strata is suitable and uniform along the length of the foundation, and capable of taking the anticipated structural loadings.

9.5 PAVEMENT DESIGN

Results of in-situ testing have given average values of CBR in the range 35% to 90% near surface.

Based on the above results and ground conditions encountered, it is recommended for preliminary design purposes a CBR value = 30% is adopted for near surface granular material and a value of 2% for any near surface cohesive material.

Consideration should also be given to the use of geotextiles to allow reduction of capping thickness. For example, biaxial geogrids such as Tensar SSLA20 and SSLA30 are often used to reduce capping thickness. The advice of a suitable contractor should be sought as to the most appropriate type of geotextile to use in the ground conditions encountered at this site. For guidance, the following table gives a comparison of granular layer thickness with and without the use of a geotextile, in accordance with the requirement of HA25/94 Part 2.

Table 16. Comparison of Capping Thicknesses with and without Geotextile

CBR	Unreinforced			Reinforced with Tensar Geogrid				
	Sub-base	Capping	Total	Sub-base	Capping	No. of Grids	Total	Thickness Saving
0.5%	Design Not Suitable			200mm	400mm	2	600mm	-
1.0%	150mm	600mm	750mm	400mm	0	1	400mm	350mm
1.5%	150mm	600mm	750mm	310mm	0	1	310mm	440mm
2.0%	150mm	600mm	750mm	260mm	0	1	260mm	490mm
3.0%	150mm	350mm	500mm	210mm	0	1	210mm	290mm
4.0%	150mm	300mm	450mm	175mm	0	1	175mm	275mm
5.0%	150mm	250mm	400mm	160mm	0	1	160mm	240mm
These figures are suitable for light access roads and car parks, based on 1000 standard axles. For heavier loaded pavements the advice of a specialist contractor should be sought.								

It should be noted the type of construction will depend on proposed finished pavement levels across the site and it is recommended the pavement design is reviewed once these levels are known. In this context, it is essential further in situ CBR testing is carried out once formation levels are known to confirm design CBR values.

All formation excavations should be examined by a suitably experienced engineer or inspector to check for soft or unsuitable material, which should be removed and replaced with compacted granular fill. Also, to ensure good compaction and remove unevenness, the formation should be compacted with equipment suitable for use in the ground conditions encountered. Careful inspection of this work will also help identify any soft spots at or just below formation level.

9.6 CHEMICAL ATTACK ON BURIED CONCRETE

The results of the chemical testing for (water soluble) sulphate and pH values within soil samples are summarised in Tables 17 and 18. The test certificates are included in Appendices 10 & 12.

The characteristic values are based on the recommendations of BRE Special Digest 1 (2005). It is considered for concrete design purposes that Brownfield and static water conditions are applicable.

Table 17. Environmental Soil Sample Results

Test Type	No. of Tests	Min Value	Max Value	Characteristic Value	Design Sulphate Class	ACEC
Made Ground						
pH value (soil)	4	7.9	8.8	7.9	DS-1	AC-1s
Water soluble sulphate (mg/l SO ₄)		<10	350	350		
Natural						
pH value (soil)	4	8.2	8.7	8.2	DS-1	AC-1s
Water soluble sulphate (mg/l SO ₄)		<10	120	120		

Table 18. Geotechnical Soil Sample Results

Test Type	No. of Tests	Min Value	Max Value	Characteristic Value	Design Sulphate Class	ACEC
pH value (soil)	3	7.0	7.1	7.0	DS-1	AC-1s
Water soluble sulphate (mg/l SO ₄)		170	250	250		

Based on these conditions, it is advised for foundations the Design Sulphate Class for the site, as defined in BRE Special Digest 1(2005), be taken as DS-1, and the Aggressive Chemical Environment for Concrete (ACEC) site classification be taken as AC-1.

The recommendations of BRE Special Digest 1 should be followed for concrete foundations and ground bearing floor slabs.

9.7 SUITABILITY OF EXCAVATED MATERIALS

Acceptability criteria and testing, and methods of compaction/placement will depend on the type of contract and specification used for the construction of the proposed development and it is recommended that earthworks specifications are reviewed by a suitably qualified engineer, once these have been prepared by the relevant parties.

The granular Made Ground and natural sand/gravel deposits could be suitable for re-use as structural fill, providing it is not contaminated and does not contain excessive amounts of clay and providing moisture contents are controlled during placement. The control of moisture contents will be important as the cohesive content of this stratum is likely to be sensitive to moisture content changes.

The natural clay and cohesive Made Ground (albeit sparse across the site) could be re-used as structural fill, subject to further compliance testing.

9.8 TEMPORARY WORKS

Formations will be susceptible to damage both by weather and trafficking, and should be protected immediately on exposure, particularly in areas where construction plant will access the site.

Excavations in the Made Ground and natural granular deposits are likely to be unstable and should be battered back to an angle of 1 in 2, or a system of close sheeting and shoring adopted to ensure stability, and in particular where personnel are required to enter excavations. All excavations should be adequately supported where personnel are required to enter.

Groundwater seepages could be encountered near surface in excavations, particularly during wetter periods. If required intermittent pumping of excavations from a suitable located sump should be adequate to keep excavations dry.

All natural soils on site should be capable of being excavated using conventional excavating machinery.

9.9 DRAINAGE

Based on the ground conditions encountered, and results of in situ testing, soakaway drainage might be suitable, subject to factors such as size of hardstanding area to be drained, inflow to soakaway and time of half emptying of the soakaway. It is advised if soakaways are being considered for a BRE365 soakaway test to be performed to corroborate their applicability in the drainage design.

10.0 ENVIRONMENTAL ASSESSMENT

10.1 METHODOLOGY

The results of the site investigation works have been assessed utilising a Tier 1 quantitative risk assessment. The risk assessment methodology used is taken from the Environment Agency (EA) (2006) '*Remedial Targets Methodology*', which supersedes R+D Publication 20 '*Methodology for the Derivation of Remedial Targets for Soil and Groundwater to Protect Water Resources*'.

The tiered approach acts as a screening process whereby low risk sites are eliminated in order to identify sites that present the greatest environmental risks. The information obtained from the site investigation is used to characterise any contaminant source and subsequently to identify any sensitive environmental receptors and appropriate target concentration at the receptor.

Any requirement for further quantitative analysis or remedial action is based on comparison of the soil and/or groundwater concentrations for each contaminant with current applicable screening criteria. A decision is then made as to appropriate action to be taken which includes; no action, continuation to the next tier assessment or to take remedial action. In a Tier 1 Assessment generic guidelines and screening values are adopted in the first instance as remedial target values as a conservative approach.

