PROPOSED COMMERCIAL DEVELOPMENT
BIOCATALYSTS, NANTGARW
RHONNDA CYNON TAFF

BIOCATALYSTS LTD

GEOENVIRONMENTAL ASSESSMENT

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Date	Status	Written By	Checked By	Approved By
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SUMMARY

The site is a roughly rectangular parcel of land with the site width increasing to the east, occupying an area of around 0.15ha. The area is currently unoccupied with a roughly level grass surface and sparse shrubbery. Historical maps show the site to have been occupied by the Nant-Garw Colliery since 1920, with two distinct phases of construction within the site. Extensive coal mining is indicated in the general area.

Trial Trenches undertaken at the site have identified Made Ground to a depth of 4.5m. Multiple steel reinforced concrete foundations and walls have been identified relating to the indicated historical structures and the associated colliery discard. Inclusions of brick fragments, whole bricks, concrete, rebar, car parts and plastic have been recovered within the Made Ground.

Laboratory testing has identified no contaminants above the respective GAC for a commercial property. Asbestos will pose a potential risk to construction workers and the nearby general public during any site clearance works. A potential risk may also be posed to site end users due to its confirmed presence within the soils, however this may be mitigated by the recommended capping layer (see Section 6.1.2).

It is understood that the site is being considered for potential development for commercial purposes and the comments and recommendations in this report assume that the development will involve a conventional portal frame construction with point loads, and line loads from conventional load-bearing brickwork construction. It is understood that the existing adjacent Biocatalyst building is constructed on wide (1.2m) reinforced concrete foundations placed on a minimum of 1.5m of excavated and re-compacted fill materials. This is likely to be a suitable solution for the proposed extension. All voided ground below and between the foundations should be infilled.

Based on our understanding of the proposed development, we conclude that further site investigation works are necessary at this stage. Identified features that require further consideration include:

- The presence of petroleum hydrocarbon compounds in the near surface soils;
- The infilled basement and additional sub-surface foundations;
- Potential for ground gas;
- Potential for shallow coal and historic workings.
- Potential for spontaneous combustion within the Colliery discard.

Recommendations for further investigation:

- Further investigation of the infilled basement;
- Ground gas assessment including installation of gas wells and monitoring of ground gases;
- Drilling and investigation of the potential for shallow mine workings.
- Additional Geo-environmental testing (Los of Ignition, Calorific Value and TPH)

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ENCLOSURES

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1.0 INTRODUCTION AND OBJECTIVES

1.1 Background

Biocatalysts Ltd (hereafter known as the Client) are proposing to redevelop the subject site as a commercial development. The Earth Science Partnership Ltd (ESP), Consulting Engineers, Geologists and Environmental Scientists, were instructed by the Client to undertake a geo-environmental assessment to identify subsurface structures and evaluate potential ground hazards which could impact on the proposed development. The site location is shown on Figure 1.

The development will comprise an extension of the existing structure, with a large portal-frame industrial unit with external areas of car parking, hard-standing and limited landscaping. The proposed development area is shown on the Site Boundary Plan in Figure 2.

1.2 Objective and Scope of Works

The scope of works for the investigation was mutually developed with the Client by ESP within an agreed budget, and comprised a desk study review of available historical Ordnance Survey maps, geological maps, memoirs, previous investigations, a site reconnaissance walkover, supervision and direction of trial trench investigation, geotechnical and geo-environmental laboratory testing, assessment and reporting.

The contract was awarded on the basis of a competitive tender quotation. The terms of reference for the assessment are as laid down in the Earth Science Partnership proposal of 22nd December 2014 (ref: db/5742b.lt1). The investigation and assessment was undertaken in February and March 2015.

1.3 Risk Assessment Methodology

The assessment was partly conducted to formulate an opinion as to the potential for hazardous substances (contamination) or conditions to exist on, at or near the site at levels or in a situation likely to warrant mitigation or consideration appropriate to the proposed end use. The risk assessment methodology used to achieve this is discussed in Section 2.9 of this report.

The assessment of the potential risk is phased with the Phase One desk study and Preliminary Risk Assessment (PRA) presented in Section 2.0 of this report, followed by a Phase Two intrusive investigation and assessment (Sections 3.0 to 7.0).

1.4 Limitations of Report

This report represents the findings of the brief relating to the proposed end use as detailed in the text. The brief did not require an assessment of the implications for any other end use, nor is the report a comprehensive site characterisation and should not be construed as such. Should an

alternative end use be considered, the findings of the assessment should be re-examined relating to this use.
Where preventative, ameliorative or remediation works are required, professional judgement will be used to make recommendations that satisfy the site specific requirements in accordance with good practice guidance.

Consultation with regulatory authorities will be required with respect to proposed works as there may be overriding regional or policy requirements which demand additional work to be undertaken. It should be noted that both regulations and their interpretation by statutory authorities are continually changing.

This report represents the findings and opinions of experienced geo-environmental and geotechnical specialists. Earth Science Partnership does not provide legal advice and the advice of lawyers may also be required.

1.5 Digital Copy of Report

An digital copy of this report (in pdf format) is included on a CD in Appendix H.

2.0 DESK STUDY, WALKOVER SURVEY AND PRELIMINARY RISK ASSESSMENT

The information presented in this section comprises a Preliminary Risk Assessment (PRA) which includes information obtained from desk based research that was used to inform decisions made in scoping the physical works. Desk study information has been obtained from various sources as described in the text, including historical maps and a Groundsure Report which are presented in Appendices A and B respectively. The site description is largely based on a site inspection made at the site on between the 10th and 14th of February 2015 during cloudy weather, and general views of the site are included as a series of inserts within this report.

2.1 Site Location and Description

The site is located off the north end of Cefn Coed Road within the Nantgarw Industrial Estate. The National Grid Reference at the centre of the site is (ST) 312001 185787. A Site Location Plan and Site Boundary Plan are presented as Figures 1 and 2 respectively.

The site is a roughly rectangular parcel of land with the site width increasing to the east, occupying an area of around 0.15ha. The area is currently unoccupied with a roughly level grass surface and sparse shrubbery. An embankment is located on the eastern section of the site, with some small outlying shrubs grading into well-established Ash trees (>10m). The embankment is associated with the construction of the adjacent A470. The site is bounded by:

- To the north: A small wire and post fence followed by shrubs and a small wooded area;
- To the east: By the aforementioned embankment that extends approximately 15m to the east onto the adjacent A470:
- To the south: By the current Biocatalyst structure;
- To the west: Parking and associated hardstanding

Vehicular access to the site is currently gained via the adjacent car park (on the west side). The boundaries generally comprise wire fencing on the north and east.

The general topography in the site is flat with the exclusion of the embankment on the east side of the site. We are not aware of a topographic survey for the site at this time; however, recent Ordnance Survey maps indicate a spot height of 50m OD for the site with the embankment extending up to 55m OD at the A470. A general layout of the site is presented on Inserts 1 and 2.

As part of this assessment, service plans have been obtained by ESP from the utility companies. Site observations and these plans indicate that the site is not crossed by any services

Insert 1: View of the site, looking east (10/02/2015)

Insert 2: View of the site, looking north east (10/02/2015)

2.2 Site History

The site history has been assessed from a review of available historical Ordnance Survey County Series and National Grid maps. The full set of historical maps is presented in Appendix A of this report. Relevant information from other sources, such as the Groundsure Data report (Appendix B), has also been incorporated, where appropriate.

A preliminary assessment of the site indicates it resides on the former Nantgarw Colliery which operated between 1911 and 1986 accessing underground workings via 2no. shafts (note the shafts are adjacent to the site), which have now been filled and capped (Ref: ESP.2742c.721).

Table 1: Review of Historical Maps

Date	On-Site	In Vicinity of Site
1875 - 1877	The north west section of site is indicated as consisting of a wooded area with an embankment and railway line occupying the south east portion of the site.	The site is generally surrounded immediately by woods with fields to the west. The Coed-Cae-Dyrys Colliery is indicated immediately to the east. This is where the railway indicated onsite propagates from. A river is indicated segregating the site and adjacent colliery.
1900	No tracks/line are no longer indicated on the bank/embankment	A Tramway extending (north east) from the Coedcae-Dyrys Colliery (indicated as disused) is indicated, extending up to a railway. The adjacent river is now listed as the Glamorganshire Canal.
1920	A structure is indicated as encroaching on the sites west boundary.	The Nantgarw Colliery is indicated adjacent to the site with 2no. shafts indicated to the west (approx. 50m). Multiple structures are indicated around the vicinity of the site.
1943	An additional structure is indicated on the south west section of the site.	Additional structures are indicated associated to the Nantgarw Colliery. Spoil piles are indicated to the north and west of the site. The canal is now listed as disused.
1958 - 1991	Both previously indicated structures are no longer indicated including the removal of the bank and a larger structure with apparent railway lines extending north. A new structure occupies the west section of the site. An elongated oval structure is indicated on the west section of the site. A temporary road is indicated running through the central portion of the site.	Significant changes are indicated to the east of the site consisting of additional structures with multiple railways lines. The shafts are no longer indicated. A housing development is indicated to the south east of the site consisting of a visible 50no. properties. A road is indicated to the east of the site.
1992	No structures indicated onsite.	Mine infrastructure no longer indicated. Industrial estate listed to the west of the site.
2002	No changes indicated	Earthworks indicated immediately north of the site. Several structures indicated to the west of the site.
2010 - 2014	No changes indicated	Additional structures indicated in accordance with the presently observed structures.

