Earth Science Partnership

Consulting Engineers | Geologists | Environmental Scientists

12 Clive Road, Canton
Proposed Residential Development

Geo-environmental & Geotechnical Assessment

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12 Clive Road,
Proposed Residential Development

Geo-environmental & Geotechnical Assessment

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Document Reference: **ESP.6503b.2908**

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Contents

1 Introduction 1
1.1 Background 1
1.2 Objective and Scope of Works 2
1.3 Report Format 3
1.4 Limitations of Report 3
1.5 Digital Copy of Report 4
2 DESK STUDY AND FIELD RECONNAISSANCE VISIT 5
2.1 Site Location and Description 5
2.2 Site History 6
2.3 Previous Investigations and Assessments 7
2.4 Contact with Regulatory Bodies & Local Information Sources 7
2.5 Hydrology 8
2.6 Geology 10
2.7 Hydrogeology 11
2.8 Environmental Setting 12
2.9 Preliminary Geotechnical Risk Register 14
2.10 Pyritic Ground 15
2.11 Radon Hazard 16
2.12 Buried Unexploded Ordnance (UXO) 16
3 PRELIMINARY GEO-ENVIRONMENTAL RISK ASSESSMENT 17
3.1 Phase One Conceptual Site Model 17
3.2 Preliminary Risk Evaluation & Plausible Pollutant Linkages 19
4 EXPLORATORY INVESTIGATION 21
4.1 Investigation Points 21
4.2 Trial Pits 21
4.3 Soakaway Infiltration Testing 21
4.4 Sampling Strategy 22
4.5 Evidence of Site Hazards Found During Site Works 22
4.6 Geotechnical Laboratory Testing 23
4.7 Geo-environmental Laboratory Testing 23
5 DEVELOPMENT OF THE REVISED CONCEPTUAL MODEL 24
5.1 Geology 24
5.1.1 Made Ground 24
5.2 Hydrogeology 24
5.3 Site Instability 25
5.4 Chronic Risks to Human Health –Generic Assessment of Risks 25

5.5 Ground Gas 28
5.6 Sulphate Attack 28
6 PHASE TWO GEO-ENVIRONMENTAL RISK ASSESSMENT 30
6.1 Discussion on Occurrence of Contamination and Distribution 30
6.2 Revised Risk Evaluation & Relevant Pollutant Linkages..... 30
7 REMEDIAL STRATEGY FOR CONTAMINATION RISKS 32
7.1 Risks to Health 32
7.2 Risks to Controlled Waters 33
7.3 Risks from Ground Gas 33
7.4 Risks to Property 34
7.5 Re-Use of Materials/Disposal of Excess Arisings 34
8 GEOTECHNICAL COMMENTS 36
8.1 Site Preparation and Earthworks 36
8.2 Geotechnical Risk Register 36
8.3 Preliminary Foundation Design and Construction..... 37
8.4 Floor Slab Foundations 37
8.5 Pavement Design 37
8.6 Susceptibility to Frost Action 37
8.7 Excavation and Dewatering 37
8.8 Soakaway Drainage..... 38
9 RECOMMENDATIONS 39

Figures

Plates

Appendix A Risk Evaluation Methodology
Appendix B Historical Maps
Appendix C Enviro-Insight Environmental Data Report
Appendix D Correspondence with Cardiff County Council
Appendix E Preliminary UXO Risk Assessment (Zetica, 2017)
Appendix F Trial Pit Records
Appendix G Results of Soakaway Infiltration Testing
Appendix H Geotechnical Laboratory Test Results
Appendix I Geo-environmental Laboratory Test Results
Appendix J Service Plans

Figures and Tables

Insert 1 Site Location Plan 1:25,000 (Ordnance Survey License No.: AL100015788). 1
Insert 2 Extract from NRW Flood Risk Map (NRW, 2017) Scale 1:5,000 9
Insert 3 Extract from BGS Drift Geology Sheet 263 (Scale 1:50,000) (BGS license number: C15/05 CSL) 10

Table 1: Review of Historical Maps 6
Table 2 Summary of hydrogeological information (ESP, 2010) 11
Table 3: Summary of Environmental Data 13
Table 4: Preliminary Geotechnical Risk Register 15
Table 5: Preliminary Risk Evaluation & Plausible Pollutant Linkages (PPL) 20
Table 6: Summary of Geo-environmental Soil Results 27
Table 7: Revised Risk Evaluation & Relevant Pollutant Linkages (RPL) 31
Table 8: Updated Geotechnical Risk Register 36
Table 9: Summary of soakaway infiltration test results 38

List of Figures

Figure 1: Proposed Development Plan

Figure 2: Exploratory Hole Location plan

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Executive Summary

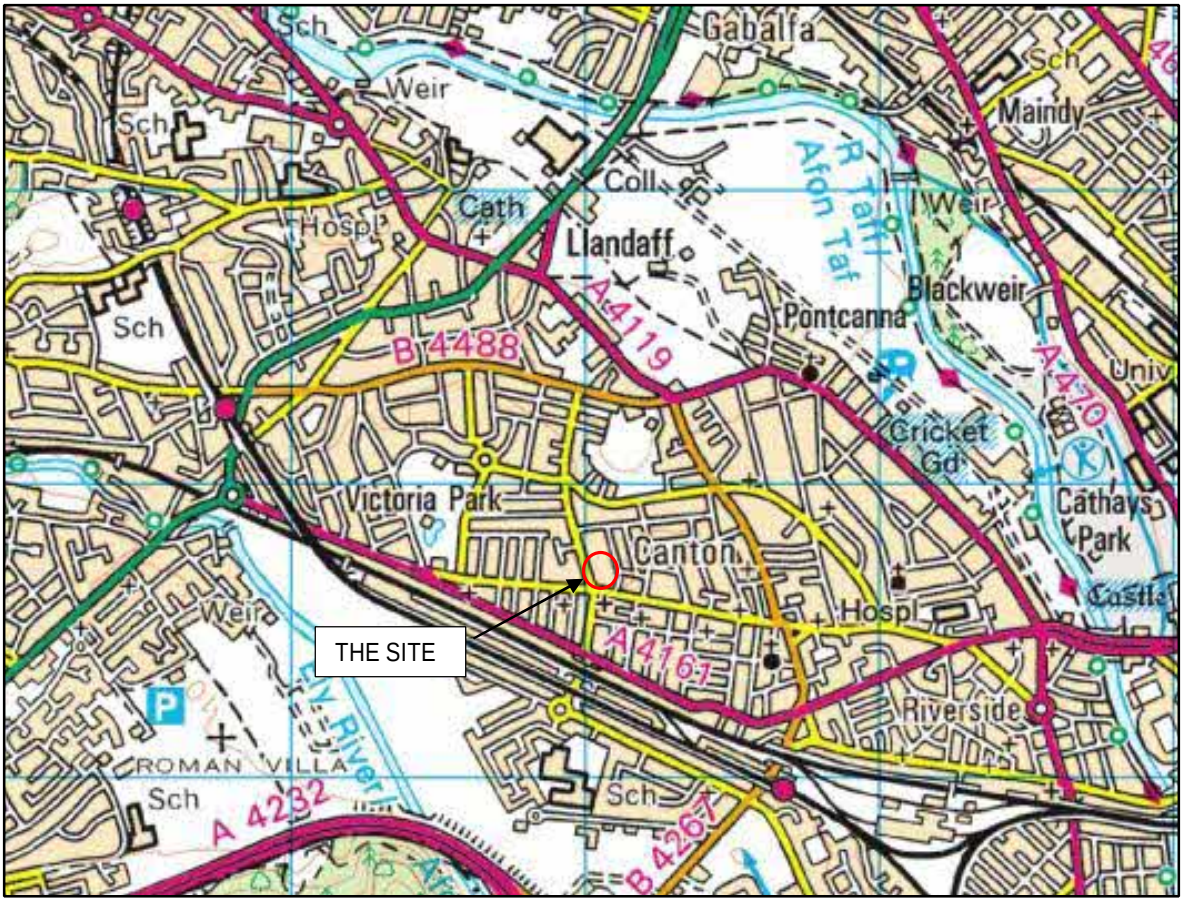
MYJM Developments is considering the redevelopment of the subject site comprising the demolition of the existing building and construction of nine self-contained apartments over three floors, with onsite car parking, cycle and refuse storage facilities. ESP have undertaken a geo-environmental and geotechnical assessment, comprising a desk study, intrusive investigation, laboratory testing and assessment of data. This report includes the Preliminary Risk Assessment and Generic Quantitative Risk Assessment (for human health and controlled waters) elements of CLR11. The key potential land quality issues identified by the assessment are summarised below:

	Potential Hazard	Anticipated Risk	Discussion
Site Setting	*Current Site Status.* *(Section 2.1)*	-	*The site is currently occupied by occupied by a vacant two storey commercial unit with a small forecourt and parking space fronting on to Clive Road and an open amenity area to the rear.*
	Identified Ground Conditions. *(Section ??)*	-	*The investigation has indicated cover of Made Ground overlying Glaciofluvial Sheet Deposits.*
	Groundwater Conditions. *(Section 5.2.1)*	-	*No groundwater identified during the investigation. We anticipate groundwater is within the superficial strata.*
	Historical Land Use. (Table 1)	-	*The site exists in a historically residential area.*
Geo-environmental	*Potential Contamination Sources* *(Section 2.8)*	*Low*	*No significant contamination sources identified.*
	Chronic Risks to Human Health *(Section 5.4)*	*Low*	*No contaminants exceeding adopted GAC values observed.*
	Risks to Controlled Waters *(Section 7.2)*	*Low*	*Site lies on a Secondary A Aquifer. No contamination identified during the investigation – low level of risk to control waters identified.*
	Hazardous Ground Gas *(Section 7.3)*	*Low*	*No Gas Protection measures advised.*
	Other Hazards *(Section 6.2)*	*High*	*Potential asbestos in existing building. Asbestos survey recommended.*
Geotechnical	*Weak/Compressible Ground, requiring non-traditional foundations* *(Section 8.5)*	*Low*	*Includes comment on foundation & floor slab solution.*
	Sulphate Attack on Buried Concrete *(Section 7.4)*	*Low*	*Laboratory testing has indicated the site is classed as AC-1 in terms of sulphate attack on buried concrete.*
	Soakaway Feasibility *(Section 8.8)*	-	*In general, we would recommend that 10-5m/s be used as a typical infiltration rate for design across the site.*
Others	*UXO* *(Section 2.11)*	*Low*	*Preliminary assessment advises no further measures are considered necessary.*
	Flooding *(Section 2.5.3)*	*Moderate / Low*	*A portion of the site is indicated to be at risk from flooding from reservoirs (very low). The site is indicated to be potentially at risk from flooding by groundwater from superficial deposits.*
	Recommendations (Section 9.0)	*Yes*	• *Asbestos survey of existing building.* • *Measure CBR values at sub-grade prior to pavement construction.* • *Investigation of the ground conditions below the current building footprint (when demolished).*

1 Introduction

1.1 Background

MYJM Developments (hereafter known as the Client) are proposing to redevelop the subject site for residential purposes. The Earth Science Partnership Ltd (ESP), Consulting Engineers, Geologists and Environmental Scientists, were instructed by C2J Architects, acting on behalf of the Client, to undertake an integrated geotechnical and geo-environmental investigation and assessment to identify and evaluate potential ground hazards which could impact on the proposed development. The site location is shown on Insert 1.