The adopted approach currently involves the following stages:

- selection of generic Tier 1 screening criteria
- comparison of measured contaminant concentrations with the generic screening criteria as part of a Tier 1 assessment
- where the Tier 1 screening level is exceeded then the Conceptual Site Model (CSM) is refined to summarise sources of contamination, potential migration/exposure pathways and potential receptors that may exist at the site and could be characterised by significant levels of risk

10.2 ENVIRONMENTAL LABORATORY RESULTS - SOIL

Soil contaminant concentrations determined by the chemical analyses have been compared against LQM CIEH (2015) 'Suitable for Use Levels for Human Health Risk Assessment' (S4ULs). Where no S4UL is available, the analytical results have been compared against CLEA (2009) Soil Guideline Values (SGVs) and CL:AIRE Category 4 Screening Levels (C4SLs). EIC/AGS/CL:AIRE (2009). The specific S4UL, SGV and C4SL criteria used for comparison purposes with soil analysis results correspond to values for land under a 'commercial/industrial' end use scenario. A copy of the assessment criteria is included as Appendix 14, and the soil analysis certificate is included in Appendix 10.

The soils assessment criteria for organic contaminants are dependent upon the organic matter content (%) of the soil. In this instance, the generic criteria used for comparison purposes corresponds to a soil organic matter (SOM) of 2.5% for made ground as the average SOM is 1.69% and 1% for natural materials as the average is 1.025%.

Metals and Metalloids

None of the metal/metalloid determinands were recorded at concentrations which exceeded their respective generic assessment criteria.

Cyanide (Complex, Free and Total) & Thiocyanate

Cyanide was not recorded above the laboratory limits of detection.

Ammonium (Water Soluble)

Water soluble ammonium was recorded at concentrations ranging between 1.0mg/kg and 6.0mg/kg. The highest concentration was identified at 0.26-0.5m bgl in WS1 on the northern section of the site.

Total Petroleum Hydrocarbon (TPH)

Petroleum hydrocarbon contaminants were identified within made ground across the site ranging from 58 – 160mg/kg TPH concentration. The highest concentration of TPHs was identified in WS1 on the northern part of the site, at 0.26-0.5m bgl.

None of the individual aliphatic / aromatic hydrocarbon fractions were identified above their respective generic assessment criterion based on land under a commercial end use and appropriate organic matter content.

Polycyclic Aromatic Hydrocarbons (PAHs)

All PAH species analysed were found to comply with their respective assessment criterion for a commercial/industrial end use.

Asbestos

Asbestos screening was undertaken on seven (7No.) samples. No asbestos containing materials or fibres were identified in any of the samples.

Total Phenols

Total phenols were not identified above the laboratory limits of detection.

Waste Acceptance Criteria - Inert

Three (3No.) samples, representative of made ground and natural materials retrieved between 0.26-1.5m bgl were subject to a Waste Acceptance Criteria Testing Suite.

The results suggest that potential arisings may be able to be deposited in an Inert Waste Landfill. It is recommended that a HazWaste Online assessment is completed and that a full set of results is forwarded to the waste disposal facilities to confirm the classification of arisings for off-site disposal and acceptance of the materials. Further tests may be required by the facilities in order to achieve the above.

pH

Soil pH was generally alkaline, ranging between 7.0 to 8.8.

11.0 REVISED CONCEPTUAL SITE MODEL

The conceptual site model established as part of the Phase I Desk Study has been refined based upon the available data. The CSM has been produced within the context of the proposed commercial development.

11.1 IDENTIFIED CONTAMINANTS AND SOURCES

The chemical analysis results carried out on soils at the site, has not identified any soil contaminant concentrations above the current generic assessment criteria for a proposed commercial end use.

Based on the findings of the investigation, it is considered that '**mild**' harm could arise to future site users and adjacent site users (human health) and controlled waters from the environmental quality of the soils and groundwater on site.

11.2 REVISED RISK ASSESSMENT

Under the terms of the Environment Act 1995, a plausible pollutant linkage must exist to link the source to the receptors in order for an environmental risk to exist. Once these have been identified the likelihood and severity of each pollutant linkage are considered such that the scenarios of most concern can be addressed. A preliminary assessment of risk is then undertaken using a risk evaluation method, based on an EA/CIRIA scoring system, which aims to categorise the significance of risk in terms of the probability of the receptors being exposed to a given hazard (i.e. high likelihood, likely, low likelihood, unlikely) and the magnitude/severity of the environmental harm resulting from the hazard.

The risk categories are then assessed based upon the consequence vs. probability assigned to each scenario, in accordance with guidance originally produced by the DETR. These categories are outlined in Appendix 7.

The identified pathways and receptors with assigned risk categories are described in Table 18 below. Further details on receptor types can be found in Tables 8 and 9, of the DEFRA (2012) Contaminated Land Statutory Guidance⁴.

Table 19. Identified Sensitive Receptors and Likelihood of Pathway being established

Pathway	Receptor	Harm	Probability	RISK
Direct contact, ingestion and Inhalation of dust/soil	Site Users	Mild	Likely – Whilst hardstanding surfaces are present, an area to the centre of the site is proposed to be retained as landscaping due to the presence of a tree with a Tree Protection Order (TPO)	L/M
Ingestion and Inhalation - dust/soil	Adjacent users	Mild	Likely – area of soft landscaping proposed to be retained in the centre of the site.	L/M
Direct contact, ingestion and inhalation of contaminated dust/soil during any maintenance works requiring the ground to be broken	Construction / Maintenance Workers	Mild	Likely – Ground workers would be in contact with potentially contaminated materials during groundworks or maintenance works that require breaking ground. This likelihood could be reduced via the use of appropriate PPE and mitigation measures.	L/M
Surface runoff of contaminated water	Inland river (417m North)	Mild	Low – It is anticipated that a surface water drainage scheme would be implemented as part of the new development which would capture any surface water run-off.	L
Lateral migration of near surface water	River Gwenfro (1052m Southwest)		Low – due to distance of the inland river from the site	L
Vertical migration of contaminants through the soil profile	Secondary A aquifers	Mild	Low – As no source of contamination was identified on site.	L
Migration of gases into building/service runs and subsequent inhalation/explosion	Future site users	Mild	Low likelihood – gas generation potential of the underlying geology is low and designated as CS1 'Very Low' risk.	L
	Construction/ maintenance workers			
Concentration of gases in exploratory holes and/or excavated trenches	Construction/ Maintenance Workers	Mild	Low – Whilst drainage runs/ excavations would allow for the concentration of any ground gases, ground gas levels recorded on site are negligible. Additionally, the risk is further mitigated by providing appropriate risk assessment prior to entry into confined spaces.	L
Direct contact	Buildings and buried services	Mild	Likely – organic compounds, in the shallow soils could impact water pipes/attenuation structures /buried concrete. The risk can be reduced through the use of appropriate pipe work for water supply.	L/M
Plant uptake of leachable contaminants / direct contact	Vegetation / soft landscaping	Mild	Low likelihood – plants are intrinsically in close contact with soils; however, no trace metals were found in phytotoxic concentrations.	L