2.3 Previous Investigations and Assessments

The site resides within an industrial estate that has been subject to a number of previous geotechnical investigations and assessments. An audit of a number of reports for geoenvironmental and geotechnical investigations at the site has been undertaken. The reports evaluated are noted in the following table.

Table 2: Review of Historical Maps

Author	Date	Title	Content
Wimpey Environmental	1991	Nantgarw Colliery. Initial Site Investigation. Rpt ref. EEE488/1	Geotechnical and geo-environmental factual and interpretive report
Robert West & Partners	1991	Proposed Development at the Pithead at Nantgarw Colliery – Report on Geotechnical, Site and Shaft Treatment and Heatings	9 no. boreholes were drilled, but no records are included.
Wimpey Environmental	1995	Infra Red Thermographic Survey, Nantgarw Colliery Ref. EPE4312S.	Assessment of combustion
Robert West Consulting	1995	Report on temperature and gas survey at site of former Nantgarw Colliery.	Assessment of combustion
Robert West Consulting	1996	Report on temperature and gas survey at site of former Nantgarw Colliery. Doc ref. GW1.	Assessment of combustion
Exploration Associates (EA)	2001	Proposed development at Nantgarw, Report on Ground Investigation. Rpt no. 151088	Geotechnical and geo-environmental factual report.
Williams Thomas Consulting	2001	Proposed Development at Nantgarw, Geotechnical Investigation, Interpretative Report.	Interpretative report for EA investigation.

Earth Science Partnership (ESP) undertook a geo-environmental assessment for a larger area encompassing the site in 2003 (ESP, 2003), that is now the Industrial Estate. The investigation comprised the excavation of 15no. trial pits, the construction of 4no. light cable percussion boreholes to a depths of between 6m and 12m, gas monitoring, laboratory testing and assessment of geotechnical and contamination and ground gas risks. For ease of reference, copies of the relevant exploratory hole records are provided in Appendix C.

The salient findings from these assessments are incorporated into the following sections.

2.4 Geology, Engineering Geology, Hydrology and Hydrogeology

2.4.1 Published Geology

The published geological map for the area of the site is 1:10,560 scale Solid and Drift Geological Sheet ST18NW and 1:50,000 scale Solid and Drift Geological Plan, Newport Sheet 249. Published records indicate that the anticipated sequence is of Fluvio-glacial deposits over solid strata attributed to the Carboniferous Upper Coal Measures (Brithdir Member). The Fluvio-glacial deposits are a varied mixture, dominantly of sands and gravels with subordinate amounts of fine grained materials. The solid strata are dominantly argillaceous in nature, siltstone, mudstone, claystone,

with minor arenaceous deposits and coal. The coals in the sequence beneath the site are of economic grade and have historically been worked by underground extraction methods.

Due to the industrial history identified at the site, it is anticipated a portion of made ground is likely to underlie the site. The made ground is likely to have derived from the industrial heritage, mainly relating to coal winning activities.

2.4.2 Engineering Geology

Information from the British Geological Society (BGS) indicates the sites superficial deposits may be subject to frost susceptibility, however generally good foundation conditions prevail. The insitu strata engineering characterises range from weak to very strong dependent upon the weathering, thickness and type of strata. Weathering profiles are typically observed within 6m of the natural surface.

2.4.3 Available BGS Borehole Records/Previous Investigation

5no. boreholes are available within 100m of the site, summarised in Table 2 below;

Table 3: Review of Historical Borehole Information

Borehole	Name	Grid Ref	Depth (m)	Description
ST18NW3	Nantgarw Colliery South Pit	311965, 185726	783	Borehole log controlled by the national coal board
ST18NW4	Nantgarw Colliery North Pit	311947, 185762	763.2	Borehole log contained by the national coal board
ST18NW212	Nantgarw Colliery	312000, 185800	NA	Restricted access
ST18NW49	Cardiff-Llangurig Trunk Rd	312050, 185800	2.1	Gravel (made ground) overlying clay
ST18NW48	Cardiff-Llangurig Trunk Rd	312060, 185680	1.5	Gravel (made ground) overlying silt and gravels

Copies of the available borehole records are presented in Appendix D.

2.4.4 Hydrology

The nearest major surface water feature to the site is an unnamed Secondary River, approximately 75m to the east. The Water Framework Directive has no information on the river status. The unnamed River flows into the River Taff approximately 400m west of the site. The Environment Agency website (EA, 2015) indicates the hydromorphological status of the River Taff is heavily modified and is currently of moderate ecological quality.

The Groundsure Report indicates that there are no surface water abstractions within 250m of the site. From a review of topographical plans and flooding maps presented on the Environment Agency (EA) website (EA, 2015), the site is not indicated to be at risk from flooding.

2.4.5 Hydrogeology

Reference to the aquifer maps published on the Natural Resources Wales website (EA, 2015) indicates that the superficial deposits (Fluvio-glacial deposits) and the bedrock (Coal Measures) beneath the site are classed as Secondary A Aquifers. Groundwater movement within the Fluvio-glacial deposits will be controlled by intergranular flow, whilst in the bedrock, flow will be via a combination of fracture and intergranular flow.

Secondary A Aquifers generally correspond with the previously classified minor aquifers, and comprise permeable layers capable of supporting water at a local, rather than strategic, scale and in some cases form an important base flow to rivers. Secondary A Aquifers are sensitive to pollution.

The Groundsure report and the groundwater resource maps on the Natural Resources Wales website (EA, 2015) indicate that there are no groundwater abstractions or Source Protection Zones within 1km of the site.

It should be appreciated that in former mining areas, such as this, groundwater conditions may still be changing in response to the cessation or reduction in pumping from underground coal workings (see Section 2.7).

2.5 Environmental Setting

The site exists in a historically industrial, and now a commercial setting. Environmental data for the vicinity of the site has been obtained via a Groundsure Report, which is presented in Appendix B. The salient data is summarised in Table 4 below.

Table 4: Summary of Groundsure Data

Item	On the Site	In the Immediate Vicinity
Historical Industrial Sites.	22no. listed historical industrial sites including; 6no. colliery's, 6no. railway sidings, 2no. unspecified mines with additional unspecified works, unspecified levels and an unspecified heap.	17no. between 0 – 250m, 29no. between 51 – 250m and 67no. between 251 – 500m. The uses include disused canals, refuse heaps, tramway siding's, disused colliery, gravel pit, unspecified heap, slag heap, unspecified shafts, unspecified ground workings, unspecified tank, pottery, smithy, cuttings, old coal level, railway building, corn mill, unspecified commercial/industrial, old air shaft, unspecified disused shaft and an unspecified old shaft.
Historical Tanks.	1no. historical unspecified tank is listed in 1943	6no. between 51 – 250m and 53no. between 250m – 500m. historically indicated tanks and unspecified tanks are indicated

Potentially Infilled Land.	13no. listed potential infilled features including unspecified ground workings, unspecified heap, colliery, unspecified disused quarry, unspecified mine and unspecified level.	17no. between 0 – 250m, 15no. between 51 – 250m and 66no. between 251 – 500m. listed potential infilled features including unspecified ground workings, unspecified heap, colliery, unspecified disused quarry, unspecified mine, canal, refuse heap, disused canal, slag heap, pond, cuttings, unspecified level. Unspecified old level, unspecified disused tip, old air shaft and old shaft.
Landfill and other waste sites.	None identified.	None identified.
Current Industrial Sites.	None identified.	
Records of petrol and fuel sites.	None identified.	None identified.
Designated Environmentally sensitive sites.	None identified.	Records of Ancient Woodlands: • 5no. identified 51-250m from site. • 1no. identified 251-500m from site.
Industrial/Commercial Sites	25no. industrial uses indicated including; railway sidings, colliery, unspecified heap, disused canal, refuse heap, gravel pits	115.no. within 500m of the site boundary. Including; railway sidings, colliery, unspecified heaps, pottery, unspecified quarryies, disused canal, refuse heap, unspecified tanks, gravel pits and unspecified electricity stations.
Discharge Consents	None identified	4no. between 329m – 415m. All currently expired and or revoked.
Pollution Incidents	None identified	None identified
Waste Management Facilities	None identified	The Willowford Tip (1280m to the west). Inert waste facility.

2.6 Contact with Regulatory Bodies & Local Information Sources

ESP have made enquiries to various departments of the Local Authority (Rhondda Cynon Taf Council) to obtain local information on the environmental and geotechnical setting of the site.

2.6.1 Environmental Health/Contaminated Land/Pollution Control

An application for information relevant to the development of the site was made to the RCT Environmental Health department on the 16th of March 2015. At the time of writing, no response has been received. Any pertinent information received will be forwarded on receipt.