Insert 1 Site Location Plan 1:25,000 (Ordnance Survey License No.: AL100015788).

The proposed development will comprise the demolition of the existing commercial building occupying the west of the site and the construction nine self-contained apartments over three floors with on site car parking, minor landscaping, cycle and refuse storage facilities.

Based on the above, we understand that the proposed structures would be classified as Geotechnical Category 2 (BS5930:2015). The proposed development layout is shown on Figure 1.

1.2 Objective and Scope of Works

The objective of the investigation was to obtain information on the geotechnical character and properties of the ground beneath the site, potential risks posed by contamination and ground gas, and to allow an assessment of these ground conditions with particular reference to the potential impact on the proposed development.

The Client has obtained planning permission for the proposed development, but the Local Planning Authority (LPA) have imposed a number of ground related planning conditions as follows:

"*Condition 3: Prior to commencement of the development an assessment of the nature and extent of contamination shall be submitted to and approved in writing by the Local Planning Authority. This assessment must be carried out by or under the direction of a suitably qualified competent person * in accordance with BS10175 (2011) Code of Practice for the Investigation of Potentially Contaminated Sites and shall assess any contamination on the site, whether or not it originates on the site.*

The report of the findings shall include:

(i) *A desk top study to identify all previous uses at the site and potential contaminants associated with those uses and the impacts from those contaminants on land and controlled waters. The desk study shall establish a 'conceptual site model' (CSM) which identifies and assesses all identified potential source, pathway and receptor linkages;*

(ii) *An intrusive investigation to assess the extent, scale and nature of contamination which may be present, if identified as required by the desk top study;*

(iii) *An assessment of the potential risks to:*
- *Human health,*
- *Groundwaters and surface waters,*
- *Adjoining land,*
- *Property (existing or proposed) including buildings, crops, livestock, pets, woodland and service lines and pipes,*
- *Ecological systems,*
- *Archaeological sites and ancient monuments; and*
- *Any other receptors identified at (i)*

(iv) *An appraisal of remedial options and justification for the preferred remedial option(s)*

All work and submissions carried out for the purposes of this condition must be conducted in accordance with DEFRA and the Environment Agency's 'Model Procedures for the Management of Land Contamination, CLR 11' (September 2004) and the WLGA/WAG/EA guidance document 'Land Contamination: A guide for Developers' (2012), unless the Local Planning Authority agrees to any variation.

** A 'suitably qualified competent person' would normally be expected to be a chartered member of an appropriate professional body (such as the Institution of Civil Engineers, Geological Society of London, Royal Institution of Chartered Surveyors, Institution of*

Environmental Management) and also have relevant experience of investigating contaminated sites.

Reason: In accordance with policy EN13 of the Cardiff Local Development Plan."

This investigation and assessment has been designed in part to address the requirements of this planning condition. In addition, the investigation was designed to identify potential geotechnical hazards at the site.

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, environmental data, geological maps, memoirs and data, and further desk study information, a field reconnaissance visit, the supervision and direction of trial pits, soakaway infiltration testing, geotechnical and geo-environmental laboratory testing, assessment of foundation options 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 7th December 2016 (ref: mte/ESP.6503b.lt1).

The investigation and assessment was undertaken in May and June 2017.

1.3 Report Format

This report includes the desk study and field reconnaissance reports (Section 2), and details of the investigation undertaken of Eurocode EC7 and BS5930:2015 (Section 4), along with the Preliminary Risk Assessment stage (Section 3) and Generic Quantitative Risk Assessment (Section 5) of CLR11. A preliminary evaluation of the resulting risks and any remedial measures potentially required to mitigate identified unacceptable risks from contamination and hazardous ground gas is included in Sections 6 and 7. However, it should be appreciated that this is a preliminary evaluation only, and will not generally meet the requirements of the Options Appraisal report of CLR11.

A preliminary risk register, identifying potential geotechnical hazards from the desk study review, is presented as Section 2.9, with a full assessment of the geotechnical conditions including foundation and floor slab options, the feasibility of soakaways, etc. in Section 0 –this complies the relevant elements of the Geotechnical Design Report of BS EN 1997-2 (Eurocode 7) and BS5930:2015. The geotechnical risk register is updated using the findings of the intrusive investigation and assessment in Section 8.2. The report concludes with a summary of any further surveys/ investigations/ assessments recommended (Section 9).

The assessment of 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 has been undertaken using the guidance published by CIRIA (2001). This is discussed in more detail in Section 3.2.1 and in Appendix A.

1.4 Limitations of Report

This report represents the findings of the brief relating to the proposed end use and geotechnical category of structure(s) as detailed in Section 1.1. The brief did not require

an assessment of the implications for any other end use or structures, nor is the report a comprehensive site characterisation and should not be construed as such. It should be appreciated that no intrusive investigation has been undertaken to date. Should an alternative end use or structure be considered, the findings of the assessment should be re-examined relating to the new proposals.

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

This report is issued as a digital version only.

2 DESK STUDY AND FIELD RECONNAISSANCE VISIT

The information presented in this section was obtained from desk-based research of sources detailed in the text, including historical maps (Appendix B), an environmental data report (Appendix C), information on a previous investigation relevant to the site (Appendix D), correspondence with the Local Authority, Cardiff County Council (Appendix E) and a preliminary unexploded ordnance risk assessment (Appendix F). Further desk study reports/data/records are included as subsequent appendices as referenced in the text.

2.1 Site Location and Description

The site is located on the eastern side of Clive Road, approximately 50m from the junction with Cowbridge Road East, in the western area of Canton, Cardiff. The National Grid Reference of the centre of the site is (ST) 316004 176716 and the postcode is CF5 1JH. A Site Location Plan is presented as Insert 1

The site comprises a rectangular shaped parcel of land of around 32m length (east to west) and 13m width (north to south), occupying an area of around 0.4ha. It is presently occupied by a vacant two storey commercial unit with a small forecourt and parking space fronting on to Clive Road and an open amenity area to the rear.

It is bounded by:

To the north: adjacent residential properties of Clive Road,

To the east: land of The Old Coach House followed by rear gardens of houses along parallel Egerton Street,

To the south: immediately by a small access lane followed by further residential properties of Clive road

To the west: immediately by Clive Road followed by residential property front of opposite residential properties of Clive Road

Vehicular access to the site is currently gained via a dropped kerb on the western boundary, leading on to Clive Road. Additional access can be gained via the side access lane to the rear of the property. The boundary to the south comprises a brick free-standing wall with gated access to the rear of the property.

The general topography in the area is relatively flat and the site itself is flat and level.

We are not aware of a topographic survey for the site at this time, however, recent Ordnance Survey maps (Appendix B) indicate a spot height of 11m OD on Clive Road, immediately to the north west of the site. Based on this, and visual observations, we consider that the elevation of the site is likely to be of the order of 11m OD.

As part of this assessment, service plans have been obtained by ESP from the utility companies –copies of this service information is presented in Appendix J.

Site observations and the utility plans indicate that the site is not crossed by any services but given the close proximity of known services, consideration must be given when undertaking any intrusive investigation or construction.

2.2 Site History

2.2.1 Published Historical Maps

The site history has been assessed from a review of available historical Ordnance Survey County Series and National Grid maps. Extracts from the historical maps are presented in Appendix B and the salient features since the First Edition of the County Series maps are summarised in Table 1.

Table 1: Review of Historical Maps

Date	On-Site	In Vicinity of Site
1880-1882	Site lies in residential area of Canton. Site encompasses several buildings comprising a main residential structure with two small buildings, front and rear gardens. Side access alley is present. A number of trees indicated in rear garden.	Site lies on Clive Road, Canton, junction with Romily Road lies approximately 300m to the north. Junction with Ely Road 50m to the south. Great Western Railway line (South wales Division) indicated 300m to the south west. River Ely lies 800m to the south west. Cardiff Water Works and associated reservoir indicated 600m to the north. Ely Paper Mills indicated 900m to the east. Cornmill indicated 580m to the south east. Nursery and associated planting indicated 200m to the west. Cattle market and slaughterhouse indicated 300m to the east. Malthouse indicated 150m to the east. Wells indicated 60m to the north and 125m to the south. Pump indicated 50m to east.
1899 - 1901	No significant changes indicated.	Extension of residential developments evident, particularly to the north east of the site. Southern railway line now indicated as Penarth Harbour & Dock Railway. Electricity works indicated 1km to south east. Sanitorium indicated 700m to south west. Canton Brick Works indicated 700m to west. Amenity spaces such as Victoria Park 500m to the north west and Sir David's Field 400m to the north indicated. Ely Road now widened and renamed Cowbridge Road.
1915	No significant changes indicated.	Further residential developments indicated to north and west. No further significant changes indicated.
1920-1922	No significant changes indicated.	No significant changes indicated.
1938-1940	No significant changes indicated.	Significant residential development >750m to the north west –Llandaff and Fairwater.
1947	No significant changes indicated.	Ely River to south west diverted and straightened, embankments indicated on either side of new river path.
1952-1954	No significant changes indicated.	Garage indicated 120m to south east. Electricity substation indicated 170m to the south. Soft Drinks Factory indicated 200m to the south.
1963-1965	Building is indicated as No 12.	Factories indicated along Sanitorium Road 450m to south west. The Lansdowne Hospital indicated 650m to south west on previous site of Sanitorium.
1973	No significant changes indicated.	Works indicated 750m to south west.
1984-1988	Building extended to span front of the site (indicated in 1985).	A4232 indicated >1km to south west (construction completed 1978).
1988-1989	No significant changes indicated.	No significant changes indicated.
1992-1994	No significant changes indicated.	No significant changes indicated.
2002-2014	No significant changes indicated.	No significant changes indicated.