KEY

M – Moderate

L/M – Low to Moderate

L - Low

Plas Coch Rd, Wrexham

Ph I Desk Study & Ph II Geo-Environmental Site Investigation

1928-19 / July 2019 / Revised 31st July 2019

Based on the comparison of the magnitude of the harm and the likelihood that a contaminant pathway would be established, it is considered a '**Low risk**' that harm could arise to human health and/or environmental receptors from contaminative issues arising as a result of the current and past site use and off-site activities. This assumes appropriate PPE/RPE is used by construction/maintenance workers.

In accordance with a '**Low Risk**' classification based on CIRIA C552, it is possible that harm could arise to a designated receptor from an identified hazard, but it is likely that this harm, if realised, would at worst normally be mild.

12.0 CONCLUSIONS & RECOMMENDATIONS

The site is located off Plas Coch Road, Wrexham and currently comprises an area of car parking with associated trees and soft landscaping features. The site was undeveloped since the late 1870s, the eastern section was part of a wooded area and the western section comprised open land. A small building was built on the northern part of the site in the 1940s. In the early 2000s, the site was developed as a car park, serving a large retail park.

The current development proposal includes the construction of a McDonalds restaurant and drive thru' with associated car parking and soft landscaping areas.

The site investigation undertaken on 11th June 2019 comprised four (4No.) Windowless sample boreholes to a maximum of 5.0m below ground level (bgl) with associated geotechnical testing, three (3No.) rotary open hole drilling to 30.0m bgl six (6No.) TRL's to a maximum depth of 1.0m bgl and two (2No.) core samples.

The exploratory holes have encountered variable Made Ground (up to 1.3m thickness) overlying interbedded sands, gravels and clays with coal (thickness 19.8m to 20.5m), Weathered Coal Measures strata (sandy clay) was encountered at depths of between 21.1m and 21.8m and Coal Measures bedrock at depths of between 23.2m and 24.2m below existing ground level.

Groundwater was not encountered in any of the exploratory holes during the fieldwork, or within standpipes during subsequent monitoring.

Samples representative of made ground and natural soils were subject to a suite of contamination testing. All contaminant concentrations were within the guidelines appropriate to the proposed commercial end-use and no asbestos fibres or asbestos containing materials were identified.

Results for the WAC-inert analysis performed in a selected number of samples suggest potential arisings may be able to be deposited in an Inert Landfill.

Maximum methane and carbon dioxide concentrations recorded on site were in the order of <0.1%v/v and 4.7 %v/v, respectively. A Characteristic Situation 1 - 'Very low' risk is considered adequate for the site on a preliminary basis, for which no special precautions are required for new buildings.

Based on the ground conditions encountered and type of proposed development, strip/pad foundations will be suitable at this site taken down into the natural loose to medium dense sand a minimum of 1.0m depth.

Floor slabs can be designed as ground bearing, providing they are placed on the natural sand deposits.

It is recommended that for foundations the Design Sulphate Class for the site, as defined in BRE Special Digest 1(2005), be taken as DS-1, and the Aggressive Chemical Environment for Concrete (ACEC) site classification be taken as AC-1s.

Results of in-situ testing have given average values of CBR in the range 35% to 90% near surface.

Based on the above results and ground conditions encountered, it is recommended for preliminary design purposes a CBR value = 30% is adopted for near surface granular material and a value of 2% for any near surface cohesive material.

Evidence of mine-workings (voids, broken ground etc.) has not been encountered in any of the boreholes. It is therefore considered the risk posed by shallow depth coal mining features beneath the site is low.

The result of the Falling Head Test, has indicated on a preliminary basis, the infiltration rate of 3.97×10^{-5} m/s.

No specific remedial measures are anticipated to be required to protect human health, environmental receptors or controlled waters and render the site suitable for its intended commercial use. However, the following recommendations are made:

- Use of appropriate water supply pipe work
- Use of appropriate PPE and good hygiene standards by construction/maintenance workers
- Ground workers should be briefed for the potential presence of unexpected contamination and/or asbestos containing materials which may be encountered during development.

Pam Brown Associates
July 2019

Terms and Conditions

1. Interpretative assessments are based upon the ground conditions as revealed by trial pits and boreholes, together with the results of any field or laboratory testing, plus other relevant data, which may have been obtained including previous site investigations. Due to the nature of geotechnical or contamination issues, there can be no certainty that any or all such areas will have been located and/or sampled.
2. Should at a future date, any additional information be made available with regard to special conditions associated with the site, the findings may be subject to amendment.
3. Where any data supplied by the client or from other sources, including that from previous site investigations, has been used it has been assumed that the information is correct. However it is always advised that without the appropriate indemnification all data supplied by others should be verified, and no responsibility can be accepted by Pam Brown Associates Ltd for inaccuracies within the data.
4. Whilst an opinion may be expressed on possible ground conditions between or beyond trial pit or borehole locations, or on the possible presence of features based on either visual, verbal or published evidence this is for guidance only and no liability can be accepted for the accuracy thereof.
5. Comments on groundwater conditions will be based upon observations made at the time of the investigation unless otherwise stated. Groundwater conditions may vary due to seasonal or other effects. Where possible an assessment of likely changes will be made for guidance purposes. Additional investigation may be required for confirmation.
6. The quotation has been prepared in the context of an agreed scope of work and should not be used in a different context. Furthermore, new information, improved practices and changes in legislation may necessitate a re-interpretation of the findings in whole or part after its original submission.
7. The copyright in the written materials shall remain the property of Pam Brown Associates Ltd, but with a royalty-free perpetual licence to the Client deemed to be granted on payment in full to Pam Brown Associates Ltd by the Client of the outstanding amounts.
8. The report is provided for sole use by the Client and is confidential to them and their professional advisers. No responsibility whatsoever for the contents of the report will be accepted to any persons other than the Client.
9. These terms apply (or in addition to another written contract which may be in place instead thereof) unless specifically agreed otherwise in writing.
10. Fees are based on the methods and evaluation stated in this proposal. This fee proposal will be void and a revised fee proposal will be produced if the client alters or requires an alteration to be made to the proposal. This quote will remain valid for three months from the date of this quote
11. The client shall be entitled to use documents prepared by the consultant in the execution of this agreement provided that: i) all fees due to the consultant at that stage have been paid, ii) the use relates only to the project or part of the project for which the material was prepared.
12. If either party to this agreement considers modifications to the project to be necessary, full details must be provided in writing.
13. Fees associated with the acquisition of data, ground investigation, laboratory testing, monitoring, etc. shall be paid in full prior to the final factual and/or interpretive report of the findings is issued. The findings of any investigation and assessment shall remain the property of PBA and may not be able to be disclosed until full payment for the above has been received.
14. Terms of payment are **strictly 30 days** from date of invoice. Payment shall be made via BACS.
15. In accordance with Late Payment of Commercial Debts Regulations (2002), Pam Brown Associates reserves the right to charge interest on any outstanding amount after the payment due date. We reserve the right to charge interest at 3% over bank base rate on overdue invoices.
16. It is the policy of the company to recover all debts, associated costs, and legal fees incurred in so doing.