2.7 Anticipated Geotechnical Hazards

Table 5: Geotechnical Hazards

Ground Stability Hazard	Potential[1]	ESP Comment
Coal Mining	High	Discussed further in Section 2.7.1
Mining (non-coal)	No hazard	No further information identified to contradict Groundsure assessment.
Collapsible Ground	Very Low	No further information identified to contradict Groundsure assessment.
Compressible Ground	Negligible	No further information identified to contradict Groundsure assessment.

Ground Dissolution	Negligible	No further information identified to contradict Groundsure assessment.
Landslides	Low	No further information identified to contradict Groundsure assessment.
Running Sand	Low	No further information identified to contradict Groundsure assessment.
Shrinking or Swelling Clays	Very Low	No further information identified to contradict Groundsure assessment.

Notes:

1. Potential as reported in Groundsure report.

2.7.1 Past Mining

As discussed in Section 2.4.1, the site is underlain by bedrock of the Upper Coal Measures bedrock, which contains several seams of coal (and bands of ironstone). An unnamed seam is shown to outcrop approximately 30m south of the site, currently no data is available on the coal seam. Information available from the published geological map for the area of the site indicates the local strata dip between 24^0 and 32^0 towards the north. The potential impacts from underlying coal measures are discussed further in Section 4.0.

A mining report has been obtained from the Coal Authority and is presented in Appendix E. This indicates that based on the available Coal Authority records:

- The property is in the likely zone of influence from workings in 5 seams of coal at 360m to 1050m depth.
- These seams were last worked in 1961
- Any ground movement from these coal seams should have stopped by now.
- The property is not within the likely zone of influence of any present underground coal workings.
- There are no known coal mine entries within, or within 20m of the boundary of the site.

2.7.2 Site Stability

The Groundsure Report has indicated 13no. uses of potentially infilled land on the site. They include such uses as colliery, unspecified mine, unspecified level, unspecified ground workings and an unspecified heap. As such it is considered there is likely to be a significant portion of Made Ground on the site and the potential exists for stability issues associated with Made Ground. The client has indicated the potential for sub-surface railway tunnel beneath the current site.

The site is not in an area where it will be affected by post-glacial landslips or limestone solution. The superficial soils are classified as of predominantly low plasticity. It is considered unlikely for problems to arise due to shrink-swell clays.

2.7.3 Pyritic Ground

The Groundsure report does not consider the potential risk posed by sulphates or pyritic ground. The natural soils underlying the site are not anticipated to contain elevated levels of pyrite, which could oxidise to sulphates. However, the potentially thick layer of Made Ground anticipated beneath the site may also contain elevated levels of pyrite.

2.7.6 Geomorphology

The existing topography and geomorphology at the site has evolved over a period of many, perhaps sixty to seventy millions of years under a number of different erosional regimes. However, the original geomorphology of the area has been altered by man's activities, in particular the construction of the historical coal mine, industrial estate and embankment to the east of the site associated with the adjacent A470 duel carriageway.

2.8 Anticipated Site Contamination & Migration Pathways

2.8.1 Potential Contamination Sources

Based on the past and current use of the site, the following may prove sources of contamination which could impact on the development, environment or end users:

- Made Ground – general diffuse contamination;
- Past use of the site as a colliery – associated contaminants
- Identified Tank – point source of contamination
- Electricity sub-station – a point source of contamination (displayed in Insert 1)
- Demolition arisings – contain suspected asbestos containing materials (ACM).

The potential contaminants associated with the above potential sources have been identified from guidelines published by DEFRA and the Environment Agency and are listed below:

- heavy metals and semi-metals (arsenic, boron, cadmium, chromium, copper, lead, mercury, nickel, selenium, zinc);
- cyanide, sulphate, sulphide;
- polyaromatic hydrocarbon (PAH) compounds;
- phenols;
- polychlorinated biphenyls (PCBs) – from around the substation;
- asbestos.

2.8.2 Potential Sources of Hazardous Ground Gas

Based on the available information, the following may prove potential sources of hazardous ground gas on or close to the site:

- Potentially significant thickness of Made Ground including arisings from the adjacent mine shaft;

Based on the guidelines presented by Wilson et al (2009), the above potential gas sources would generally be classified as of low/moderate gas generation potential and the level of risk for an on-site development will therefore be low to moderate.

The BRE Report BR211 (2007) classifies the risk from radon, based on the underlying geology. Radon is a colourless, odourless, radioactive gas, which can pose a risk to human health. It originates where uranium and radium are naturally present in the bedrock and can move through fractures in the bedrock and overlying superficial deposits to collect in spaces in structures.

The Groundsure report identifies that the site lies in an area where less than 1% of homes are above the action level for radon. Therefore no radon protection measures are required.

2.8.3 Potential Receptors

As discussed in Section 1.1, the proposed site development will comprise commercial premises with some minor landscaping. The site is located some 400m from the River Taff above a Secondary A Aquifer.

The most vulnerable receptors with regards to any contamination or hazardous ground gas present are considered to be:

- Future employees, the critical receptors being employees outside during their break periods;
- Construction and maintenance workers;
- The adjacent unnamed Secondary River and River Taff;
- The groundwater within the Upper Coal Measures strata, which is classified as a Secondary A Aquifer.

2.8.4 Potential Migration Pathways

A cover of made ground is anticipated across the site due to its prior use. Further to this the adjacent commercial plots are located in a historically highly mined area and may prove potential sources of hazardous ground gas on or close to the site. The following are considered the most likely pathways with regard to any contamination present beneath the site.

Employees:

- Ingestion of soils and inhalation of dust in outside areas.
- Dermal contact with contaminated soils.
- Potential explosive risk from flammable ground gas.
- Potential exposure to toxic ground gas.

Construction and maintenance workers:

- Ingestion of soils and inhalation of dust across site.
- Dermal contact with contaminated soils.

Groundwater:

- Leaching of mobile contaminants into the permeable horizons within the bedrock.

Buildings:

- Sulphate attack on buried concrete.
- Potential explosive risk from flammable ground gas.

2.9 Preliminary Risk Evaluation & Plausible Pollutant Linkages

The land use history of the site and surrounding area, as established from the desk study and walkover, has identified a number of potential contamination linkages due to ground conditions or former operations either on, adjacent to, or in the vicinity of the site. Note that these potential linkages will need to be later assessed and re-established using actual site data obtained from an exploratory investigation.

2.9.1 Introduction to Risk Evaluation Methodology

The methodology set out in CIRIA C552 (2001), *Contaminated Land Risk Assessment – A guide to Good Practice*, has been used to assess whether or not risks are acceptable, and to determine the need for collating further information or remedial action.

Whilst at a later stage, this methodology may be informed by quantitative data (such as laboratory test results) the assessment is a qualitative method of interpreting findings to date and evaluating risk. The methodology requires the classification of:

- The magnitude of the potential consequence (severity) of risk occurring (defined below);
- The magnitude of the probability (likelihood) of risk occurring (defined below).

Table 6: Classification of Consequence

Classification	Definition	Examples
Severe	• Short-term (acute) risk to human health likely to result in *Significant Harm*. • Short-term risk of pollution to a sensitive water resource. • Catastrophic damage to buildings/property. • Short-term risk to ecosystem, or organism forming part of that ecosystem.	• High concentrations of Cyanide at surface of informal recreation area. • Major spillage of contaminants from site into controlled water. • Explosion causing building collapse.
Medium	• Chronic damage to human health. • Pollution of sensitive water resource. • A significant change to ecosystem, or organism forming part of that ecosystem.	• Contaminant concentrations exceed assessment criteria. • Leaching of contaminants to Secondary aquifer. • Death of species within nature reserve.
Mild	• Pollution of non-sensitive water resources. • Significant damage to crops, buildings, structures. • Damage to sensitive buildings, structures or the environment.	• Pollution of Secondary groundwater sources. • Damage to building rendering it unsafe to occupy.

Minor	• Harm, although not necessarily significant harm, which may result in financial loss, or expenditure to resolve. • Non permanent risks to human health (easily prevented by means of PPE). • Easily repairable effects of damage to buildings and structures.	• The presence of contaminants at such concentrations that PPE is required during site works. • The loss of plants in a landscaping scheme. • Discoloration of concrete.

Table 7: Classification of Probability

Classification	Definition
High Likelihood	There is a pollutant linkage and an event that either appears very likely in the short term and almost inevitable over the longer term. Or, there is already evidence at the receptor of harm or pollution.
Likely	There is a pollution linkage and all the elements are present and in the right place, which means that it is probable that an event will occur. Circumstances are such that an event is not inevitable, but possible in the short term and likely over the longer term.
Low Likelihood	There is a pollutant linkage and circumstances are possible under which an event could occur. However, it is by no means certain that even over a longer period such an event would take place, and is less likely in the shorter term.
Unlikely	There is a pollutant linkage, but circumstances are such that it is improbable that an event would occur, even in the very long term.

The classifications defined above are then compared to indicate the risk presented by each pollutant linkage, allowing evaluation of a risk category.