2.2.2 Other Sources

The following information has been gathered from other external sources.

The district of Canton has a long history dating back as far as the 13th Century when the Earl (or Baron) de Kanetune established a manor and surrounding lands from nearby Llandaff and Leckwith parishes.

For several hundred years, nearby Canton Cross was the site of the largest and most significant trading market in the South Wales area, including the transport of goods to be exported from the docks at Cardiff, Penarth and Swanbridge.

Whereas many nearby areas, such as Grangetown and Leckwith capitalised on the nearby docks for advancements in industrialisation, Canton has been characterised by smaller family businesses and residential areas. The Cattle Market and Slaughterhouse, mentioned in Table 1 above, opened in 1859 and by the late 19th century included stables, a meat market and fairs were held monthly.

Many local family businesses started life on nearby Cowbridge Road, some trading for more than 100 years.

As can be seen in the maps described in Table 1, there has been little development of Canton itself since the 1960s/70s but the area remains popular due to its archetypal Victorian housing, proximity to the city centre and abundance of amenities.

2.2.3 Archaeological Setting

A full archaeological assessment was not included within the brief, but we have not been advised of, or identified, any obvious evidence of any significant archaeological features on the site. We recommend that consideration is given to employing a specialist archaeological consultant to review the historical and archaeological setting.

2.3 Previous Investigations and Assessments

Earth Science Partnership (ESP) undertook a Site Investigation and Flood Consequences Assessment approximately 200m to the south west of the site in 2010 (ESP.4565s.Ph1/1659) for a then proposed social housing scheme. The investigation included the following investigation points:

Eight trial pits to a maximum depth of 3.5m.

Soakaway infiltration testing was undertaken in three test pits and geotechnical and geo-environmental laboratory testing undertaken. An assessment of geotechnical and contamination and ground gas risks was completed. For ease of reference, copies of the salient exploratory hole records from this investigation, along with a plan showing their positions, are presented in Figure 2 and the salient information is discussed further in the following relevant sections.

2.4 Contact with Regulatory Bodies & Local Information Sources

The following departments of the Local Authority (Cardiff County Council) have been contacted as part of this assessment:

- Environmental Services/Health/Pollution Control;
- Building Control;
- Trading Standards (Petroleum Officer).

At the time of issue of this report, we have not yet received a response from the consultees. Once received, any response will be forwarded under separate cover. It should be appreciated that their responses may contain salient information on the site which could not be taken into account during the preparation of this report.

2.5 Hydrology

2.5.1 Surface Water Features

The nearest major surface water feature to the site is the River Ely (classified as a Primary River) which flows from north to south approximately 900m to the south west.

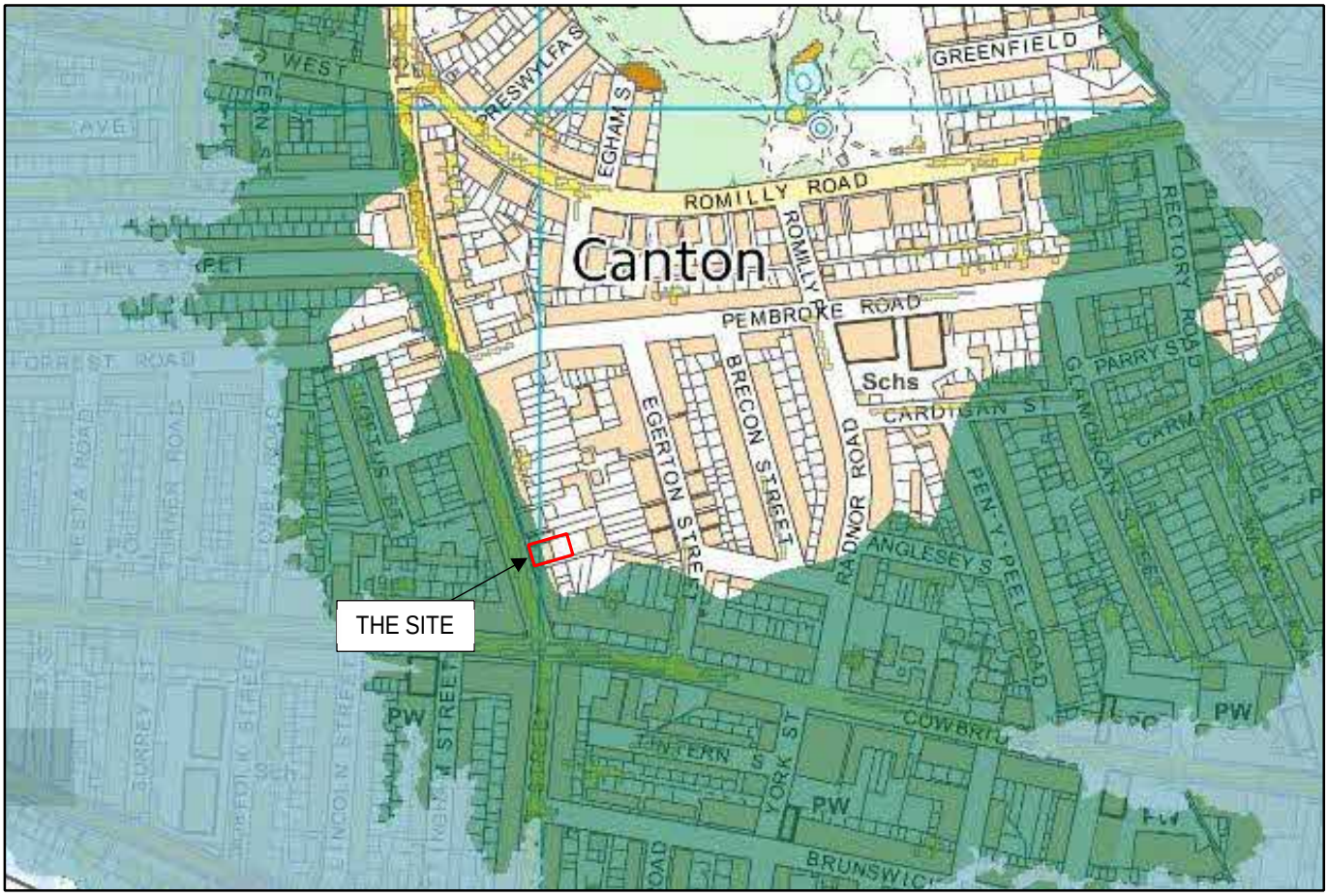
The environmental data report (Appendix C) indicates that the latest data shows the water quality (in terms of chemistry) in the River Ely between the site and the confluence with the Fairwater Brook, approximately 1km to the west was classified as Grade B (good) between 2005 and 2006, improving to Grade A (very good) between 2007 and 2008. The environmental data report does not provide any data for the water quality over the same stretch of river in terms of biology.

2.5.2 Surface Water Abstractions

The environmental data report (Appendix C) indicates that there are no surface water abstractions within 250m of the site.

2.5.3 Flooding (River & Sea)

From a review of flooding maps presented in the environmental data report and maps available on the Natural Resources Wales website (Insert 2), the majority of the site is not indicated to be at risk of flooding by rivers, reservoirs or surface water, and it does not lie within a Flood Alert or Warning Area. However, a portion to the west of the site is indicated to be at risk from flooding from reservoirs. The risk from this flooding is indicated to be very low.



Insert 2 Extract from NRW Flood Risk Map (NRW, 2017) Scale 1:5,000

2.5.4 Flooding (Groundwater)

The site is indicated to be potentially at risk from flooding by groundwater from superficial deposits.

No further assessment of flood risk has been taken as part of this report.

2.6 Geology

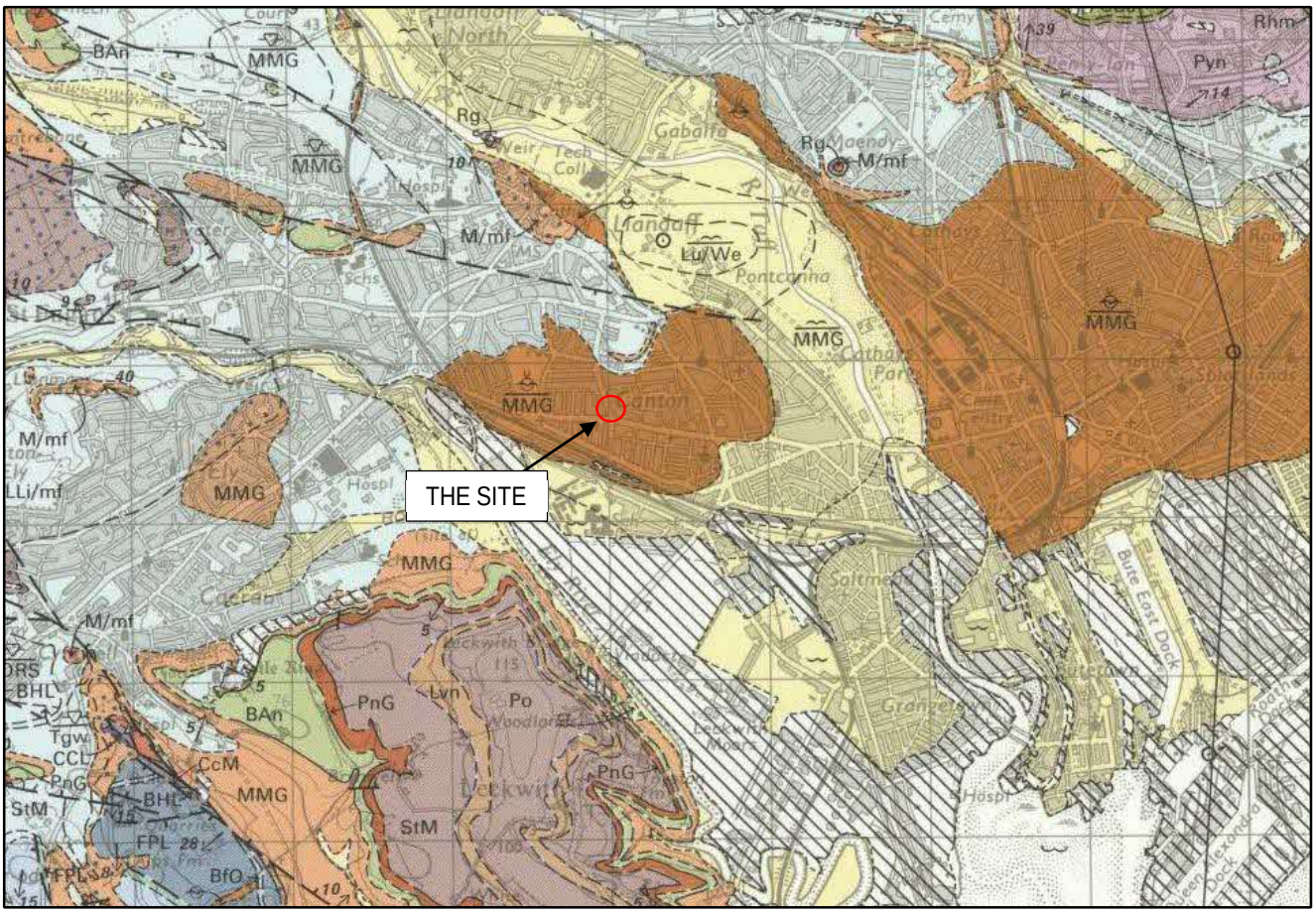
2.6.1 Published Geology

The published 1:10,560 scale geological map for the area of the site (Sheet ST17NE) indicates the site to be underlain by Fluvioglacial Terrace Deposits (undifferentiated) overlying bedrock of the Mercia Mudstone Group.