FIGURES



Pam Brown Associates

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Needwood House, Lancaster Park
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Project:

Plas Coch Rd,
Wrexham
LL11 2BA

Title:

Site Location Plan

Scale: NTS

Job No.: 1928-19

Figure 1



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Needwood House, Lancaster Park
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Project:

Plas Coch Rd,
Wrexham
LL11 2BA

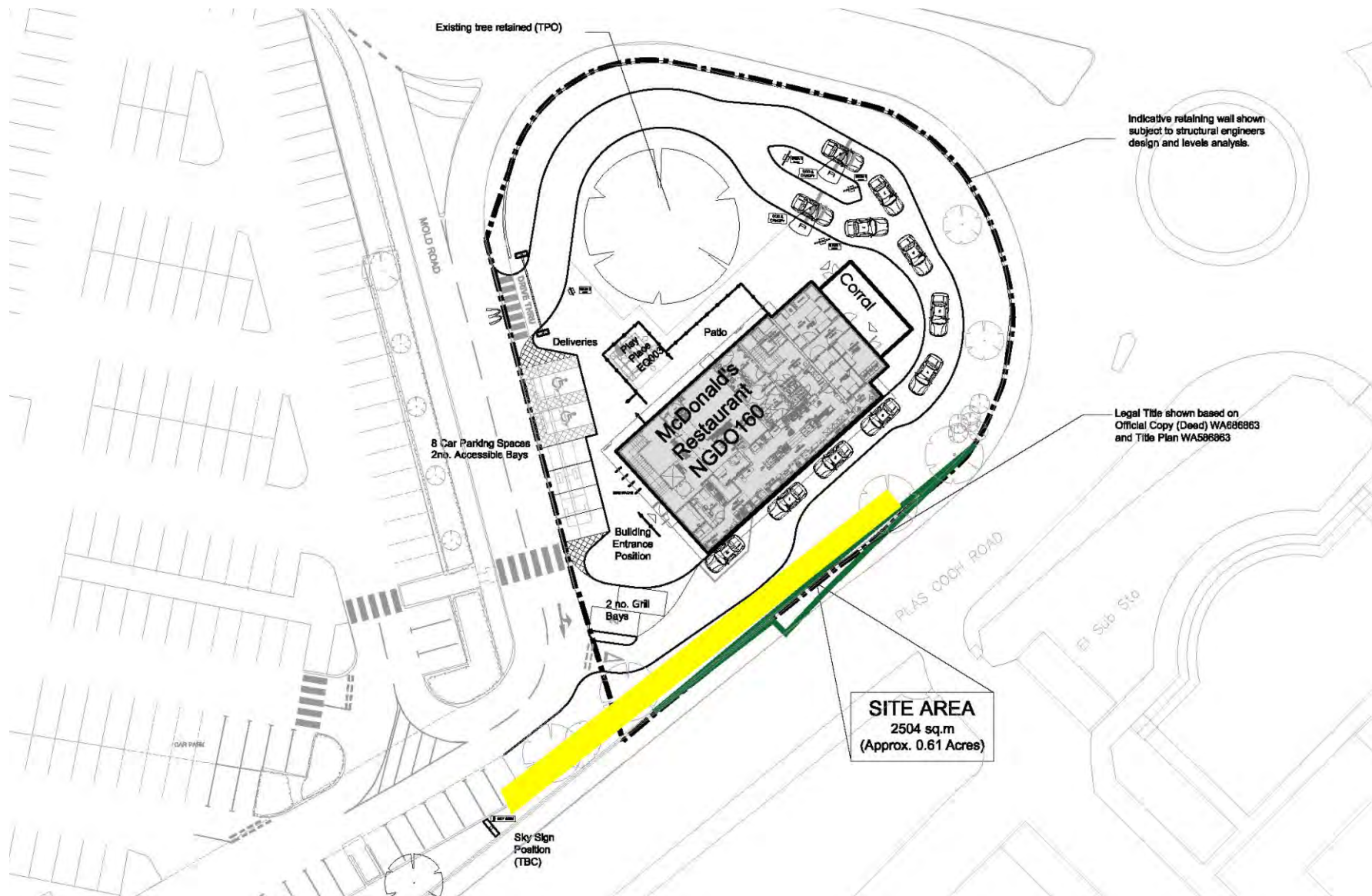
Title:

Existing Site Plan

Scale: NTS

Job No.: 1928-19

Figure 2



Based on AEW Architects drawing 'Feasibility Site Layout Option 4, dated 22/02/2019