Table 8: Risk Categories – Comparison of consequence against probability

		Consequence			
		Severe	**Medium**	**Mild**	**Minor**
Probability	**High Likelihood**	Very High Risk	High Risk	Moderate Risk	Moderate / Low Risk
	Likely	High Risk	Moderate Risk	Moderate / Low Risk	Low Risk
	Low Likelihood	Moderate Risk	Moderate / Low Risk	Low Risk	Very Low Risk
	Unlikely	Moderate / Low Risk	Low Risk	Very Low Risk	Very Low Risk

Table 9: Description of Risk Categories

Classification	Description
Very High Risk	• There is a probability that severe harm could arise to a designated receptor from an identified hazard. Or, there is evidence that severe harm to a designated receptor is currently happening. • The risk, if realised, is likely to result in a substantial liability. • Urgent investigation (if not already undertaken) and remedial action are likely to be required.
High Risk	• Harm is likely to arise to a designated receptor from an identified hazard. • Realisation of the risk is likely to present a substantial liability. • Urgent investigation (if not already undertaken) is required, and remedial action may be necessary in the short term and are likely over the longer term.
Moderate Risk	• 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 mild. • Investigation (if not already undertaken) is normally required to clarify the risk and to determine potential liability. Some remedial action may be required in the longer term.
Low Risk	• 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.
Very Low Risk	• There is a very low possibility that harm could arise at a receptor. In the event of such harm being realised, it is not likely to be severe.

The methodology described above has been used to establish Plausible Pollutant Linkages and to evaluate the risks posed by those linkages, using information known about the site, at this stage.

2.9.2 Tabulated Preliminary Risk Evaluation & Plausible Pollutant Linkages

Table 10: Preliminary Risk Evaluation & Plausible Pollutant Linkages (PPL).

Source	Pathway	Receptor	Classification of Consequence	Classification of Probability	Risk Category	Further Investigation or Remedial Action to be Taken
Potential contaminants in Made Ground	Direct contact/ inhalation/ ingestion of contaminated soil or dust	Site Users (employees)	Medium – potential for chronic levels.	Low likelihood[1]	Moderate/Low Risk	Sampling of near-surface soils to confirm levels of contamination present.
	Direct contact/ inhalation/ ingestion of contaminated soil or dust	Construction/ Maintenance Workers	Minor – standard PPE likely to be sufficient	High likelihood[1]	Moderate/Low Risk	
	Leaching of soil contaminants	Impact on Groundwater	Medium – site lies on Secondary A Aquifer	Likely[1]	Moderate Risk	
	Leaching of soil contaminants	Impact on Secondary River River Taff	Medium – site lies adjacent to river (75m)	Likely[1]	Moderate Risk	
Soil sulphate	Aggressive groundwater	Buried Concrete	Mild – damage to structures	High likelihood[2]	Moderate Risk	Sampling of soils to confirm levels of sulphate and pH.
Asbestos in Made Ground	Ingestion of fibres	Demolition/ Construction Workers	Medium – potential for chronic levels	High Likelihood[3].	High Risk	Sampling of soils to confirm presence of asbestos.
Ground gas generated by Made Ground and infilled land on site.	Asphyxiation/poisoning. Injury due to explosion.	Site Users/Visitors.	Severe – acute risk.	High Likelihood – Significant covering of Made Ground and historical infilled land identified at the site.	Very High Risk	Potential for significant Made Ground and infilled comprising unknown materials. Further investigation required.
	Damage through explosion.	Building/Property	Severe – acute risk.			
	Asphyxiation/poisoning. Injury due to explosion.	Construction and Maintenance Workers.	Severe – acute risk.			
Radon Gas	Migration into Buildings	Site Users (residents)	Medium – potential for chronic levels	Unlikely[4]	Low Risk	No radon protection measured required. See Section 2.8.2.

Notes:

1. The presence of contamination has not yet been confirmed on site.
2. The probable Made Ground at the site has the potential for high sulphate levels.
3. Due to the likelihood of significant Made Ground, it is likely that historical asbestos containing materials (ACM) will be present.
4. Radon risk identified in Sitecheck report – see Section 2.8.2.
5. The above risk evaluation is updated following the intrusive investigation and testing in Table 13 in Section 5.2.

3.0 EXPLORATORY INVESTIGATION

An exploratory investigation was undertaken between the 10th and 13th of February 2015 during warm overcast conditions. The ESP inspection was undertaken by a Project Engineer with the site being accessed from the adjacent road. The aim of the inspection was to complete a site walkover to clarify the desk study, construct trial pits, trenches and acquire samples for laboratory testing. An additional aim of the investigation was to locate a potential sub-surface tunnel beneath the site.

The field investigation comprised extensive trenches logged at 17no. locations. The exploratory holes were supervised and logged by an Engineering Geologist in accordance with BS5930:2010. Descriptions and depths of the strata encountered are presented on the exploratory hole records in Appendix F. The exploratory hole and trench positions are shown on Figure 3. The coordinates shown on the exploratory hole records are approximate only and have been interpolated from the recent Ordnance Survey maps.

3.1 Exploratory Holes

No specific point sources of contamination have been identified on the site with the exclusion of the structures identified within the historical review on the west portion of the site. The exploratory investigation was spread across the site in order to provide both a general overview of the site and to assist in the identification of the potential sub-surface railway tunnel as indicated by the client. The excavation methodology was to construct trenches across the site to intersect sub-surface structures and varying ground conditions.

Trial pits and trenches have been chosen as the primary investigation technique as this provides the quickest most effective manner in which to expose near surface subsurface conditions. In order to complete the investigatory works in the unknown ground conditions a 13 Tonne machine was selected for the investigatory works. During the investigation frequent obstructions (concrete slabs with reinforcement-bar) were encountered restricting the depth of excavation as specified within the Trial Pit Logs.

3.2 Trial Pits

17no. trial pits (TP1a to TP11) were excavated across the site using a tracked hydraulic excavator. The trial pits were excavated to a maximum depth of 4.5m. Disturbed samples were collected from the trial pits for laboratory testing. On completion, the trial pits were backfilled with arisings in layers compacted with the excavator bucket. The arisings were left slightly proud of the adjacent surface to allow for future settlement. No man entry into the pits was undertaken.

The trial pit records are presented in Appendix F.

3.3 Sampling Strategy

3.3.1 Soil Sampling

Sampling was undertaken on a targeted and stratified soil sampling strategy to provide a holistic representation of the ground medium. Samples were taken from each trial pit within the pervasive soil horizons. Sample collection depths are shown within the trial pit logs (Appendix F).

The sampling procedures were selected on the basis of the suitability for the laboratory testing proposed. Disturbed samples recovered from trial pits are classified as Class 3 (suitable for classification, moisture content and chemical analysis) provided that they are sealed on collection. Soil samples taken for analysis were collected in suitable clean sealed tubs and bags provided by the testing laboratory (e.g. clean polyethylene jars with fitted lids for routine soil testing, clear or amber glass containers with screw on air-tight caps for organic contaminants, glass vials for volatile contaminants, etc.). Immediately after collection the samples were placed in sealed cool boxes where they remained during storage and transport to the laboratory.

3.4 Evidence of Site Hazards Found During Site Works

With regard to potential hazards identified in Section 2.8.1, the following observations were made. A significant portion of Made Ground consisting of colliery discard and steel reinforced concrete slabs, foundations, brick fragments, whole bricks, concrete, rebar, car parts and plastic was observed. In addition to the colliery discard evidence of other inert discard including window frames and car parts were observed within the Trial Pits.

3.4.1 Site Stability

Significant quantities of Made Ground consisting of coarse soils with inclusions of demolition rubble discussed above have been encountered. As a result spalling was noted within coarse grained soils from depths of 1.5m. No evidence of sub-surface infrastructure attributable to a tunnel was identified however evidence of an infilled basement was found in the south west portion of the site, discussed in section 4.4. Multiple concrete structures were observed at varying depth. The distribution of observed structures is discussed further in Section 4.4.

3.4.2 Site Evidence of Contamination

No direct visual/olfactory evidence of contamination was identified in the exploratory holes. However, significant Made Ground was identified across the site from surface level to a maximum excavation depth of 4.5m, which can contain elevated levels of contaminants such as metals and polyaromatic hydrocarbon (PAH) compounds. During the investigation a slight organic (possible hydrocarbon) odour was noted in the central portion of the site during excavation activities,

however no point sources were identified. Trial pitting in the south west section of the site where the historical tank was identified in the Groundsure Report resulted in no evidence of a tank structure.

3.5 Geotechnical Laboratory Testing

Geotechnical laboratory testing was undertaken on samples from the suitable quality classes recovered from the exploratory holes in order to obtain information on the geotechnical properties on the soils beneath the site.

Due to the potential presence of pyrite, these samples were analysed to determine the levels of total sulphur and acid soluble sulphate in accordance with the analytical methods specified in BRE Special Digest 1 (BRE, 2005).

The results of the sulphate testing are included with the geo-environmental test results in Appendix G.

3.6 Geo-environmental Laboratory Testing

Laboratory testing has been undertaken to identify the levels of selected contaminants within samples of soil and leachate generated from shallow soils, The geo-environmental analyses were carried out by a UKAS accredited testing laboratory with detection limits being generally compatible with the relevant guideline values adopted in the assessment (see Section 2).

3.6.1 Soil Samples

To allow an assessment of the potential chronic risks posed to human health, a total of 8no. selected samples of the near-surface Made Ground have been analysed for the contaminants identified in Section 2.8.1, plus other determinands typically present on brownfield sites in the UK.