The sheet indicates the superficial strata to comprise orange-brown sand, in part clayey, pebble cobble gravel with silt and fine sand up to 1m thick overlying the gravel.

The published 1:50,000 scale geological map for the area of the site (Sheet 263, available on the website of the British Geological Survey, 2017) indicates a similar succession.

Reference to the up-to-date mapping available on the website of the British Geological Survey (BGS, 2017) also indicates a similar succession but the superficial deposits have been renamed Glaciofluvial Sheet Deposits.



Insert 3 Extract from BGS Drift Geology Sheet 263 (Scale 1:50,000) (BGS license number: C15/05 CSL)

2.6.2 Available BGS Borehole Records

Reference to the website of the British Geological Survey (BGS, 2017) indicates no available records of boreholes in the immediate vicinity of the site. Several boreholes

are present in the larger area (>150m) indicating Mercia Mudstone Bedrock from depths of approximately 10m.

2.6.3 Previous Investigation

The previous investigation (Section 2.3) identified the following generalised succession of strata beneath the site:

- Made Ground: identified to a depth of 0.2 to 0.9m as Tarmacadam and Gravel;
- Fluvioglacial Terrace Deposits: identified immediately beneath the Made Ground to a depth of 3.5m as Clay and Gravel.

2.7 Hydrogeology

2.7.1 Aquifer Classification

Reference to the aquifer maps published on the environmental data report indicates that the superficial deposits beneath the site (Glaciofluvial Sheet Deposits) are classed as Secondary A Aquifer, whilst the bedrock (Mercia Mudstone Group) is classed as Secondary B.

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.

Secondary B Aquifers generally correspond with the previously classified water bearing parts of non-aquifers and comprise strata of generally lower permeability, but which may store and yield limited amounts of groundwater due to localised features such as fissures, thin permeable horizons and weathering. In some circumstances, Secondary B Aquifers can be sensitive to pollution.

2.7.2 Anticipated Groundwater Bodies

The previous investigation at the site (Section 2.3) produced the following comments on groundwater:

Table 2 Summary of hydrogeological information (ESP, 2010)

Hole ID	Stratum	Comment on groundwater encountered
TP1	Fluvioglacial Terrace Deposits (Granular)	Damp from 1m depth.
TP2	Fluvioglacial Terrace Deposits (Granular)	Damp from 0.3m depth.
TP3	Fluvioglacial Terrace Deposits (Granular)	Damp from 1.3m depth.
TP4	Fluvioglacial Terrace Deposits (Granular)	Damp from 1.8m depth.
TP5	Fluvioglacial Terrace Deposits (Granular)	Damp from 0.5m depth.
TP6	Fluvioglacial Terrace Deposits (Granular)	Damp from 0.9m depth.
TP7	Fluvioglacial Terrace Deposits (Granular)	Damp from 0.9m depth.

Based on the information from this previous investigation and the flood risk potential (see Section 2.5.4), we consider that the shallowest main groundwater body beneath the site is likely to be located within the Glaciofluvial Sheet Deposits.

2.7.3 Abstractions and Groundwater Vulnerability

The environment data report indicates that the nearest groundwater abstraction point lies approximately 534m to the south west of the site. This abstraction is reportedly used for non-evaporative cooling for Dairy Crest Ltd. This abstraction activity is not associated with a Source Protection Zone.

The groundwater vulnerability reported in the environmental data report indicates the site to be underlain by a minor aquifer of high vulnerability.

2.7.4 Groundwater Movement

Groundwater movement within the superficial Glacial deposits will be controlled by intergranular flow whilst, in the Mercia Mudstone bedrock, fracture flow is likely to be dominant.

2.8 Environmental Setting

2.8.1 Summary of Environmental Data

The site exists in a historically rural, and now an urban setting. An environmental data report has been obtained for the site and is presented in Appendix C, and the data therein is summarised in Table 3 below and, where salient, discussed in Section 2.8.2.

Table 3: Summary of Environmental Data

	Item	On the Site	In the Immediate Vicinity
8	Environmentally Sensitive Sites [2]	None identified.	None recorded within 500m of the site.
1	Potentially Contaminative Land Use	None identified.	Two recorded within 250m of the site, including a Nursery 128m to the west and a Malthouse 182m to the east.
1	Historical Tanks, PFS, Garages, Energy Facilities	None identified.	Four electricity substations (107m to the north, 162m to the south, 208m to the south east) and three garages (92m to the south east, 114m to the south and 247m to the south west) recorded within 250m of the site.
1	Potentially Infilled Land	None identified in environmental data rpt[3]	None recorded within 250m of the site.
2	IPPC Authorisations	None identified.	None recorded within 500m of the site.
2	Discharge Consents	None identified.	None recorded within 500m of the site.
2	List 1 and 2 Dangerous Substances Sites	None identified.	None recorded within 500m of the site.
2	Radioactive Substance Sites	None identified.	None recorded within 500m of the site.
2	Enforcements	None identified.	None recorded within 500m of the site.
2	Pollution Incidents	None identified.	1no incident recorded within 500m of the site. Incident occurred in 2002 with the pollutant being described as oils and fuel, water impact –3, land and air impact –4.
2	Contaminated Land under Part 2A EPA 1990.	None identified.	None recorded within 500m of the site.
3	Waste Management Facilities	None identified.	Five recorded within 1km of the site. See Section 2.8.2.
4	Current Industrial/Commercial Sites	None identified.	18 recorded within 250m of the site. See Section 2.8.2.

Notes
1. Numbers on left refer to relevant Sections in environmental data report (Appendix C).
2. Sensitive land uses include Sites of Special Scientific Interest, Nature Reserves, National Parks, Special Areas of Conservation, Special Protection Areas, Ramsar sites, World Heritage sites and Ancient Woodland.
3. Nitrate vulnerable areas relate to the agricultural use of fertilizers and are not considered further in this assessment.

2.8.2 Further Discussion on Salient Environmental Features

Waste Management Facilities

Five waste management facilities identified within 1km of the site including 462m to the south west (inert waste), 832m to the south (inert, industrial commercial, household and special waste), 909m to the south (inert waste), 913m to the south (inert waste) and 993m to the south east (inert, industrial, commercial, household and special waste).

Current Industrial/Commercial Sites

18 sites identified within 250m of the site including the following:

- 70m south –Holloway Partnership (civil engineers).
- 78m north east –Moon Signs (sign company).

- 84m west –K A R Canton (vehicle repair/testing/servicing).
- 93m west –Design & Signs (workwear).
- 97m north west –Acoustic Ceilings Ltd. (building suppliers).
- 107m west –Hearing Aid Solutions (disability and mobility equipment).
- 107m south –Just MOT's (vehicle repair, testing & servicing).
- 111m south east –Prestige Motors (new vehicles).
- 118m north –Electricity Sub Station (electrical feature).
- 146m south east –LDP Services (published goods).
- 147m east –Brecon Motors Cardiff (vehicle repair, testing & servicing).
- 173m south –Electricity Sub Station (electrical feature).
- 183m west –Cariff Balloons (giftware).
- 214m south east –Electricity Sub Station (electrical feature).
- 226m east –Burroughs (civil engineers).
- 235m east –Burgoynes (civil engineers).
- 249m south east –Romilly Car Sales (secondhand vehicles).

2.8.3 On-Site Bulk Liquid Storage

The historical maps and field reconnaissance visit have provided no evidence of any past or recent above ground or underground bulk liquid (e.g. fuels/oils) storage on site.

2.8.4 On-Site Bulk Materials and Waste Storage

The field reconnaissance visit indicated no evidence of recent materials or waste storage on the site.

2.9 Preliminary Geotechnical Risk Register

2.9.1 Summary of Potential Geotechnical and Geomorphological Hazards

The potential for select geotechnical hazards at the site is provided in the environmental data (Appendix C). The potential hazards, as reported in these reports are listed in Table 4 below, along with any salient further information on the potential hazard identified by ESP in the preparation of this report. Where a potential hazard has been identified, it is discussed further in subsequent sections.

Table 4: Preliminary Geotechnical Risk Register

Ground Stability Hazard	Potential[1]	ESP Comment
Coal Mining	Low	No further information identified to contradict data report.
Mining (non-coal)	Low	No further information identified to contradict data report.
Shrinking or Swelling Clays	Very Low	See Section 2.9.2
Landslides	Very Low	No further information identified to contradict data report.
Ground Dissolution (Soluble Rocks)	Negligible	No further information identified to contradict data report.
Compressible Ground	Negligible	See Section 2.11
Collapsible Ground	Very Low	No further information identified to contradict data report.

Notes
1. Potential as reported in environmental data report (Appendix C)
2. Salient hazards discussed in following sections.
3. An updated Geotechnical Risk Register, following intrusive investigation of salient hazards, is presented as Table 8

2.9.2 Shrinkable and Swelling Soils

The environmental data reports the risk of shrinkable and swelling soils is Very low indicating ground conditions of predominantly low plasticity.

However, there is the possibility of the presence of fine grained Glacial Deposits beneath the site which are susceptible to shrinkage and swelling. Also, depending on the design of the proposed development, if any existing vegetation or trees are removed from the site this may change the moisture content of the shallow soils resulting in potential volume change.

We consider that the potential for shrinkable and swelling soils at the site should be advanced from that reported in the environmental data report (Table 3, Very Low) to Moderate.