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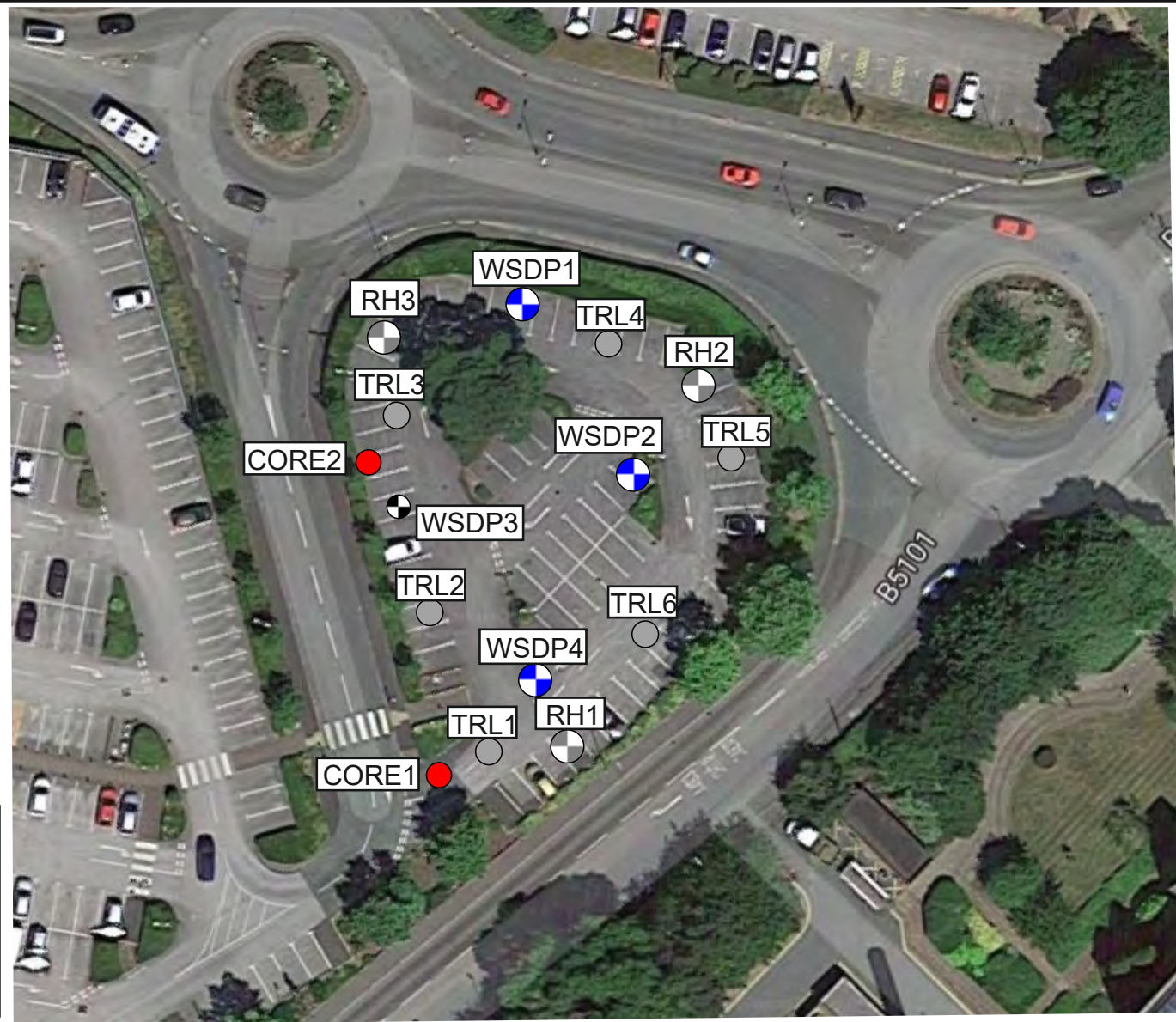
Title:

Proposed Site Plan

Scale: NTS

Job No.: 1928-19

Figure 3



Key

- Installed Window sample hole
- Window Sample Hole
- Rotary Borehole
- TRL location
- Coring location

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Project:

Plas Coch Rd,
Wrexham
LL11 2BA

Title:

Exploratory Location Plan

Scale: NTS

Job No.: 1928-19

Figure 4

APPENDICES

APPENDIX 1

Pam Brown Associates

2 LANCASTER PARK, NEWBOROUGH ROAD,
BURTON-ON-TRENT/NEEDWOOD, DE13 9PD

Groundsure
Reference:

GS-6089603

Your Reference: 1928-19_

Report Date 11 Jun 2019

Report Delivery Method: Email - pdf

Geo Insight

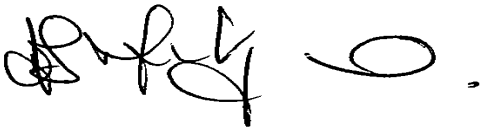
Address: LAND OFF PLAS COCH RETAIL PARK, PLAS COCH, WREXHAM, LL11 2BA

Dear Sir/ Madam,

Thank you for placing your order with Groundsure. Please find enclosed the **Groundsure Geo Insight** as requested.

If you need any further assistance, please do not hesitate to contact our helpline on 08444 159000 quoting the above Groundsure reference number.

Yours faithfully,



Managing Director
Groundsure Limited

Enc.
Groundsure Geo Insight

Address: LAND OFF PLAS COCH RETAIL PARK, PLAS COCH, WREXHAM, LL11 2BA

Date: 11 Jun 2019

Reference: GS-6089603

Client: Pam Brown Associates

NW N NE



SW S SE

Aerial Photograph Capture date: 07-May-2017
Grid Reference: 332567,351303
Site Size: 0.2380ha

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Overview of Findings

The Groundsure Geo Insight provides high quality geo-environmental information that allows geo-environmental professionals and their clients to make informed decisions and be forewarned of potential ground instability problems that may affect the ground investigation, foundation design and possibly remediation options that could lead to possible additional costs.

The report is based on the BGS 1:50,000 and 1:10,000 Digital Geological Map of Great Britain, BGS Geosure data; BRITPITS database; Non-coal mining data and Borehole Records, Coal Authority data including brine extraction areas, PBA non-coal mining and natural cavities database, Johnson Poole and Bloomer mining data and Groundsure's unique database including historical surface ground and underground workings.

For further details on each dataset, please refer to each individual section in the report as listed. Where the database has been searched a numerical result will be recorded. Where the database has not been searched '-' will be recorded.

Section 1: Geology 1:10,000 Scale

1.1 Artificial Ground	1.1 Is there any Artificial Ground/ Made Ground present beneath the study site at 1:10,000 scale?	No
1.2 Superficial Geology and Landslips	1.2.1 Is there any Superficial Ground/Drift Geology present beneath the study site at 1:10,000 scale?*	Yes
	1.2.2 Are there any records of landslide within 500m of the study site boundary at 1:10,000 scale?	No
1.3 Bedrock, Solid Geology and linear features	1.3.1 For records of Bedrock and Solid Geology beneath the study site* see the detailed findings section.	
	1.3.2 Are there any records of linear features within 500m of the study site boundary at 1:10,000 scale?	Yes

Section 2: Geology 1:50,000 Scale

2.1 Artificial Ground	2.1.1 Is there any Artificial Ground/ Made Ground present beneath the study site?	No
	2.1.2 Are there any records relating to permeability of artificial ground within the study site*boundary?	No
2.2 Superficial Geology and Landslips	2.2.1 Is there any Superficial Ground/Drift Geology present beneath the study site?*	Yes
	2.2.2 Are there any records of permeability of superficial ground within 500m of the study site?	Yes
	2.2.3 Are there any records of landslide within 500m of the study site boundary?	No
	2.2.4 Are there any records relating to permeability of landslips within the study site* boundary?	No

Section 2: Geology 1:50,000 Scale

2.3 Bedrock, Solid Geology and linear features

2.3.1 For records of Bedrock and Solid Geology beneath the study site* see the detailed findings section.

2.3.2 Are there any records relating to permeability of bedrock ground within the study site boundary?

Yes

2.3.3 Are there any records of linear features within 500m of the study site boundary?

Yes

Section 3: Radon

3. Radon

3.1 Is the property in a Radon Affected Area as defined by the Health Protection Agency (HPA) and if so what percentage of homes are above the Action Level?