The suite of geo-environmental laboratory testing undertaken comprised:

- Arsenic, cadmium, total chromium, chromium VI, copper, lead, mercury, nickel, selenium, zinc;
- US EPA 16 polyaromatic hydrocarbon (PAH) compounds;
- Total monohydric phenols;
- Total cyanide, pH value, asbestos screen, soil organic content;

The soil test results are presented in Appendix G.

4.0 DEVELOPMENT OF THE CONCEPTUAL MODEL

4.1 Geology

The exploratory holes have identified the site to be underlain by Made Ground. Variability is observed within the Made Ground and is discussed in more detail in the following sections. The Made Ground has been identified to a maximum depth of 4.5m. Typically the excavations have been terminated prior to this due to steel reinforced concrete obstructions.

Information from previous investigations (ESP 2003) has indicated a borehole (BH2) within the immediate vicinity of the site has been 'terminated' at a maximum depth of 3.8m due to an obstruction. 3no. subsequent attempts have been made at the hole with obstructions restricting drill string penetration. An adjacent borehole (BH101) has encountered Made Ground to a depth of 2.8m, subsequently followed by Fluvioglacial Deposits to a depth of 11.6m into underlying Upper Coal Measures (hole terminated at 12m).

Made Ground: Encountered in all Trial Pits and Trenches. The Made Ground typically consists of brown to black Gravels underlain by gravelly Clays. Within the gravel matrix brick fragments, whole bricks, concrete, rebar, car parts and plastic have been recovered. The composition of Made Ground is variable but generally is a mixture of demolition rubble and general colliery discard. Significant obstructions were encountered within the Made Ground likely representing rubble or in-situ buried steel reinforced concrete foundations.

A higher inclusion of steel rebar and concrete fragments was observed along the sites west boundary of the site where a significant portion of building debris was observed.

Fluvioglacial Deposits: not encountered in the investigation but anticipated to be present at depths of around 4-5m consisting of very dense brown sand sub-rounded to rounded Gravels.

Upper Coal Measures Bedrock: not encountered in the investigation but anticipated to be present at depths in excess of 10m consisting of strong grey Sandstones with occasional coal seams.

4.2 Hydrogeology

4.2.1 Groundwater Bodies

The investigation identified ponded groundwater above the concrete slab in TP2d, however it is thought this is a perched water table due to the slab structure. The exploratory holes were completed and backfilled within one working day. Due to the low permeability soils, it is possible that groundwater may be present within the depth of investigation, but there was insufficient time for it to be recorded.

4.2.2 Hydraulic Gradient

No monitoring of long-term groundwater levels has been undertaken at the site to date. However, based on the site setting and available information, we consider that the hydraulic gradient beneath the site is likely to be towards the River Taff and to the south.

4.3 Site Stability

4.3.1 Mining Hazard

Although the site is underlain by Coal Measures bedrock, no investigation for underground workings has been undertaken. Information supplied by the Coal Authority has indicated the site is unlikely to experience any subsidence from underlying historical workings (>300m depth).

A conceptual cross section utilising information from the published geological map for the area is presented in Figure 4. The schematic section suggests the unnamed seam discussed in Section 2.7 is anticipated approximately 14m below the site on the south boundary and approximately 37m on the north boundary.

4.3.2 Other Stability Issues

During the excavation of some trial pits, instability was observed resulting in the collapse of the pit walls. The more severe spalling was observed in the coarse fractions of the soils, particularly where large slabs of concrete were excavated. In some cases this was due to peeling off of material from subsurface walls and concrete slabs. Unravelling of the cobbles from depths of around 1.5m was observed. The collapsing of pit sidewalls resulted in difficulty when attempting to expose solid sub-surface structures (i.e. the 3m concrete structure).

4.4 Sub Surface Model

An approximate ground model has been devised through excavation and discovery of the subsurface structures. The findings of the intrusive investigation are discussed below.

4.4.1 Sub Surface Structures

Multiple steel reinforced concrete slabs and foundations have been observed at varying depths during the excavation and their extents and depths are shown in Figure 5. It must be noted the

lateral extent of the slab indicated on the east of the site has not been proved. Typically all slabs exposed within 1m of surface level are approximately 0.6m thick, see Insert 3. An additional concrete surface is approximately 3m below surface level and is located in the south west quadrant of the site, see Insert 4. This is bounded by a concrete wall (to the west) extending to within 0.4m of the surface aligned roughly north south.

The concrete structures have a significant portion of steel rebar included within the slabs as shown in Insert 3, however this observation was not pervasive to the east of the site. Multiple brick walls have been encountered, however investigation indicated several as not being in situ and therefore these have not been plotted.

Insert 3: 2no. Subsurface Slabs with re-bar. Image taken looking South over TP1c

Insert 4: Subsurface concrete slab observed striking north south at 3m depth (Tp2d)

4.4.2 Sub Surface Model

The historic footprint of the structures has been superimposed upon the exposed concrete slabs and brick walls. The overlay is shown in Figure 6 and shows a correlation between the historic building footprints and the identified slabs. This is principally relevant in two locations; where the concrete wall uncovered strikes parallel to the 1958-1974 building footprint and the oval concrete pad observed in the west of the site. The concrete wall uncovered is shown in Insert 5.

Insert 5: Subsurface concrete wall observed adjacent to 3m deep concrete slab striking roughly north south in the centre of the site. Note. The Made Ground has peeled from the wall.

The concrete slab may represent a basement floor however further investigation is required to determine the conditions below the concrete. There is no significant evidence for any basement structures associated with structures in place between 1920 and 1943.

4.5 Soil Contamination

4.5.1 Methodology

The long term risks to health have been assessed using methodologies and frameworks determined by the Environment Agency within documents SR2, SR3, SR4 and the CLEA Technical Review published to support the Contaminated Land Exposure Assessment Model (CLEA). Where applicable, reference has been made to the supporting Toxicological reports (TOX Series) and the Soil Guideline Value reports (SGV Series). It is assumed that the reader is familiar with the above documents and it is not intended to repeat these described methodologies in detail, for further information, please refer directly to the specific documents.

In order to provide an initial 'screen' to identify elevated levels of contaminants, a Generic Quantitative Risk Assessment (GQRA) has been undertaken using the most appropriate Generic Assessment Criteria (GAC) determined by assessment of exposure frequency/duration relevant to the critical receptor.

4.5.2 Assessment Criteria

Where available, the Soil Guideline Values (SGV) published by the Environment Agency have been adopted as the Generic Assessment Criteria (GAC). However, SGV are only available for a limited number of contaminants for three proposed land uses (residential, commercial and allotments). Where no SGV is available, GAC published by the Chartered Institute of Environmental Health (CIEH) and Land Quality Management (LQM) have been adopted. For more exotic, predominantly organic, compounds neither SGV nor CIEH/LQM assessment criteria have been published. In this instance, GAC published by CL:AIRE have been adopted. Details of the source of the GAC adopted for each contaminant are presented on the assessment table below.

The GAC published by CIEH/LQM and CL:AIRE have been developed using the CLEA UK software for the land use scenarios outlined in the CLR documents.

The proposed development comprises office facilities and commercial premises, with external hardstanding and landscaping. Therefore, the GAC appropriate for the commercial land use have been adopted in this assessment.

The GAC for most organic compounds are dependent on the organic content of the soil. Analysis has shown that the soil organic content in the soils analysed ranged from 3 to 14%. Therefore, for the purposes of this assessment, GAC for a soil organic content of 1% has been adopted. This again is considered a conservative approach for the majority of the soils at the site.

4.5.3 Generic Quantitative Risk Assessment

The results of the Generic Quantitative Risk Assessment are presented in Table 10 below.

Table 11: Summary of Geo-environmental Soil Results

Determinand	Range Recorded	GAC	Source of GAC	Exceedances
Metals and Semi-metals				
Arsenic	5.8 – 13 mg/kg	640mg/kg	SGV[2]	None
Beryllium	0.3 – 0.9 mg/kg	12mg/kg	S4UL[3]	None
Cadmium	0.4 – 1.2 mg/kg	230mg/kg	SGV[2]	None
Chromium (total)[1]	8.9 – 21 mg/kg	8,600mg/kg	S4UL[3]	None
Chromium (hexavalent)	< 1 mg/kg	33mg/kg	S4UL[3]	None
Copper	15 – 73 mg/kg	68,000mg/kg	S4UL[3]	None
Lead	24 – 600 mg/kg	200mg/kg	C4SL[5]	None
Mercury[2]	0.08 – 0.84 mg/kg	3,600mg/kg	SGV[2]	None
Nickel	12 – 34 mg/kg	1,800mg/kg	SGV[2]	None
Selenium	<0.5 – 1 mg/kg	13,000mg/kg	SGV[2]	None
Zinc	64 - 200 mg/kg	730,000mg/kg	S4UL[3]	None
Polyaromatic Hydrocarbons (PAH)				
Acenaphthene	<0.1 – 0.5 mg/kg	84,000mg/kg*	S4UL[3,7]	None
Acenaphthylene	<0.1 – 0.5 mg/kg	83,000mg/kg*		None
Anthracene	< 0.1 – 0.1 mg/kg	520,000mg/kg		None
Benzo(a)anthracene	<0.1 – 0.9 mg/kg	170mg/kg		None
Benzo(a)pyrene	<0.1 – 0.5 mg/kg	35mg/kg		None
Benzo(b)fluoranthene	<0.1 – 0.5 mg/kg	44mg/kg		None
Benzo(ghi)perylene	<0.1 – 0.8 mg/kg	3,900mg/kg		None