2.9.3 Compressible Ground

The alluvial deposits potentially anticipated beneath the site comprise soils of probable low strength and contain organic materials and, hence, are potentially compressible. The Made Ground soils anticipated beneath the site are potentially compressible, particularly where containing organic materials are present, which could lead to significant settlement at the surface. Therefore, we consider that the potential for compressible ground at the site should be advanced from that reported in the environmental data report (Table 4, Negligible) to Moderate.

2.10 Pyritic Ground

The bedrock underlying the site are listed by the BRE (2005) as potentially containing elevated levels of pyrite, which may oxidise to sulphates and lead to aggressive attack on buried concrete.

Depending on its origin, the Made Ground and Glaciofluvial Sheet Deposits anticipated beneath the site may also contain elevated levels of pyrite.

Given the above, we consider that the potential for sulphate/pyrite attack on buried concrete would be Moderate

2.11 Radon Hazard

The environmental data report (Appendix C) indicates that the site does not lie in a radon affected area as defined by the Health Protection Agency as less than 1% of properties are above the action level.

Reference to the UK radon maps published by Public Health England (PHE, 2017) also indicates that the site lies in an area classified as a maximum radon potential of less than 1%.

These maps indicate the worst level of radon potential, based on existing information gathered mainly from residential properties within the 1km square in which the site is located. It is designed as a preliminary evaluation only.

Reference to BRE 211 (Scivyer, 2007) indicates that the site lies in a 1km square where the maximum requirements are for no radon protection measures in new buildings (domestic or non-domestic).

Given the currently available information, the risk from radon is considered Low.

2.12 Buried Unexploded Ordnance (UXO)

The environmental data report does not consider the potential risk from unexploded ordnance at the site.

The Cardiff area was heavily targeted by the Luftwaffe during World War Two. Reference to UXO risk maps available on-line (Zetica, 2017) suggests that the site is located within a Moderate risk region with regards to the risk from buried unexploded ordnance.

Given the above, a Preliminary UXO Desk Study assessment of risk has been completed by a specialist Ordnance consultant in accordance with CIRIA guidelines (Stone et al, 2009) and is presented in Appendix E (Zetica, 2017). This indicates that during World War II the site was located in the County Borough of Cardiff, which officially recorded 562 high explosive bombs with a moderate regional bombing density of 40 bombs per 405ha.

No readily available records have been found indicating that the site was bombed.

Given the above, we consider that the potential for unexploded ordnance beneath the site would be Low.

3 PRELIMINARY GEO-ENVIRONMENTAL RISK ASSESSMENT

3.1 Phase One Conceptual Site Model

3.1.1 Background

The Phase One Conceptual Site Model lists the potential sources of geo-environmental risk, the receptors at risk and the pathways between the two. These are discussed in the following sections.

3.1.2 Potential Sources of Soil/Water Contamination

3.1.2.1 Potential Contamination Sources:

Although no contaminative former use has been identified for the site, it has been previously developed as a residential dwelling and commercial premises. Therefore, we anticipate that there could be a covering of Made Ground, which could contain contaminants.

3.1.2.2 Potential Contaminants Present:

The potential contaminants associated with the above potential sources have been identified from various guidelines published by DEFRA, the Environment Agency and others. Based on this guidance and our experience, we consider that the following contaminants could be present on the site:

- heavy metals and semi-metals (arsenic, beryllium, cadmium, chromium, copper, lead, mercury, nickel, selenium, vanadium, zinc); plus other metals as indicated (e.g. barium, boron);
- cyanide, sulphate, sulphide;
- polyaromatic hydrocarbon (PAH) compounds;
- phenols;
- asbestos.

No evidence has been identified from the desk study to suggest that radioactive substances may be present on the site. The potential presence of radon in discussed in Section 3.1.4.

3.1.3 Potential Sources of Hazardous Ground Gas

The site is not located within 250m of an existing or former recorded landfill, nor are there any recorded instances of land filling in the vicinity. From the desk study information, there is no evidence of any potential on-site or nearby off-site sources of hazardous ground gas at the site.

Notwithstanding the above the site exists in a traditionally residential area and may have been subject to several phases of development not identified within the historical maps. As such a cover of Made Ground may be present with potetential to generate gas.

3.1.4 Potential Sources of Radon

As discussed in Section 2.11, the risk from radon is low and no radon protection measures are required for development.

3.1.5 Potential Receptors

As discussed in Section 1.1, the proposed site development will comprise residential properties with landscaping and vehicle parking areas, but no private gardens.

The site is located 950m from the River Ely and above a Secondary A Aquifer.

Given the above, we consider that the most vulnerable receptors with regards to any contamination or hazardous ground gas present are likely to be as follows.

- Future residents, the critical receptors being young children.
- Construction and maintenance workers.
- Buried concrete (foundations, drainage etc.).
- The groundwater within the Glaciofluvial Sheet Deposits strata beneath the site (classified as a Secondary A Aquifer).

3.1.6 Potential Migration Pathways

Based on the Conceptual Site Model discussed in the previous sections, the following are considered the most likely migration pathways with regard to any contamination or hazardous ground gas present beneath the site.

3.1.6.1 Site Users:

- Ingestion of soils and inhalation of dust in landscaping areas.
- Ingestion of edible plants and dust associated with such plants.
- Dermal contact with contaminated soils.
- Exposure to asbestos containing materials within the shallow soils.

3.1.6.2 Construction and Maintenance Workers:

- Exposure to asbestos containing materials within the existing buildings.
- Exposure to asbestos containing materials within the shallow soils.
- Ingestion of soils and inhalation of dust across site.
- Dermal contact with contaminated soils.

3.1.6.3 Groundwater:

- Leaching of mobile contaminants into the water-bearing strata within the bedrock.

Although the majority of the site is to be hard-surfaced, any soakaways constructed for the development have the potential to leach contaminants from the infiltration strata, which could then impact on the groundwater beneath the site.

3.2 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.

3.2.1 Introduction to Risk Evaluation Methodology

The methodology set out in CIRIA C552 *Contaminated Land Risk Assessment – A Guide to Good Practice* (Rudland et al, 2001), 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 (Table A1 in Appendix A):
- The magnitude of the probability (likelihood) of risk occurring (Table A2 in Appendix A).

The classifications defined above are then compared to indicate the risk presented by each pollutant linkage, allowing evaluation of a risk category (Tables A3 and A4 in Appendix A). These tables have been revised slightly from those presented in CIRIA C552, to allow for the circumstances where no plausible linkage has been identified and, therefore, no risk would exist.

The methodology described above has been used to establish Plausible Pollutant Linkages (PPL) based on the Conceptual Site Model generated for the site and proposed development, and to evaluate the risks posed by those linkages, using information known about the site, at this desk study stage. This is presented as Table 5 in Section 3.2.2 below.

3.2.2 Tabulated Preliminary Risk Evaluation & Plausible Pollutant Linkages

Table 5: 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 shallow soils	Direct contact/ inhalation/ ingestion of contaminated soil or dust	Site Users (residents)	Medium –potential for chronic levels.	Low likelihood[2]	Moderate/Low Risk	Sampling of near-surface soils to confirm levels of total contamination present.
	Direct contact/ inhalation/ ingestion of contaminated soil or dust	Construction/ Maintenance Workers	Minor –standard PPE likely to be sufficient	Low likelihood[2]	Very Low Risk	
	Leaching of soil contaminants	Impact on Groundwater	Medium –site lies on Secondary Aquifer	Low likelihood[2]	Moderate/Low Risk	Sampling of near-surface soils to confirm levels of leachable contamination present.
Asbestos in existing buildings/ stockpile	Ingestion of fibres	Demolition Workers/ Ground Workers	Medium –potential for chronic levels	High Likelihood[3]	High Risk	Asbestos survey of building/ stockpiles
Asbestos in shallow soils	Ingestion of fibres	Construction/ Maintenance Workers	Medium – potential for chronic levels	High Likelihood[3]	High Risk	Sampling of shallow soils for asbestos.
Soil sulphate and pyrite	Aggressive groundwater	Buried Concrete	Mild – damage to structures	High likelihood4	Moderate Risk	Sampling of soils to confirm levels of sulphate
Hazardous ground gas/ vapours	Asphyxiation/ poisoning. Injury due to explosion.	Site Users/Visitors.	Severe –acute risk.	Low likelihood[5]	Moderate Risk	Ground investigation to confirm the presence/absence of Made Ground at the site.
	Damage through explosion.	Building/Property	Severe –acute risk.		Moderate Risk	
	Asphyxiation/ poisoning. Injury due to explosion.	Construction and Maintenance Workers.	Severe –acute risk.		Moderate Risk	
Radon gas	Migration into Buildings	Site Users (residents)	Medium – potential for chronic levels	Low Likelihood[6]	Moderate/Low Risk	See Section 7.3.2

Notes:
1. Methodology and details of risk consequence, probability and category based on CIRIA C552 (2001) and presented in Section 3.2.1.
2. Although Made Ground is anticipated, the presence of contamination has yet to be confirmed on site.
3. The presence of asbestos in existing buildings and shallow soils cannot be discounted.
4. Made Ground can potentially contain sulphates/pyrite (Section 2.10).
5. No potential sources of hazardous ground gas/vapours have been identified in the desk study (Section 3.1.3).
6. Radon risk identified in environmental data report (Section 3.1.4).
7. The above risk evaluation is updated following the intrusive investigation and testing in Table 7 in Section 0.

4 EXPLORATORY INVESTIGATION

4.1 Investigation Points

4.1.1 Introduction

The intrusive investigation was undertaken on 18th May 2017 in accordance with BS5930:2015 and BS10175:2013, and was designed to investigate both geo-environmental and geotechnical hazards identified in the desk study (Section 2). It comprised trial pitting accompanied with soakaway infiltration testing.

The exploratory holes were supervised and logged by an engineering geologist in general accordance with BS5930:2015. Descriptions and depths of the strata encountered are presented on the trial pit records in Appendix F. The investigation point positions are shown on Figure 2.

4.1.2 Investigation Strategy

The investigation strategy was generally designed in accordance with BS10175:2013, taking into account the additional potential for geotechnical hazards to be present.

As no specific potential contaminant sources or geotechnical hazards were identified in the desk study (see Sections 2.9 and 3.1.2), the investigation points were spread across the site to obtain a general overview of the ground conditions present. The investigation point locations were positioned to maximise the information that could be obtained, allowing for the constraints imposed by the physical features on site including the current structure. Notwithstanding the above constraints, we consider that the investigation undertaken has been sufficient to identify the key ground issues at the site.

4.2 Trial Pits

Three trial pits (TP1 to TP3) were excavated across the site on 18th May 2017 using a wheeled, backacting excavator. The trial pits were excavated to a maximum depth of 2.2m. The tarmacadam and concrete surface was broken out prior to the excavation of the pits using a hydraulic breaker. The trial pit records are presented as Appendix F.