The property is in a Radon Affected Area, as between 10 and 30% of properties are above the Action Level.

3.2 Radon Protection

Full radon protective measures are necessary.

Section 4: Ground Workings

	On-site	0-50m	51-250	251-500	501-1000
4.1 Historical Surface Ground Working Features from Small Scale Mapping	0	1	9	Not Searched	Not Searched
4.2 Historical Underground Workings from Small Scale Mapping	0	0	0	0	8
4.3 Current Ground Workings	0	0	0	0	1

Section 5: Mining, Extraction & Natural Cavities

	On-site	0-50m	51-250	251-500	501-1000
5.1 Historical Mining	0	0	0	0	8
5.2 Coal Mining	1	0	0	0	0
5.3 Johnson Poole and Bloomer Mining Area	0	0	0	0	0
5.4 Non-Coal Mining*	1	1	0	0	0
5.5 Non-Coal Mining Cavities	0	0	0	0	0
5.5 Natural Cavities	0	0	0	0	0

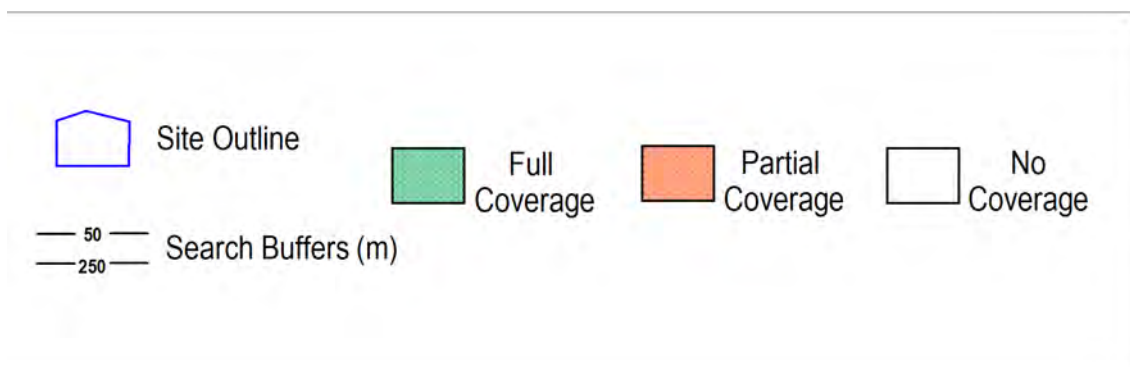
Section 5: Mining, Extraction & Natural Cavities	On-site	0-50m	51-250	251-500	501-1000
5.6 Brine Extraction	0	0	0	0	0
5.7 Gypsum Extraction	0	0	0	0	0
5.8 Tin Mining	0	0	0	0	0
5.9 Clay Mining	0	0	0	0	0
Section 6: Natural Ground Subsidence	On-site				
6.1 Shrink-Swell Clay	Very Low				
6.2 Landslides	Very Low				
6.3 Ground Dissolution of Soluble Rocks	Negligible				
6.4 Compressible Deposits	Negligible				
6.5 Collapsible Deposits	Very Low				
6.5 Running Sand	Very Low				
Section 7: Borehole Records	On-site	0-50m	51-250		
7 BGS Recorded Boreholes	0	0	5		
Section 8: Estimated Background Soil Chemistry	On-site	0-50m	51-250		
8 Records of Background Soil Chemistry	1	4	0		
Section 9: Railways and Tunnels	On-site	0-50m	51-250	250-500	
9.1 Tunnels	0	0	0	Not Searched	
9.2 Historical Railway and Tunnel Features	0	0	0	Not Searched	
9.3 Historical Railways	0	0	0	Not Searched	
9.4 Active Railways	0	0	0	Not Searched	
9.5 Railway Projects	0	0	0	0	

1:10,000 Scale Availability



1_10,000 Availability Legend

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Availability of 1:10,000 Scale Geology Mapping

The following information represents the availability of the key components of the 1:10,000 scale geological data.

ID	Distance	Artificial Coverage	Superficial Coverage	Bedrock Coverage	Mass Movement Coverage
1	0.0	Some deposits are mapped	Full	Full	Some deposits are mapped
N2	1293.0	Some deposits are mapped	Full	Full	Some deposits are mapped

Guidance: The 1:10,000 scale geological interpretation is the most detailed generally available from BGS and is the scale at which most geological surveying is carried out in the field. The database is presented as four types of geology (artificial, mass movement, superficial and bedrock), although not all themes are mapped or available on every map sheet. Therefore a coverage layer showing the availability of the four themes is presented above.

The definitions of coverage are as follows:

Geology	Full Coverage	Partial Coverage	No Coverage
Bedrock	The whole tile has been mapped	Some but not all the tile has been mapped	No coverage
Superficial	The whole tile has been mapped	Some but not all of the tile has been mapped	No coverage
Artificial	Some deposits are mapped on this tile	-	No deposits are mapped
Mass Movement	Some deposits are mapped on this tile	-	No coverage