Benzo(k)fluoranthene	<0.1 – 0.9 mg/kg	1,200mg/kg		None
Chrysene	<0.1 – 1 mg/kg	350mg/kg		None
Dibenzo(a,h)anthracene	<0.1 – 0.9 mg/kg	3.5mg/kg		None
Fluoranthene	<0.1 – 1 mg/kg	23,000mg/kg		None
Fluorene	<0.1 – 1.3 mg/kg	63,000mg/kg*		None
Indeno(123-cd)pyrene	<0.1 – 1 mg/kg	500mg/kg		None
Naphthalene	<0.4 – 1.1 mg/kg	190mg/kg*		None
Phenanthrene	<0.4 – 1.1 mg/kg	22,000mg/kg		None
Pyrene	<0.1 – 0.8 mg/kg	54,000mg/kg		None
Other Organic Compounds				
Phenol	<0.3 – 0.4 mg/kg	760mg/kg	S4UL[3,7]	None
Misc.				
Asbestos[6]	**Asbestos (Amosite Chrysotile) identified in 4no. Trial Pits**			

Notes to Table 11:

1. In the absence of Chromium VI, all chromium present likely to be Chromium III. GAC for Chromium III adopted.
2. GAC for inorganic mercury adopted.
3. GAC for organic compounds based on 1% soil organic content.
4. CL:AIRE/EIC GAC published by CL:AIRE and Environment Industries Commission.
5. ESP - Generic Assessment Criteria generated by ESP using CLEA software.
6. No assessment criteria available for asbestos.
7. Exceedances highlighted in red and bold.
8. Laboratory results presented in Appendix G

* GAC exceeds solubility or vapour saturation limit.

From Table 10, all the determinands analysed were below their respective GAC. However Asbestos has been identified in 4no. Trial Pits. The summary information is shown below and the positions of the Trial Pits are indicated on Figure 3;

Table 12: Summary of Asbestos positive results

Trial Pit	Depth	Result	Comments
TP1b	0.5	Amosite Chrysotile	Amosite & Chrysotile present as small cement fragment & fibre bundles
TP2a	1.2	Amosite	Amosite present as fibre bundles
TP4	0.4	Chrysotile	Chrysotile present as small clump and fibre bundles
TP9	0.5	Amosite	Amosite present as fibre bundles

5.0 CONTAMINATION RISK EVALUATION AND RELEVANT POLLUTANT LINKAGES

5.1 Discussion on Occurrence of Contamination and Distribution

Review of all the available information indicates the site has been historically used for colliery works. This has resulted in multiple structures being erected including the construction of railways associated with coal transport. All historic buildings have been demolished and removed and subsequently replaced by the currently observed adjacent commercial premises. With the latest phase of construction works a sub-station has been identified, however this is not indicated on the Groundsure Report suggesting it is a smaller local user network station.

Previous investigations over the Nantgarw industrial estate have identified elevated levels of Polyaromatic Hydrocarbons (PAH) in comparison to the values observed from the site specific testing. However, the historical elevated values reside well within the GAC implemented within this assessment (Table 11). Laboratory testing indicating no instances where contaminants exceed recommended guideline values within the soils.

During the recent investigation no definitive visual and olfactory evidence of hydrocarbon contamination was noted in the area, however a multitude of demolition rubble and household waste was observed. Faint odours were also noted when excavating in the central area of the site however determining the location of the odour was unsuccessful.

Amosite and chrysotile asbestos was identified in TP1B at 0.5m depth (as a small cement fragment and fibre bundle) and chrysotile asbestos was identified in TP4 at 0.4m depth (as a small clump). Amosite (fibre bundles) were identified in TP2a at 1.2m.

A risk has been identified pertaining to polychlorinated biphenyls (PCBs) and Petroleum Hydrocarbons through desk study information. However no testing for contamination, principally due to the limited scope of this preliminary study, which was primarily undertaken to investigate and determine the extent of the subsurface structure known to be present. Further testing for PCB's is recommended.

As such it may be stated the investigation undertaken at the stated time with the conditions described suggests contamination issues pertaining to Asbestos. Land clearance requirements pose a potential contamination risk and may require re-evaluation to define the impact on the site.

5.2 Revised Risk Evaluation & Relevant Pollutant Linkages

As discussed in detail within Section 2.0, the methodology set out in CIRIA C552 (2001), *Contaminated Land Risk Assessment – A guide to Good Practice*, has been used to assess whether or not risks are acceptable, and to determine the need for collating further information or remedial action.

The risks evaluated at the desk study stage of this report (Section 2.0) have been updated and revised following information learned from the exploratory works and results of laboratory testing.

Table 13: Preliminary Risk Evaluation & Plausible Pollutant Linkages (PPL).

Source	Pathway	Receptor	Classification of Consequence	Classification of Probability	Risk Category	Further Investigation or Remedial Action to be Taken
Potential contaminants in Made Ground	Direct contact/ inhalation/ ingestion of contaminated soil or dust	Site Users (employees)	Medium – potential for chronic levels.	Low likelihood[1]	Moderate/Low Risk	Laboratory testing of near surface soils identified low levels of contamination across the site. This is discussed further in Sections 6.1.2 and 6.1.4.
	Direct contact/ inhalation/ ingestion of contaminated soil or dust	Construction/ Maintenance Workers	Minor – standard PPE likely to be sufficient	Low likelihood[1]	Very Low Risk	
	Leaching of soil contaminants	Impact on Groundwater	Medium – site lies on Secondary A Aquifer	Low likelihood[1]	Moderate/Low Risk	
	Leaching of soil contaminants	Impact on Secondary River River Taff	Medium – site lies adjacent to river (75m)	Low likelihood[1]	Moderate/Low Risk	
Soil sulphate	Aggressive groundwater	Buried Concrete	Mild – damage to structures	High likelihood[2]	Moderate Risk	Laboratory testing identified potentially high levels of sulphate within the Made Ground. This is discussed further in Section 6.4.2.
Asbestos in Made Ground	Ingestion of fibres	Demolition/ Construction Workers	Medium – potential for chronic levels	High Likelihood[3].	High Risk	Laboratory testing identified asbestos (crysotile and amosite) in50% of samples tested. This is discussed further in Section 6.1.1.
Ground gas generated by Made Ground and infilled land on site.	Asphyxiation/poisoning. Injury due to explosion.	Site Users/Visitors.	Severe – acute risk.	High Likelihood – Significant covering of Made Ground and historical infilled land identified at the site.	Very High Risk	Significant Made Ground identified across the site. This is discussed further in Section 6.3
	Damage through explosion.	Building/Property	Severe – acute risk.			
	Asphyxiation/poisoning. Injury due to explosion.	Construction and Maintenance Workers.	Severe – acute risk.			
Radon Gas	Migration into Buildings	Site Users (residents)	Medium – potential for chronic levels	Unlikely[4]	Low Risk	No radon protection measured required. See Section 2.8.2.

Notes:

1. The presence of contamination has not yet been confirmed on site.
2. The probable Made Ground at the site has the potential for high sulphate levels.
3. Due to the likelihood of significant Made Ground, it is likely that historical asbestos containing materials (ACM) will be present.
4. Radon risk identified in Sitecheck report – see Section 2.8.2.
5. The above risk evaluation is updated following the intrusive investigation and testing in Table 13 in Section 5.2.

6.0 REMEDIAL STRATEGY FOR CONTAMINATION RISKS

The following recommendations are based on interpretations made from the relatively limited site investigation data obtained to-date. If at any stage of the construction works, contamination or a potential for such contamination is identified that is different to that presented within this report, all of the following should be reviewed and the advice of a Geoenvironmental Specialist sought immediately.

At present, the site could incur potentially significant liabilities under UK law, with respect to the contamination identified (Asbestos). These are controlled by planning legislation where further risk assessment and remediation are likely to be required to allow development to proceed.

Further investigation and remedial action is also required to detect and define the potential hydrocarbons and ground gasses. The recommended further works are discussed further in Section 8.0.

6.1 Risks to Health

6.1.1 Asbestos

Amosite and chrysotile asbestos was identified in the Made Ground in TP1B at 0.5m depth (as a small cement fragment and fibre bundle) and chrysotile asbestos was identified in TP4 at 0.4m depth (as a small clump). Amosite (fibre bundles) were identified in TP2a at 1.2m.

The asbestos will pose a potential risk to construction workers and the nearby general public during any site clearance works. A potential risk may also be posed to site end users due to its confirmed presence within the soils, however this may be mitigated by the recommended capping layer (see Section 6.1.2).

We recommend that the advice of an appropriately qualified asbestos specialist should be sought. Further specialist sampling and testing to delineate the area impacted may be required prior to the clearance works. Testing may also be required subsequent to the undertaking of the works to validate that no on-going risk is proposed to end users.