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.

4.3 Soakaway Infiltration Testing

Soakaway infiltration tests were undertaken in general accordance with BRE Digest 365 (2007) in two trial pits across the site (TP1 and TP2) The results of the infiltration testing, and the calculated infiltration rates, are presented in Appendix G.

Clean water was added from a large capacity bowser/tanker and the water level monitored as it percolated into the soil. Sufficient time and water was available to repeat the test (a total of two fills) in both locations. On completion of the testing in

each pit, any remaining water was removed from the test pit and it was backfilled with the excavated arisings.

4.4 Sampling Strategy

4.4.1 Soil Sampling

Soil samples were collected from the exploratory holes as discussed in the previous sections. The sampling procedures were selected on the basis of the suitability for the laboratory testing proposed (see Sections 4.6 and 4.7).

A non-targeted, random sampling strategy was used to obtain representative information on soil contamination across the site as a whole. Samples for logging and geotechnical laboratory testing purposes were collected at regular intervals within the exploratory holes.

4.4.2 Soil Sample Quality

Samples of soil recovered from investigations are classified as Classes 1 to 5 in terms of quality and depend on the investigation and sampling method, the particle size of the strata sampled, and the presence of groundwater. Class 1 and 2 samples are those in which there has been no or only slight disturbance of the soil structure, with moisture contents and void ratios being similar to the in-situ soil. Class 3 and 4 samples contain all the constituents of the in-situ soil in their original proportions, and the soil has retained its original moisture content, but the structure of the soil has been disturbed. In Class 5 samples, the soil structure and original layering cannot be identified and the water content may have changed from that in-situ. The category and class of samples are discussed further in BS EN ISO 22476:2006, EN 1997-2:2007 and BS5930:2015.

In general terms, disturbed samples recovered from trial pits (bulk bags and small tubs) are classed as Class 3 (if dry), Class 4 (fine soil below the water table), or Class 5 (coarse soils from beneath the water table).

4.5 Evidence of Site Hazards Found During Site Works

4.5.1 Site Stability

Minor to moderate spalling of the cobbles from the sidewalls below 1.0m depth was observed in the pits. No other geotechnical hazards were identified in the exploratory holes.

4.5.2 Site Evidence of Contamination

A slightly organic odour (non-hydrocarbon) was noted in the Made Ground in TP3 between 0.1 –0.25m depth. No direct visual evidence of contamination was identified in the exploratory holes. However, Made Ground was present across the site which can contain elevated levels of contaminants such as metals and polyaromatic hydrocarbon (PAH) compounds.

4.6 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.

Particle size analysis were undertaken by a UKAS accredited laboratory on samples selected by ESP in accordance with the methodologies presented in BS1377:1990. The results are presented in Appendix H.

Selected samples were also analysed for soil sulphate and pH value in accordance with the analytical methods specified in BRE Special Digest SD1 (BRE, 2005). Due to the potential presence of pyrite in the soils (see Section 2.10), these samples were also analysed to determine the levels of total sulphur, acid soluble sulphate in accordance with the analytical methods specified in BRE Special Digest SD1 (BRE, 2005).

4.7 Geo-environmental Laboratory Testing

Laboratory testing has been undertaken to identify the levels of selected contaminants within samples of soil.

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 4.1.1).

4.7.1 Soil Samples

The PRA (Section 3.1.2) did not identify any particular contaminants of concern at the site. However, given the presence of Made Ground, in order to allow an assessment of the potential chronic risks posed to human health, a total of four selected samples of the Made Ground have been analysed for contaminants typically found on brownfield sites in the UK.

The general suite of geo-environmental laboratory testing undertaken comprised:

- Arsenic, barium, beryllium, boron, cadmium, total chromium, chromium VI, copper, lead, mercury, nickel, selenium, vanadium, zinc;
- US EPA 16 polyaromatic hydrocarbon (PAH) compounds;
- Total monohydric phenols;
- Total cyanide/asbestos qualitative screen (presence or absence);
- Soil organic content, pH value;

The geo-environmental soil test results are presented in Appendix I.

5 DEVELOPMENT OF THE REVISED CONCEPTUAL MODEL

5.1 Geology

The exploratory holes have identified the site to be underlain by Made Ground over Glaciofluvial Sheet Deposits. These strata are discussed in more detail in the following sections.

5.1.1 Made Ground

Encountered in all exploratory holes to a maximum depth of 0.9m comprising of an upper and lower portion described in the subsequent sections.

5.1.1.1 Upper Made Ground

Encountered in TP1 and TP2 between surface and 0.5m depth. Comprising dark brown slightly clayey gravelly sands with plastic and concrete fragments with many rootlets. The composition of the above unit indicates the material is likely to comprise of a portion of demolition material.

5.1.1.2 Lower Made Ground

Encountered in all exploratory holes between 0.4 –0.9m as a black brown very clayey sand to sandy clay. The recovered gravels consisted of fragments of coal, sandstone and limestone.

5.1.2 Glaciofluvial Sheet Deposits

Encountered in all exploratory holes to a maximum depth of 2.2m as a loose to medium dense orange brown slightly clayey sandy cobbly gravel. The gravel and cobbles are predominantly rounded to subrounded. The Glaciofluvial Sheet Deposits on TP03 between 0.25 to 0.6m were recovered as a firm very gravelly clay.

Particle size analyses within the laboratory have indicated the coarse-grained glacial soils to comprise between 6 and 58% gravel, predominantly coarse, between 6 and 21% sand and between 9 to 36% cobbles. Based on our observations on site, these proportions would appear representative of the in-situ soils

5.1.3 Mercia Mudstone Bedrock

Not encountered in the investigation. Bedrock is anticipated to be present at depths of around 10m, comprising medium strength red brown mudstone, see Section 2.6.2.

5.2 Hydrogeology

5.2.1 Groundwater Bodies

The investigation did not identify any groundwater to a depth of 2.2m. However, the exploratory holes were completed within one working day and the near-surface soils contained a fine grained portion of soils. Therefore, it is possible that groundwater may

be present within the depth of investigation, but there was insufficient time for it to be recorded.

Based on the above findings and the Conceptual Ground Model and salient information form boreholes in the general Cardiff area, we consider that the main groundwater body beneath the site is within the glacial soils, at around 5m depth.

5.2.2 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 south.

5.3 Site Instability

During the excavation of the trial pits, some minor to moderate spalling of the pit wall was experienced within the cobbles.

5.4 Chronic Risks to Human Health –Generic Assessment of Risks

5.4.1 Assessment 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.

5.4.2 Assessment Criteria

In 2014, DEFRA published the Category 4 Screening Levels (C4SL) for use in Part 2A determinations. The C4SL are designed to be more pragmatic, but still strongly precautionary, assessment criteria compared to the previous assessment criteria (SGV – see below) used to assess chronic human health risks. They are designed for use in deciding whether land is suitable for use and definitely not contaminated, and DEFRA and the Welsh Government have recommended that they be used in assessing human health risks during the planning regime (i.e. as part of standard development investigations). However, the C4SL have been calculated for a limited number of contaminants at this stage, and range of land uses including residential, commercial and public open space, but are based on a 'low level' of risk rather than the 'minimal level' of risk adopted by the Environment Agency in preparing their Soil Guideline Values (SGV). At the time of writing, the use of the C4SL in planning has not yet been accepted by many parties, including some regulators. The C4SL have also only been published for

a limited number of contaminants. The C4SL have not been generally adopted in this assessment.

In this assessment, where available, the Soil Guideline Values (SGV) published by the Environment Agency have been adopted as the Generic Assessment Criteria (GAC) in the first instance. However, the SGV are only available for a limited number of contaminants for three proposed land uses (residential, commercial and allotments - not public open space). Where no SGV is available, the Suitable For Use Levels (S4ULs) published in January 2015 by the Chartered Institute of Environmental Health (CIEH) and Land Quality Management (LQM) have been adopted (Nathanail et al, 2015). These assessment criteria adopt updated toxicological data and exposure models, but the same 'minimal level' of risk as the SGV (i.e. unlike the C4SL). The S4ULs have been published for a large number of contaminants typically found on brownfield sites in the UK, and for the same range of land uses as the C4SL, i.e. including public open space scenarios.

For more exotic, predominantly organic, compounds no SGV, S4UL or C4SL assessment criteria have been published. In this instance, GAC published by CL:AIRE and the Environmental Industries Commission (CL:AIRE/EIC, 2010) have been adopted. These GAC have also been developed using the CLEA UK software based on a 'minimal level' of risk and for the same land use scenarios as the SGVs (i.e. not public open space).

At the time of writing there is no published SGV, S4UL or CL:AIRE/EIC assessment criteria for lead. For the purposes of this assessment, and in the absence of any other current authoritative guidance, the Category 4 Screening Level (C4SL) value published by DEFRA has been adopted.

Details of the source of the GAC adopted for each contaminant are presented on the assessment table below.

The proposed development comprises residential accommodation, without private gardens, but with limited external landscaping. No growing of edible plants is anticipated, therefore, the GAC appropriate for public open space around residential properties have been adopted in this assessment. Should the scheme change to include areas of private gardens and/or growing the results will need to be reviewed and further risk assessment undertaken as the results denote an exceedance of lead when compared to the more stringent residential with plant uptake senario.

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 5.5 to 10%. For the purposes of this assessment, GAC for a soil organic content of 1% has been adopted. This again is a conservative approach for the majority of the soils at the site.

5.4.3 Generic Quantitative Risk Assessment

The samples analysed for soil contaminants comprised four samples of Made Ground. At this stage, all samples have been considered across the site as one averaging area.

The results of the Generic Quantitative Risk Assessment are presented in Table 6 below. The risks from asbestos are considered further in Section 7.1.1.