1 Geology (1:10,000 scale).

1.1 Artificial Ground map (1:10,000 scale)



Artificial Ground Legend

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1. Geology 1:10,000 scale

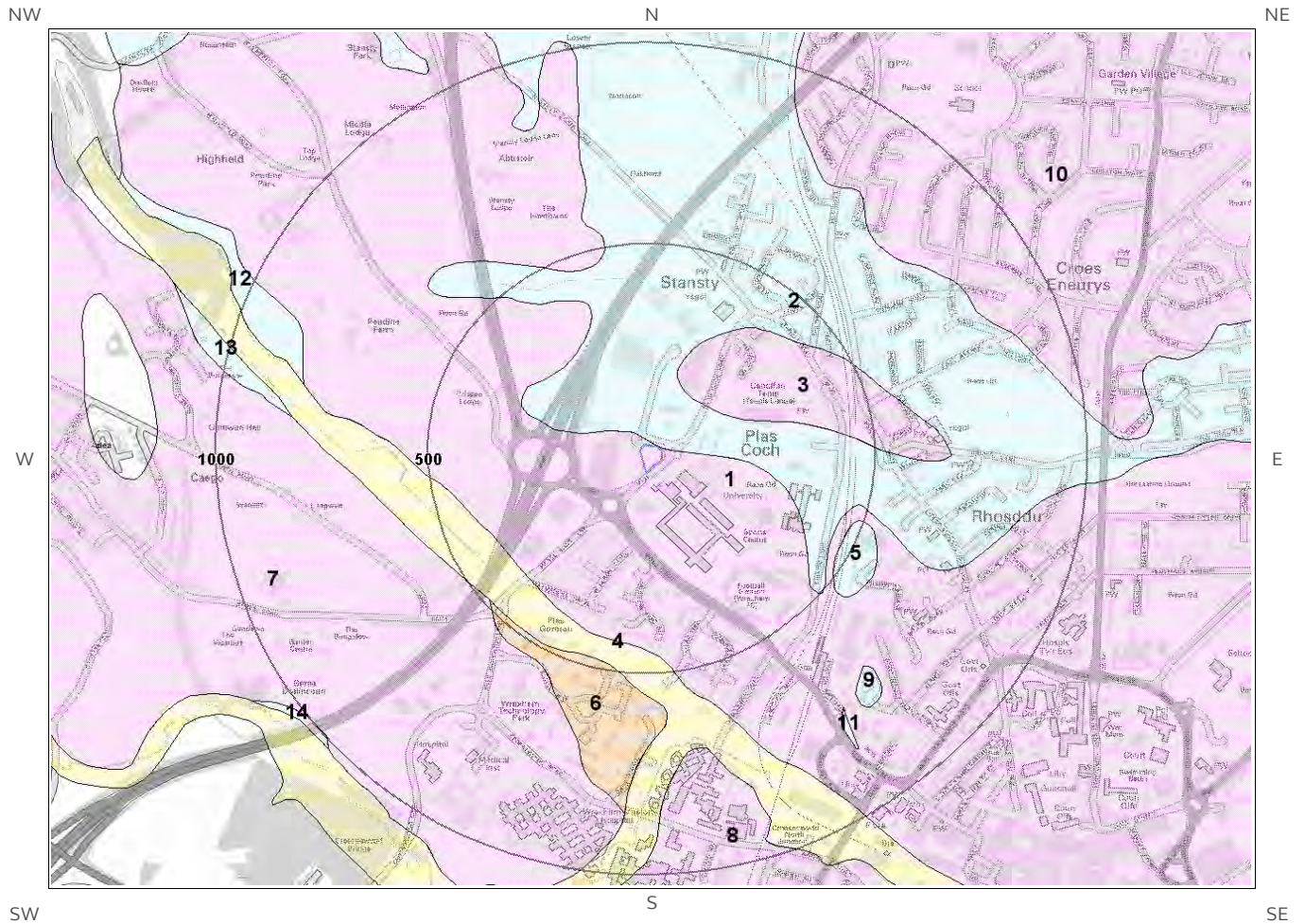
1.1 Artificial Ground

The following geological information represented on the mapping is derived from 1:10,000 scale BGS Geological mapping.

Are there any records of Artificial/ Made Ground within 500m of the study site boundary at 1:10,000 scale? Yes

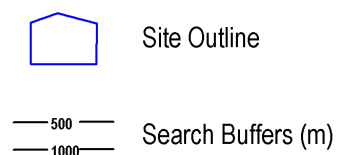
ID	Distance	Direction	LEX Code	Description	Rock Description
1	118.0	SW	MGR-ARTDP	Made Ground (Undivided)	Artificial Deposit
2	354.0	N	MGR-ARTDP	Made Ground (Undivided)	Artificial Deposit
3	447.0	SE	MGR-ARTDP	Made Ground (Undivided)	Artificial Deposit

1.2 Superficial Deposits and Landslips map (1:10,000 scale)



Artificial Ground Legend

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1.2 Superficial Deposits and Landslips

The following geological information represented on the mapping is derived from 1:10,000 scale BGS Geological mapping

1.2.1 Superficial Deposits/ Drift Geology

Are there any records of Superficial Deposits/ Drift Geology within 500m of the study site boundary at 1:10,000 scale? Yes

ID	Distance (m)	Direction	LEX Code	Description	Rock Description
1	0.0	On Site	GFDU-XSV	Glaciofluvial Deposits - Sand And Gravel	Sand And Gravel
2	2.0	NE	TILL-DMTN	Till - Diamicton	Diamicton
3	147.0	NE	GFDU-XSV	Glaciofluvial Deposits - Sand And Gravel	Sand And Gravel
4	380.0	SW	ALV-C	Alluvium - Clay (unlithified Deposits Coding Scheme)	Clay
5	470.0	SE	TILL-DMTN	Till - Diamicton	Diamicton
6	476.0	S	RTDU-XSV	River Terrace Deposits (undifferentiated) - Sand And Gravel	Sand And Gravel
7	485.0	SW	GFDU-XSV	Glaciofluvial Deposits - Sand And Gravel	Sand And Gravel