The following sections assume that the asbestos risk will be successfully mitigated.

6.1.2 Site End Users

Assuming an end use of commercial land, the levels of contamination (excluding Asbestos) at the site are not considered to pose a risk to future site users. However, due to the nature of the material present at the site, we cannot rule out the potential for isolated areas of contamination. In addition, organic, potentially hydrocarbon, odours were noted (as discussed in Section 3.4.2), although no specific source was identified in the desk study or intrusive investigation. We recommend that supplementary testing of the Made Ground at the site should be undertaken to

further assess the potential risk from Asbestos and also include analysis of the soils for TPH and PCB's.

If a cover system is preferred at this stage, 600mm of suitable material could be introduced to the non-hardstanding areas as a cover system together with a suitable geotextile layer placed at the base of the imported material. In areas of hardstanding the pollutant linkage will be further broken by the concrete/tarmac surfaces; however a 600mm cover of sub-base/granular fill is still likely to be required to protect against future changes in site layout. The sourcing, transportation and placement of the capping layer should be designed, supervised, and validated by an appropriate geoenvironmental specialist.

6.1.3 New Service Connections

The current water industry guidance for the suitability of pipe materials on potentially contaminated sites (Blackmore et al, 2010) has extremely onerous requirements and it is likely, based on this guidance, that the levels of contaminants on site may prevent the use of plastic pipework. We recommend that enquiries are made to the local water authority to confirm their requirements for underground service materials for this development.

6.1.4 Risk to Construction and Maintenance Workers

Provided the risks associated with the asbestos in the Made Ground are mitigated (see Section 6.1.1 above), the resulting risks to construction and maintenance workers from the remaining levels of contamination at the site are likely to be acceptable.

Notwithstanding the above, we recommend that construction workers adopt careful handling of the potential contaminants and good standards of personal hygiene should be adopted to reduce the risk of possible ingestion and skin contact should any hotspots be encountered. The contractor should comply with the appropriate current Health and Safety at work legislation. The recommendations contained within the Health and Safety Executive Document: Protection of Workers and the General Public During the Development of contaminated Land should be implemented.

6.1.5 General Public

As above, provided the risks associated with the asbestos present within the Made Ground are mitigated, particularly given the close proximity of a public pathway and nearby residences to the site, we do not anticipate any significant risks to the general public from the development of the site. Careful dust control measures should be adopted during construction to minimise the risk to the general public.

6.2 Risks to Controlled Waters

The following considerations are pertinent:

- Significant historic contaminative former uses has been identified at the site and include a colliery and associated railway land;
- Made Ground was identified in all of the trial pits at the site up to a maximum depth of 4.5m. Man-made materials such as slag, ash, brick and glass fragments were common;
- Potential olfactory evidence of hydrocarbon contamination was noted in the soils beneath the central portion of the site;
- The nearest major surface water feature to the site is an Secondary River located approximately 75m to the east;
- The site is situated on a shallow Secondary A Aquifer and deeper Secondary A Aquifers.

At this time laboratory results indicate acceptable levels of contamination posing no risk to controlled waters. However with the above considerations and lack of testing for Hydrocarbons and PCB's it is advised additional testing is implemented to provide a holistic assessment to the risks posed.

If at any stage of the clearance works, contamination or a potential for such contamination is identified that is different to that presented within this report, the controlled waters risk should be reviewed and the advice of a Geoenvironmental Specialist sought immediately.

6.3 Risks from Ground Gas

6.3.1 Risk to the Development – Degradation of Organic Material

A preliminary risk assessment and site characterisation has been carried out in relation to a source, pathway and target methodology. The likelihood and severity of an event is considered as part of the risk assessment process and in accordance with C665 (Wilson et al, 2007).

Historical infilling at the site may have contained organic materials and a slight organic odour was identified during the trial pitting. If at any stage of the clearance works, strong visual or olfactory evidence of organic materials are identified that are different to that presented within this report, the advice of a Geoenvironmental Specialist sought immediately.

6.3.2 Risk to the Development – Made Ground

It is understood the adjacent existing building has been protected from ground gas migration with the installation of a geo-membrane under the ground bearing floor slab.

A significant amount of Made Ground was encountered during the site works. Made Ground has the potential for generation of ground gasses, most notably Carbon Dioxide. We recommend that monitoring wells are installed at the site and a gas monitoring regime is undertaken in order to establish the levels of Ground Gas at the site and assess the risk to the construction workers and site end users.

6.3.3 Risk to the Development – Radon

The site lies in an area identified by the BRE as less than 1% of properties are above the action level from radon. No further precautions are required to mitigate the risk.

6.3.4 Risk to Construction and Maintenance Workers

Made Ground could pose a risk to construction workers due to the generation of ground gasses. Subsequently this could result to asphyxiation in confined spaces. All deep excavations should therefore be treated as confined spaces and suitable precautions taken prior to man entry until further analysis is completed.

Carbon dioxide is a particular risk in Made Ground materials as it is commonly present and as it is heavier than air, it can displace it at the base of excavations, which can then lead to workers being at risk from asphyxiation. If during construction any organic materials are encountered they should be excavated and replaced.

6.4 Risks to Property

6.4.1 Spontaneous Combustion

The Made Ground has been identified to contain a portion of unburnt colliery spoil, including a fraction of coal. These materials have the potential to combust, given the correct environment (including a heat source and oxygen).

We consider that the colliery spoil at the site should be considered potentially combustible until additional testing (e.g loss of ignition and calorific value) is undertaken to correctly ascertain the risk posed.

6.4.2 Sulphate Attack on Buried Concrete

The assessment of the concrete protection against sulphate attack has been undertaken in accordance with BRE SD1 (2005).

Classification of Site:

Due to the presence of 4.5m of Made Ground comprising colliery spoil and refuse waste on the site, we consider that it should be considered as a 'brownfield' site in terms of concrete classification.

Groundwater Setting:

No groundwater was encountered in the exploratory holes to a depth of 4.5m, aside from so minor ponding observed above concrete slab. However, no long term monitoring (in excess of 24 hours) of groundwater levels has been undertaken. Therefore, in accordance with the BRE guidelines, we recommend that groundwater be considered as 'mobile' in terms of foundation concrete assessment.

Sulphate Levels:

Laboratory test results indicate the levels of water soluble sulphate (as SO_4) in the Made Ground soils to be between 71 and 400 mg/l. As levels of water soluble sulphate are less than 3,000mg/l, there is no need to consider the levels of magnesium present in the soils. Levels of total sulphur ranged between 0.09 and 0.49%. From these results, the calculated levels of total potential sulphate are between 0.27 and 1.47%. Due to this a potential for pyrite exists, with the sample (TP3A 1.5m), measured at 1.47% total potential sulphate, likely to contain pyrite. .

pH values in the Made Ground varied between 7.5 and 11.7, indicating near neutral to alkaline soil conditions to exist. As the pH levels all exceed 5.5, there is no need to further assess the soils for the types of acids present (e.g. hydrochloric and nitric acids).

Foundation Concrete Design:

Using the above results, we consider that the following characteristic values are applicable for the shallow soils at the site (all as SO_4):

Water soluble sulphate:	275mg/l;
Total potential sulphate:	1.03%
pH value:	8.2

Based on these characteristic values, we consider that the site would be classified as Design Sulphate Class DS-3 and Aggressive Chemical Environment for Concrete Class AC-3, allowing for mobile groundwater.

7.0 GEOTECHNICAL COMMENTS

7.1 Site Preparation and Earthworks

7.1.1 Invasive Plants

No evidence of Japanese Knotweed or Himalayan Balsam was identified on the site during the site works.

7.1.2 Existing Foundations and Services

Multiple old steel reinforced concrete slabs and foundations have been identified beneath the site associated with the former colliery. The distribution and depths of the structures are defined in Section 4.4. The shallow foundations and structures should be grubbed up to a minimum of 1.5m below foundation level as part of the site preparation works. Any voids created should be infilled with compacted, suitable, granular fill materials. Where old foundations extend under the existing building thermal lancing of the steel reinforced concrete may be required.

No live services are listed within the site, however an electrical signal has been detected during the site investigation. The approximate location of the signal is indicated in Figure 3, striking north south on the east section of the site. The presence of the signal requires the implementation of a suitable exclusion zone when planning the development and site works. Further details should be obtained from the electricity provider.

7.1.3 New Services

For new services, flexible pipework and connections should be provided as a safeguard against potential settlements. Consideration could be given to increasing the gradients on sewage connections to mitigate against possible settlements.

7.1.4 Earthworks

The historic infrastructure (steel reinforced concrete slabs and old foundations) associated with the former colliery will require grubbing up as part of the re-development. Prior to removal, the contamination status of all material to be taken off-site should be classified to allow suitable disposal.

Any permanent cuttings or embankment surcharges associated with earthworks or landscaping within the site should be kept to a minimum to avoid any possible adverse effects on the existing stability of the site. Any proposed changes to the topography should reviewed by a geotechnical engineer.