Table 6: Summary of Geo-environmentalSoil Results

Determinand	Range Recorded	GAC	Source of GAC	Exceedances
Metals and Semi-metals				
Arsenic	18 - 30 mg/kg	79mg/kg	S4UL[2]	None of four.
Barium	160 - 490 mg/kg	1,300mg/kg	CL:AIRE[4]	
Beryllium	0.7 - 1 mg/kg	2.2mg/kg	S4UL[2]	
Boron	< 0.2 - 0.6 mg/kg	21,000mg/kg	S4UL[2]	
Cadmium	0.3 - 0.8 mg/kg	120mg/kg	S4UL[2]	
Chromium (total)[5]	18 - 24 mg/kg	1,500mg/kg	S4UL[2]	
Chromium (hexavalent)	< 1 mg/kg	7.7mg/kg	S4UL[2]	
Copper	45 - 310 mg/kg	12,000mg/kg	S4UL[2]	
Lead	120 - 410 mg/kg	630mg/kg	C4SL[5]	
Mercury[6]	0.24 - 0.54 mg/kg	120mg/kg	S4UL[2]	
Nickel	20 - 29 mg/kg	230mg/kg	S4UL[2]	
Selenium	< 0.5 - 1 mg/kg	1,100mg/kg	S4UL[2]	
Vanadium	30 - 33 mg/kg	2,000mg/kg	S4UL[2]	
Zinc	100 - 310 mg/kg	81,000mg/kg	S4UL[2]	
Polyaromatic Hydrocarbons (PAH)				
Acenaphthene	< 0.03 mg/kg	15,000mg/kg	S4UL[2,7]	None of four.
Acenaphthylene	< 0.03 mg/kg	15,000mg/kg		
Anthracene	< 0.03 mg/kg	74,000mg/kg		
Benzo(a)anthracene	< 0.03 - 0.17 mg/kg	29mg/kg		
Benzo(a)pyrene	< 0.03 - 0.14 mg/kg	5.7mg/kg		
Benzo(b)fluoranthene	< 0.03 - 0.25 mg/kg	7.1mg/kg		
Benzo(ghi)perylene	< 0.03 - 0.09 mg/kg	640mg/kg		
Benzo(k)fluoranthene	< 0.03 - 0.08 mg/kg	190mg/kg		
Chrysene	< 0.03 - 0.22 mg/kg	57mg/kg		
Dibenzo(a,h)anthracene	< 0.03 - 0.04 mg/kg	0.57mg/kg		
Fluoranthene	0.05 - 0.46 mg/kg	3,100mg/kg		
Fluorene	< 0.03 mg/kg	9,900mg/kg		
Indeno(123-cd)pyrene	< 0.03 - 0.09 mg/kg	82mg/kg		
Naphthalene	< 0.03 mg/kg	4,900mg/kg		
Phenanthrene	< 0.03 - 0.2 mg/kg	3,100mg/kg		
Pyrene	0.04 - 0.41 mg/kg	7,400mg/kg		
Other Organic Compounds				
Phenol	<0.3 mg/kg	760mg/kg	S4UL[2,7]	None of four.

Notes
1. Assessment for public open space (landscaping around residential units, without growth of home-grown produce.
2. S4ULs Suitable 4 Use Levels. Copyright Land Quality Management Limited, reproduced with permission; Publication No. S4UL3156. All Rights Reserved. No SGV published for this land use.
3. CL:AIRE/EIC GAC published by CL:AIRE and Environment Industries Commission.
4. C4SL: Category 4 Screening Level. No current SGV, S4UL or CLAIRE/EIC assessment criteria for lead. Category 4 Screening Level adopted in assessment.
5. In the absence of Chromium VI, all chromium present likely to be Chromium III. GAC for Chromium III adopted.
6. GAC for inorganic mercury adopted.
7. GAC for organic compounds based on 1% soil organic content.
8. GAC for xylene based on p-xylene (lowest S4UL).
9. ESP - Generic Assessment Criteria generated by ESP using CLEA software.
10. Exceedances highlighted in red and bold.
11. Laboratory results presented in Appendix I.

From Table 6.it is clear that all the determinands analysed were below their respective GAC. No further statistical analysis is warranted.

5.4.4 Asbestos

No evidence of asbestos was identified in the samples analysed.

5.5 Ground Gas

5.5.1 Degradation of Organic Materials

No monitoring for ground gas was undertaken as part of this investigation.

The desk study identified potential areas of Made Ground, that has been confirmed by the intrusive investigation.

Whilst potential sources for ground gas has been identified, no putrescible/potentially gassing materials were encountered during the investigation. Given the location of the proposed development the potential for significant gas concentrations is considered unlikely. It is therefore considered that the risk from combustible or noxious gas at the site is low. If during development, any organic or putrescible material is encountered, it should be removed from site and replaced with suitable fill material.

5.5.2 Radon

As discussed in 2.11 no radon protection is required for the development.

5.6 Sulphate Attack

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

5.6.1 Classification of Site

Due to the presence of 0.9m of Made Ground comprising on the site, we consider that it should be considered as 'brownfield' in terms of concrete classification. For the purpose of this assessment the Made Ground and Glacial Deposits have been assessed together.

5.6.2 Groundwater Setting

No groundwater was encountered in the exploratory holes to a depth of 2.2m. However, no long term monitoring (in excess of 24 hours) of groundwater levels has been undertaken. Moist arisings were observed from approximately 1.0m, see Section 5.2.1. Therefore, in accordance with the BRE guidelines, we recommend that groundwater be considered as 'mobile' in terms of foundation concrete assessment.

5.6.3 Sulphate Levels

Laboratory test results indicate the levels of water soluble sulphate (as SO_4) to be between 16 and 23mg/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 acid soluble sulphate varied between 0.01 and 0.03% and total sulphur between 0.03 and 0.07%. From these results, the calculated levels of total potential sulphate are between 0.09 and 0.21%, and oxidisable sulphides are between 0.08 and 0.18%. As the levels of oxidisable sulphide are well below 0.3%, pyrite is unlikely to be present.

5.6.4 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:	25mg/l;
Total potential sulphate:	0.23%
pH value:	7.8

6 PHASE TWO GEO-ENVIRONMENTAL RISK ASSESSMENT

6.1 Discussion on Occurrence of Contamination and Distribution

No evidence of unacceptable levels of contamination has been identified in the investigation, when compared to the GAC's for residential land use with no plant uptake.

6.2 Revised Risk Evaluation & Relevant Pollutant Linkages

As discussed in detail within Section 3.2.1, the methodology set out in CIRIA C552 (2001) 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 (Table 5, Section 3.2.2) have been updated and revised in Table 7 following information learned from the exploratory works and results of monitoring and laboratory testing.

Table 7: Revised Risk Evaluation & Relevant Pollutant Linkages (RPL)

Source	Pathway	Receptor	Classification of Consequence	Classification of Probability	Risk Category	Further Investigation or Remedial Action to be Taken
Potential contaminants in shallow soils	Direct contact/ inhalation/ ingestion of contaminated soil or dust	Site Users (residents)	Medium –potential for chronic levels.	Unlikely[2]	Low Risk	See Section 7.1 for further discussion.
	Direct contact/ inhalation/ ingestion of contaminated soil or dust	Construction/ Maintenance Workers	Minor – standard PPE likely to be sufficient	Unlikely[2]	Very Low Risk	
	Leaching of soil contaminants	Impact on Groundwater	Medium – site lies on Principal Aquifer	Unlikely[2]	Low Risk	See Section 7.2 for further discussion.
Asbestos in existing buildings	Ingestion of fibres	Demolition/ Construction Workers	Medium –potential for chronic levels	High Likelihood	High Risk	See Section 7.1.1 for further discussion.
Asbestos in shallow soils	Ingestion of fibres	Demolition/ Construction Workers	Medium –potential for chronic levels	Unlikely[4]	Low Risk	See Section 7.1.1 for further discussion.
Soil sulphate	Aggressive groundwater	Buried Concrete	Mild – damage to structures	Unlikely[3]	Very Low Risk	See Section 7.4.2 for further discussion.
Ground gas generated in organic alluvial soils	Asphyxiation/ poisoning, injury by explosion	Site Users / Visitors (residents)	Severe	Unlikely[6]	Moderate/Low Risk	See Section 7.3 for further discussion.
	Damage through explosion	Buildings	Severe	Unlikely[6]	Moderate/Low Risk	
	Asphyxiation/ poisoning, injury by explosion	Construction/ Maintenance Workers	Severe	Unlikely[6]	Moderate/Low Risk	
Radon Gas	Migrating into Buildings	Site Users (residents)	Medium – potential for chronic levels	Unlikely[5]	Low Risk	See Section 5.5.2 for further discussion.

Notes:
1. This table updates Table 5 in Section 3.2.2 using results of the investigation. Methodology and details of risk consequence, probability and category presented in Appendix A.
2. No contaminants analysis were above the adopted GAC
3. Low levels of sulphates recorded in–see Section 5.6.
4. No asbestos identified in shallow soils on site –see Section 5.4.4
5. No radon risk identified in Groundsure report –see Section 3.1.4.
6. No prosecutable materials identified –see Section 5.5.

7 REMEDIAL STRATEGY FOR CONTAMINATION RISKS

The following recommendations are based on interpretations made from the relatively limited site investigation data obtained to-date, and do not form the full Options Appraisal stage of CLR11. 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 geo-environmental specialist sought immediately.

7.1 Risks to Health

7.1.1 Asbestos

No evidence of asbestos was detected at the site. However, it cannot be discounted that during the construction, excess building materials could have been placed on the site. Given the date of construction these should not have included significant amounts of asbestos, however, this cannot be totally discounted

If any suspected asbestos containing materials (ACM) are identified during development, the advice of a suitably qualified specialist should be sought immediately. Any identified ACM would need to be removed from site by a licensed specialist contractor.

7.1.2 Site End Users

Assuming an end use of flats, with no growing of edible plants the identified levels of soil contamination at the site are not considered to pose a risk to future site users. Therefore, no specific remedial measures are considered necessary for the development. Should the end use be changed further geo-environmental specialist advice should be sought.

Notwithstanding the above, as discussed in Section 7.1.1, it cannot be discounted that former hollows in the site surface may have been infilled in the past with contaminated materials. If any evidence of Made Ground or other contaminated soils is identified during development, further geo-environmental specialist advice should be sought.

7.1.3 New Service Connections

The current water industry guidance for the suitability of pipe materials on potentially contaminated sites (Blackmore et al, 2010) has onerous requirements and it is likely/possible, 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.

7.1.4 Risk to Construction and Maintenance Workers

The site is anticipated to be of low risk however short term (acute) risks to construction and maintenance workers are generally poorly understood within the industry, certainly when compared to the volume of research undertaken on long term risks. However, we anticipate that the levels of contamination at the site are not likely to pose a severe

acute risk to construction workers or future maintenance workers. Ground workers would need to undertake their own assessment of the risks to their workers.

7.1.5 General Public/Neighbouring Properties

We do not anticipate any significant risks to the general public from the development of the site. However, careful dust control measures should be adopted during construction to minimise the risk (and nuisance) to the general public and neighbouring residents.

7.2 Risks to Controlled Waters

No specific assessment of the risks to controlled waters has been undertaken to date. However, the following points are considered salient.