1.2.2 Landslip

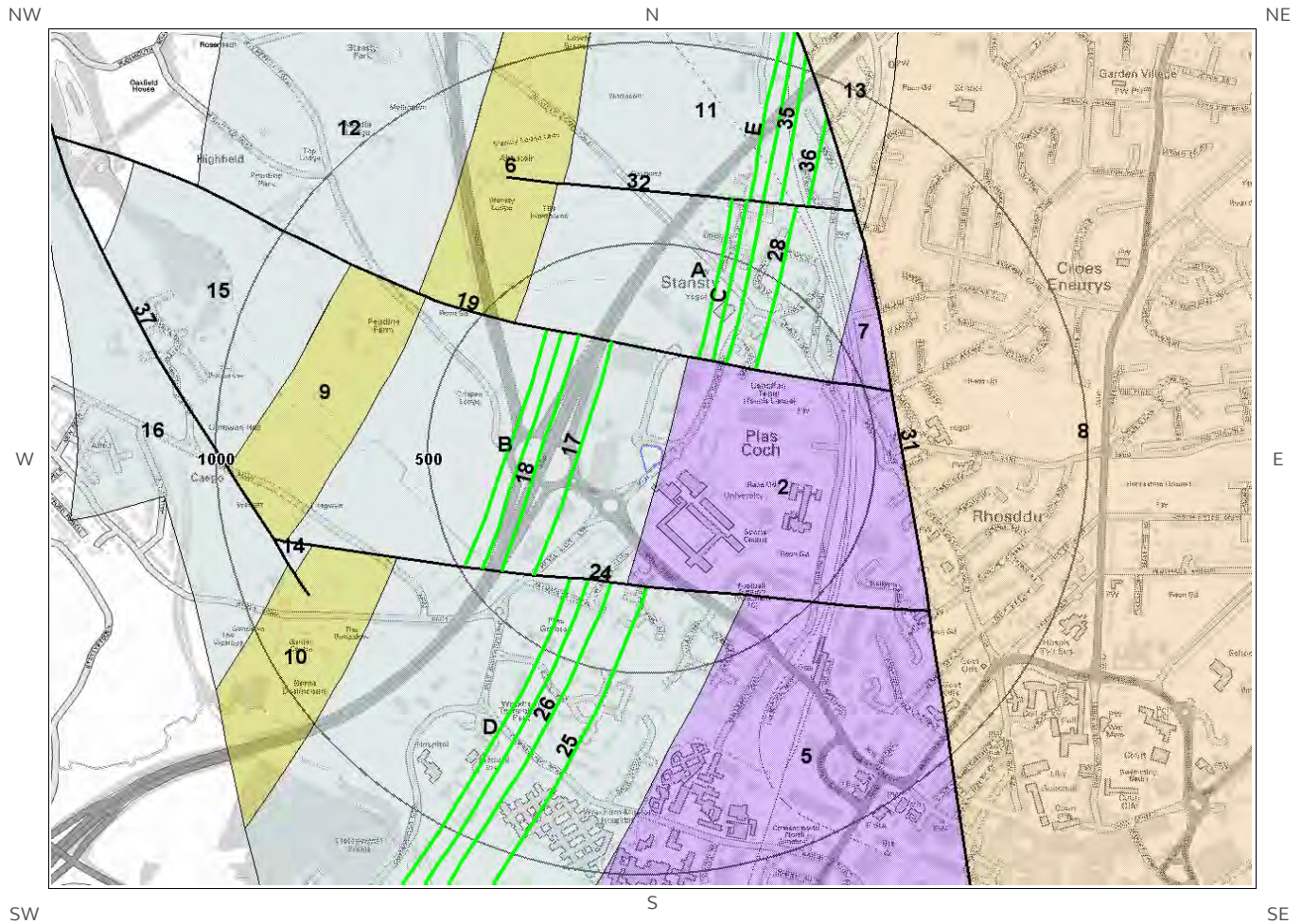
Are there any records of Landslip within 500m of the study site boundary at 1:10,000 scale? No

Database searched and no data found.

The geology map for the site and surrounding area are extracted from the BGS Digital Geological Map of Great Britain at 1:10,000 scale

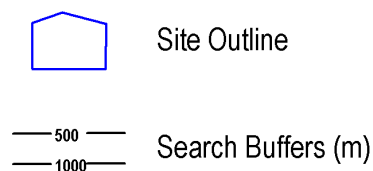
This Geology shows the main components as discrete layers, these are: Artificial / Made Ground, Superficial / Drift Geology and Landslips. These are all displayed with the BGS Lexicon code for the rock unit and BGS sheet number. Not all of the main geological components have nationwide coverage.

1.3 Bedrock and linear features map (1:10,000 scale)



Bedrock and linear features Legend

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1.3 Bedrock and linear features

The following geological information represented on the mapping is derived from 1:10,000 scale BGS Geological mapping.

1.3.1 Bedrock/ Solid Geology

Records of Bedrock/Solid Geology within 500m of the study site boundary at 1:10,000 scale.

ID	Distance (m)	Direction	LEX Code	Description	Rock Age
1B	0.0	On Site	PLMC-MDSS	Pennine Lower Coal Measures Formation And Pennine Middle Coal Measures Formation (undifferentiated) - Mudstone, Siltstone And Sandstone	Bolsovian Sub-age - Langsettian Sub-age
2	1.0	E	ETM-MDST	Etruria Formation - Mudstone	Westphalian Age
3A	233.0	N	PLMC-MDSS	Pennine Lower Coal Measures Formation And Pennine Middle Coal Measures Formation (undifferentiated) - Mudstone, Siltstone And Sandstone	Bolsovian Sub-age - Langsettian Sub-age
4D	281.0	S	PLMC-MDSS	Pennine Lower Coal Measures Formation And Pennine Middle Coal Measures Formation (undifferentiated) - Mudstone, Siltstone And Sandstone	Bolsovian Sub-age - Langsettian Sub-age
5	385.0	SE	ETM-MDST	Etruria Formation - Mudstone	Westphalian Age
6	430.0	NW	PLMC-SDST	Pennine Lower Coal Measures Formation And Pennine Middle Coal Measures Formation (undifferentiated) - Sandstone	Bolsovian Sub-age - Langsettian Sub-age
7	434.0	NE	ETM-MDST	Etruria Formation - Mudstone	Westphalian Age

1.3.2 Linear features

Are there any records of linear features within 500m of the study site boundary at 1:10,000 scale? ☒ Yes

ID	Distance (m)	Direction	Category Description	Feature Description
17	138.0	W	ROCK	Coal seam, inferred
18	222.0	W	ROCK	Coal seam, inferred
19	233.0	N	FAULT	Normal fault, inferred
20A	239.0	NE	ROCK	Coal seam, inferred
21C	249.0	NE	ROCK	Coal seam, inferred
22B	258.0	W	ROCK	Coal seam, inferred
23C	260.0	NE	ROCK	Coal seam, inferred
24	281.0	S	FAULT	Normal fault, inferred
25	285.0	S	ROCK	Coal seam, inferred
26	285.0	S	ROCK	Coal seam, inferred
27B	296.0	W	ROCK	Coal seam, inferred
28	296.0	NE	ROCK	Coal seam, inferred
29D	299.0	SW	ROCK	Coal seam, inferred
30D	316.0	SW	ROCK	Coal seam, inferred

The geology map for the site and surrounding area are extracted from the BGS Digital Geological Map of great Britain at 1:10,000 scale.

This Geology shows the main components as discrete layers, these are: Bedrock/ Solid Geology and linear features such as faults. These are all displayed with the BGS Lexicon code for the rock unit and BGS sheet number. Not all of the main geological components have nationwide coverage.