7.1.5 Geotechnical Hazards

The site is underlain by the Coal Measures bedrock. The desk study investigation indicates that there is a risk from shallow mining. As such it is recommended drilling of the site to confirm the presence of coals seams is undertaken.

It should be appreciated that in any area of past mining activity the possibility of the existence of unrecorded mine entries cannot be discounted. It should also be noted that the intrusive investigation has been limited to 4.5m, and any mining features below this depth will not have been uncovered. During site clearance operations and all excavation, a careful watch should be maintained for any isolated pockets of loose fill, brickwork or other anomalous features which may be indicative of past mining operations. Any such features should be subject to further investigation.

Currently the proposed structure has no direct interaction with the embankment on the east portion of the site. If any changes are made to the proposed development advice should be sought

Shallow Floor Slabs and Walls

Shallow floor slabs (<1m) and large concrete pad are dispersed across the site, however due to the presence of reinforcement-bar within the slabs the thickness of many slabs has not been determined. In addition to this a concrete wall has been uncovered in the central portion of the site; trending north south and cutting back to the west (see Figure 6). The wall is located with the historical colliery building suggesting the wall forms a basement to the structure. As part of the site clearance the structures should be accessed to confirm the full dimensions.

Deep Slabs (3m)

Floor slabs associated to a potential basement floor in the south west portion of the site has been identified. As part of the site clearance the structure should be accessed to confirm its full dimensions.

7.2 Foundation Design and Construction

It is understood that the site is being considered for potential development for commercial purposes and the comments and recommendations in this report assume that the development will involve a conventional portal frame construction with point loads, and line loads from conventional load-bearing brickwork construction.

It is understood that the existing adjacent Biocatalyst building is constructed on wide (1.2m) reinforced concrete foundations placed on a minimum of 1.5m of excavated and re-compacted fill materials. This is likely to be a suitable solution for the proposed extension. The formation excavation should be carefully inspected and all voided ground below and between the buried foundations should be infilled.

The following hazards will require consideration prior to construction;

1. The existing Made Ground soils contain materials which would not be suitable for re-use within the re-compacted fill (e.g. large steel reinforced concrete slabs). These materials would need to be crushed to a suitable size or removed from site and replaced with imported granular fill material;
2. A large area would be required for the crushing plant and temporary storage of excavated soils;
3. The large scale excavation of the Made Ground could increase the risk of releasing any asbestos materials within the Made Ground soils;
4. The presence of old basements and the proximity of the adjacent building;
5. Where old steel reinforced foundations extend under the existing adjacent building thermal lancing or other suitable technique may be required.

The use of vibro-ground treatment has also been considered, but this unlikely to be feasible given the proximity of the existing commercial premises and steel reinforced concrete structures in the ground.

An alternative foundation solution may be piling but will require careful consideration due to the steel reinforced concrete foundations at the site. Further investigation is required to ascertain an appropriate depth for piled foundations and if any potential worked seams would have an influence on a pile design.

The following criteria should be considered for pile design:-

- The magnitude and resulting effect of different structural loadings;
- Pile/soil/structure interaction effects;
- The design philosophy for pile bearing capacity – the piles are likely to be end-bearing and are likely to only penetrate a short distance into the very dense Fluvio-glacial Gravels. In addition, the estimation of pile bearing capacity in the Upper Coal Measure bedrock requires careful consideration of the skin friction developed over the penetration depth into the rock and the end bearing resistance beneath the pile toe;
- The potential for buckling in the Gravels and Made Ground;
- The presence and distribution of steel reinforced concrete obstructions.

The final safe working load on the pile will be dependent on the pile type, diameter and length of the piles, the penetration into the bearing stratum, the depth of Fluvio-glacial Gravels/Made Ground and its negative skin friction and the settlement tolerances required.

Discussions should be held with specialist piling contractors to obtain specific piling proposals based on their particular proprietary system and to evaluate costs. They should be asked to provide a performance specification for his considered method and in particular the magnitude of total and differential settlements, which would be guaranteed. The contractor should monitor closely the pile installations and should satisfy himself that the ground conditions encountered are as good or better than those assumed in his design. Test loading will be required on a proportion of the piles to confirm that they are adequate to carry the design working loads.

If required, further guidance on design criteria can be given by this office when structural loadings, design and cost implications have been finalised.

7.3 Floor Slab Foundations

We consider that ground bearing floor slabs constructed on the existing, untreated Made Ground could suffer unacceptable settlements. Therefore, the floor slab should either be suspended across the installed piles, or piled separately. The floor slab design should accommodate any gas protection required – see Section 6.3.1.

7.4 Pavement Design

The existing adjacent Biocatalysts building has been constructed on ground bearing floor slabs on reinforced and re-compacted fill materials placed to a suitable engineering specification. Depending on the applied loading and settlement tolerances this may be a suitable solution for the proposed extension.

California Bearing Ratio (CBR) tests have not been carried out at the site, but based on experience and published guidelines, a CBR value of <2% is considered appropriate for preliminary design purposes, for the near surface coarse-grained/fine-grained soils. Actual design values should be determined for designated areas as required.

The final sub-grade should be inspected by a qualified engineer, and any soft or loose material removed and replaced as necessary, to ensure that the Design CBR value is achieved. It is further recommended that the sub-grade be proof-rolled with a suitable roller prior to the placement of the sub-base materials. In order to improve the sub-base performance the use of a suitable geogrid may be considered

7.4.2 Susceptibility to Frost Action

The near surface fine grained/coarse grained soils are considered to be non-frost susceptible.

7.5 Excavation and Dewatering

It is anticipated that excavation throughout most of the site will be require higher capacity machines due to the presence of multiple concrete slabs with cemented reinforcement-bar.

For shallow excavations where there is no danger to life, support of excavation sides is unlikely to be necessary. Where concrete walls are uncovered material should be cleared back to the surface due to the potential for Made Ground to peel from the surface. However, if deeper foundation excavations are required (due to thick Made Ground) support may be required as spalling was noted within coarse grained soils. Should indication of excavation instability be noted at any depth, support should be provided as appropriate

Based on our understanding of the proposed development, no significant groundwater ingress is anticipated. Where water ingress occurs it is likely that pumping from screened sumps within shallow excavations will be adequate.

7.6 Soakaway Drainage

No soakaway infiltration testing has been undertaken at the site however, based on the findings of the investigation, some preliminary comments can be made. The shallow soils encountered in the investigation (to a depth of 4.5m) are a mixture of both fine and coarse grains due to the variability of Made Ground encountered. Soakaway infiltration testing in accordance with BRE 365 should be undertaken at the proposed positions and depths of soakaways to confirm the likely infiltration rates.

The infiltration stratum at the site would be the superficial deposits (Fluvio-glacial deposits) and the bedrock (Coal Measures) beneath the site are classed as Secondary A Aquifers. The groundwater within the aquifers is vulnerable to pollution. The Environment Agency had a policy that no direct discharge of surface run-off would be accepted in vulnerable groundwater aquifers. Given the shallow depth of the bedrock at the site, any soakaways would result in the direct discharge of surface water run-off into the aquifer. We recommend that enquiries are made to Natural Resources Wales (who have taken over the role of the Environment Agency) to identify whether they would allow such discharge at the site. As a minimum, risk mitigation measures such as oil interceptors are likely to be required.

8.0 RECOMMENDED FURTHER WORK

Asbestos

Fibres of amosite (brown) and chrysotile (white) asbestos have been identified in the Made Ground. Prior to any further works at the site (earthworks/construction or exploratory) we recommend that the advice of an appropriately qualified asbestos specialist should be sought to confirm the risk to end users and construction workers. Further specialist sampling and testing to delineate the area impacted may be required prior to the clearance works. Testing may also be required subsequent to the undertaking of the works to validate that no on-going risk is proposed to end users.

Ground Gas

As discussed in Section 6.3.2, a significant amount of Made Ground was encountered during the site works. Made Ground has the potential for generation of ground gasses, most notably Carbon Dioxide. We recommend that monitoring wells are installed at the site and a gas monitoring regime is undertaken in order to establish the levels of Ground Gas at the site and assess the risk to the construction workers and site end users.

Spontaneous Combustion

The Made Ground has been identified to contain a portion of unburnt colliery spoil, including a fraction of coal. These materials have the potential to combust, given the correct environment (including a heat source and oxygen). Further testing for loss of ignition and calorific value is recommended.

We consider that the colliery spoil at the site should be considered potentially combustible until additional testing is undertaken to correctly ascertain the risk posed.

Additional Exploratory Works

We consider that the following further investigation and assessment be undertaken:

- Investigation to determine the presence of potential sub-surface worked coal seams;
- Supplementary geo-environmental sampling and testing in order to assess the levels of potential contamination for a groundwater risk assessment
- Sampling and testing for spontaneous combustion of the colliery spoil.
- Rotary Openhole drilling in order to determine the depth to a suitable founding strata and determine the depth and nature of the bedrock underlying the site. In addition, the drillholes constructed should be installed with a gas and groundwater monitoring well.
- Following the installation of the monitoring wells, a monitoring regime should be undertaken in order to establish the potential for ground gases at the site and assess the risk to construction workers and site end users. In addition, the groundwater levels at the site can be established within the monitoring wells in order to provide further detail for the foundation design.

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