- No significant past contaminative use has been identified at the site.
- The levels of soil contaminants are below the GAC adopted.
- The proposed development comprises a conventional residential dwelling which will include areas of car parking which are anticipated to be hard surfaced – surface drainage from these areas could contain leached oils and fuels from vehicle spills and leaks.
- Soakaways are being considered for the development.
- The site is underlain by fine and coarse grained glacial soils.
- The bedrock beneath the site is classified as a Secondary B aquifer. The glacial soils are defined as a Secondary A. Groundwater is anticipated within the superficial soils from depths of approximately 5m.
- The River Ely lies some 900m to the east at its closest point,

Given the above, we consider that the overall risk to controlled waters from the development of the site is likely to be low and no further assessment is warranted. However, some risk mitigation is likely to be required where soakaways are used to dispose of surface water run-off –see Section 8.8 for further discussion.

7.3 Risks from Ground Gas

7.3.1 Risk to the Development –Degradation of Organic Material

No monitoring for ground gas was undertaken as part of this investigation.

Whilst potential sources for ground gas has been identified, no significant putrescible/potentially gassing materials were encountered during the investigation. In addition, no significant pathways for gas migration have been identified. It is therefore considered that the risk from combustible or noxious gas at the site is low. If during development, any organic or putrescible material is encountered, it should be removed from site.

7.3.2 Risk to the Development –Radon

As discussed in Section 3.1.4, the Preliminary Risk Assessment has indicated that no radon protection is required.

7.3.3 Risk to Construction and Maintenance Workers

Based on the above results we do not consider there is a particular risk to construction and maintenance workers, and there is no requirement to define shallow excavations as confined spaces. However, we recommend good site practice and all excavations should be considered potentially confined spaces.

7.4 Risks to Property

7.4.1 Spontaneous Combustion

No evidence of combustible materials has been identified in the shallow soils. Therefore, the risk from spontaneous combustion is considered to be low.

7.4.2 Sulphate Attack on Buried Concrete

The characteristic values form Section 5.6.4 are applicable for the shallow soils at the site (all as SO4). Based on these characteristic values, we consider that the site would be classified as Design Sulphate Class DS-1 and Aggressive Chemical Environment for Concrete Class AC-1, allowing for mobile groundwater.

7.5 Re-Use of Materials/Disposal of Excess Arisings

All soils or other materials excavated from any site are generally classified as waste under the Waste Framework Directive (European Union, 2008) and their re-use is controlled by this legislation.

If the soils are to be re-used on site (e.g. within the red-line planning boundary), provided that they are 'uncontaminated' or other naturally occurring deposits and they are certain to be used for the purposes of construction in their natural state on the site from which they are excavated, they may be excluded from waste regulation (CLAIRE, 2011). A Materials Management Plan (MMP) may be required –further guidance can be provided by this office once proposals have been finalised. However, if they are man-made or contaminated materials, their use on the site may be limited.

If the soils are to be removed from site, they are automatically classified as waste, and they may only be:

1. Disposed at a licensed landfill;
2. Disposed at a licensed, permitted soil treatment centre; or
3. Removed to a Receiver Site for beneficial re-use.

In Scenarios 1 and 2, the materials must be transferred by a licensed waste carrier and the waste producer (the developer) must ensure that the destination landfill or treatment centre is a legitimate operation (e.g. by requesting a copy of the Environmental Permit before releasing the soils). Prior to removal from site, the excavated arisings would need to be classified as either 'hazardous' or 'non-hazardous' waste based on the hazard that they pose–a WM3 assessment (note that this is a different assessment to the risk assessments reported on in earlier sections of this report). This can commonly be undertaken on the results of soils testing undertaken

during the investigation, although further sampling and testing may be required. Only once the soils have been classified under the WS3 assessment, would Waste Acceptability Criteria (WAC) testing then be required to determine the type of landfill in which the arisings could be disposed in Scenario 1. Further testing and assessment may also be required by the soil treatment centre in Scenario 2.

In Scenario 3, management of soils could be undertaken via an Environmental Permit or Exemption. However, these can take time and are costly to arrange. Therefore, in certain circumstances, it is permissible to use the protocols laid down in the CL:AIRE Definition of Waste, Development Industry Code of Practice (DoWCoP, Duckworth, 2011) to classify the arisings and put a management plan in place to control the use. This involves approval of the proposals by a Qualified Person and is generally more efficient (in terms of time and cost) to implement.

Further guidance on the legislative requirements of the re-use/disposal of materials generated by the development can be provided by this office once the development proposals have been finalised.

8 GEOTECHNICAL COMMENTS

8.1 Site Preparation and Earthworks

8.1.1 Invasive Plants

No evidence of invasive plants such as Japanese Knotweed/Himalayan Balsam etc. was identified on the site during the site works.

8.1.2 Existing Foundations and Services

No evidence of old foundations and underground structures have been identified in the investigation area. The foundations of the current structure on site will require grubbing up within the zone of influence of the development as part of the site preparation works.

8.1.3 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.

8.1.4 Earthworks

We have not been advised that the development requires any significant earthworks. The site is relatively flat and, therefore, no such earthworks are anticipated.

8.2 Geotechnical Risk Register

The Preliminary Geotechnical Risk Register (Table 4) has been updated Table 8 with additional information from the intrusive investigation.

Table 8: Updated Geotechnical Risk Register

Hazard	Risk	Comments
Coal Mining	Low	No coal bearing strata in the local area.
Mining (non-coal)	Low	No evidence of mining in the local area.
Shrinking or Swelling Clays	Low	Minor clay bands identified.
Landslides	Low	Not in an areas susceptible to landslides.
Ground Dissolution (Soluble Rocks)	Low	No solution feature bearing stratum present.
Compressible Ground	Low	No significant compressible ground observed, see Section 8.3.
Collapsible Ground	Low	No evidence for collapsible ground identified.
Notes 1. This table updates Table 4 in Section 2.9.1using the results of the intrusive investigation. 2. Further discussion is presented in the following sections.		

8.3 Preliminary Foundation Design and Construction

We understand that the site is being considered for potential development for a three-storey structure.

On the basis of the available investigation information, we consider that mass concrete spread foundations could be used at the site, placed at a depth of 1.0m below surface level, that an allowable bearing pressure of 125kPa is appropriate (using a factor of safety of 3). This could potentially be increased if required by the client by undertaking boreholes at the site. ESP advise the subsurface conditions below the current structure are investigated prior to aforementioned proposed development.

For all spread foundation options, the formations should be cleaned, and subsequently inspected by a suitably qualified engineer prior to placing concrete. Should any soft, compressible or otherwise unsuitable materials be encountered they should be removed and replaced by lean mix concrete or suitable compacted granular material. We recommend that a blinding layer of concrete be placed on the formation after excavation and inspection in order to protect the formation against softening and disturbance.

8.4 Floor Slab Foundations

Due to the presence of over 600mm of Made Ground soils at the site, we consider that ground bearing floor slabs would not be suitable for the development, and floor slabs should be suspended.

8.5 Pavement Design

We understand that vehicle access roads/hardstanding are proposed at the site.

8.5.1 Design CBR Value

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.

8.6 Susceptibility to Frost Action

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

8.7 Excavation and Dewatering

It is anticipated that excavation throughout most of the site will be within the capabilities of conventional mechanical excavators. Old foundations will require higher capacity machines for their removal.

For shallow excavations where there is no danger to life, support of excavation sides is unlikely to be necessary. Should any 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 above 2m depth. Where water ingress occurs it is likely that pumping from screened sumps within shallow excavations will be adequate.

8.8 Soakaway Drainage

8.8.1 Soakaway Design

Soakaway infiltration tests were undertaken in two test pits excavated across the site (TP1 and TP2). The results of the testing are presented in Appendix G.

Sufficient infiltration was achieved within the test to allow an infiltration rate to be calculated at both locations. The calculated infiltration rates are presented in Table 9 below.

Table 9: Summary of soakaway infiltration test results

SA Test	Test Pit	Test depth (m)	Measured Infiltration Rate Fill 1	Measured Infiltration Rate Fill 2	Infiltration Soils
SA1	TP1	1.9	5 x 10^{-5} m/s	3 x 10^{-5} m/s	Slightly clayey cobbly sands and gravels
SA2	TP2	1.8m	3 x 10^{-5} m/s -	2 x 10^{-5} m/s	Slightly clayey cobbly sands and gravels

Notes:
1. Testing undertaken in accordance with BRE 365. Water level fell to 25% of fill depth.

In general, we would recommend that 10^{-5} m/s be used as a typical infiltration rate for design across the site. However, it must be appreciated that where fine-grained soils are present, infiltration rates will be lower.

8.8.2 Soakaway Discharge

As the soakaway is located more than 18m from the nearest surface water course, a discharge consent will not be required. However, prior to construction, this should be confirmed with Natural Resources Wales/the Environment Agency.

The infiltration stratum at the site would be the superficial soils, which is classed as a Secondary A aquifer and the groundwater within is vulnerable to pollution. The Environment Agency has a general policy that no direct discharge of surface run-off would be accepted in vulnerable groundwater aquifers. 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.

9 RECOMMENDATIONS

We consider that the following further investigation and assessment would be required or prudent prior to development: examples below:

- Further environmental sampling and geotechnical investigation of the ground conditions below the current building footprint (when demolished).
- Probe holes within the proposed building footprint to assist in a review of the ground conditions and foundation options, if required by the client (Section 8.3).
- Asbestos survey of existing building (Section 7.1.1).
- Measure CBR values at sub-grade prior to pavement construction (Section 8.5.1).
- Enquiries to NRW/EA to confirm acceptance of soakaways and any risk mitigation measures required (Section 8.8.3).
- Undertake a flood risk assessment at the site, if required (Section 2.5.3).

Further advice and costings for the above works can be provided by ESP if required.

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Figures

Plates

Appendix A 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. The following tables have been used to classify the risk for each pathway. Tables A2 to A4 have been revised to include for circumstances where no plausible risk has been identified.

Table A1 - 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 A 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 A2: 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.
No Linkage	No plausible linkage has been established.

Table A3: 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
	No Linkage	No Risk			

Table A4: 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.
No Risk	· No risk mitigation required.

Appendix B Historical Maps

Appendix C Enviro-Insight Environmental Data Report

Appendix D Correspondence with Cardiff County Council

Appendix E Preliminary UXO Risk Assessment (Zetica, 2017)

Appendix F Trial Pit Records

Appendix G Results of Soakaway Infiltration Testing

Appendix H Geotechnical Laboratory Test Results

Appendix I Geo-environmental Laboratory Test Results

Appendix J Service Plans